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Collaboration Now for the Future: IV Conference on the Biodiversity and Management of the Madrean Archipelago

Emory Oak savanna, Peloncillo Mountains, Coronado National Forest, New Mexico. Animas Mountains in the Background (Photo by Daniel G. Neary, USDA Forest Service, Rocky Mountain Research Station)

Abstract

This Proceedings contains the abstracts in English and Spanish of papers presented at the 4th conference on the Madrean Archipeligo held May 14-18, 2018, in Tucson, Arizona. It also contains several full-length papers that expand on the abstracts. The Report presents updates on research presently going on in the Madrean Archipeligo region of Arizona, New Mexico, Sonora, and Chihuahua. The region is known as the "Sky Islands" of southern Arizona and New Mexico and the Sierra Madre Occidental of Sonora and Chihuahua. In between the mountain ranges are the grasslands and desert lands that form the "seas" that isolate the flora and fauna of the highlands. The wide range of ecosystems from the intermountain deserts and grasslands contribute to the high biodiversity of the region. Contributions to the Proceedings came from researchers in the USA, Mexico, and Portugal. Topics include climate, Madrean history, mammals, invertebrates, aquatic fauna, plants, hydrology, soils, riparian areas, herpetofauna, biodiversity, grasslands, fire, mining, monitoring, and other topics.

Keywords: forest restoration, history, climate, soils, vegetation, geomorphology, watersheds, water quality, water quantity, fluvial ecosystems, fish and invertebrate fauna, riparian ecosystems

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Collaboration Now for the Future: IV Conference on the Biodiversity and Management of the Madrean Archipelago

Editors

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Gerald J. Gottfried, Research Forester (Retired), Forest and Woodland Ecosystems Program, Forestry Sciences Laboratory, Rocky Mountain Research Station, USDA Forest Service, Flagstaff, AZ 86001.

Cover Photo – *Emory oak woodland to the west of the Animas Valley in New Mexico including the Peloncillo Mountains (Foreground) and Animas Mountains (Background)*

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PREFACE

The Southwestern Borderlands Ecosystem Management Research Project was initiated in 1994. The project was the result of a successful proposal by Dr. Leonard DeBano (Rocky Mountain Research Station, deceased) and Larry Allen (Malpai Borderlands Project Coordinator, Coronado National Forest, retired). Dr. Jerry Gottfried and Dr. Carl Edminister (Rocky Mountain Research Station, retired) were instrumental in organizingestablishing, and encouraging research efforts. One of the major factors in the success of the proposal was the support of the Coronado National Forest, the Malpai Borderlands Group, the Animas Foundation, The Nature Conservancy, the Natural Resources Conservation Service, the Bureau of Land Management, the Sky Island Alliance, the U.S. Geological Survey, the Arizona Geological Survey, and The University of Arizona, School of Renewable Natural Resources. Other important contributors including Collaborating Partners, Conference Organizing Committee, and Conference Sponsors are listed below in the document. The Madrean Archipeligo Proceedings are the results of a conference held every five years to summarize the research progress. This volume summarizes the presentations made at the 4th Madrean Archipeligo Conference in 2018. It contains all the abstracts in English and Spanish.

These have not been edited and represent what was submitted at the time of the Conference. They are provided to give readers a better idea of the full scope of the Conference. Some authors have contributed full papers to the proceedings. Most are in English but some are in Spanish. These documents have been inserted after their respective abstracts.

The Editors
January 2022

ACKNOWLEDGMENTS

We would like to dedicate this particular volume to several scientists and researchers who have made substantial contributions to the Borderlands Ecosystem Management Project and Madrean Archipeligo conservation. The first is Dr. Carlton Edminster, USDA Forest Service Rocky Mountain Research Station, who provided the administrative support as program manager. The second is the late Dr. Malchus B. Baker Jr., a former USDA Forest Service Rocky Mountain Research Station research hydrologist, for his career-long commitment to research on the hydrology and watershed management of Southwest forests and woodlands. The third person is the late Dr. Leonard DeBano, a former USDA Forest Service, Rocky Mountain Research Station Project Leader and Research Soil Scientist. The fourth is the late Dr. Peter Ffolliott, a University of Arizona Professor in the School or Renewable Natural Resources who contributed substantially to the Borderlands effort. Finally, the authors would like to acknowledge the late Dr. Benee F. Swindel, a former USDA Forest Service, Southern Research Station Project Leader and Research Forester and Intensive Management Practices Assessment Center Project Leader, for his timeless and eternal counseling in the art of “perseverance”.

A special remembrance is due to Dr. Phil Rosen, University of Arizona, who recently passed away. He was known for his contributions to conservation in the Madrean Archipeligo and especially the Tucson shovel-nosed snake.

The lead author wishes to thank the 42 reviewers for insightful and helpful reviews, suggestions, information, and assistance from that led to substantial technical and editorial improvements in the manuscript. Administrative support from Dr. Frank McCormick, Air-Water-Aquatic Environments Program Manager, Rocky Mountain Research Station, is gratefully acknowledged.

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Collaboration Now for the Future: IV Conference on the Biodiversity and Management of the Madrean Archipelago

Colaborando Hoy para el Futuro: IV Congreso de la Biodiversidad y la Gestión del Archipélago Madrense

May 14-18, 2018
Tucson, Arizona

Editors:

Daniel G. Neary
Gerald J. Gottfried

Special Credits and Acknowledgments

Special acknowledgements are due to several groups of collaborators and supporters of the IVth Madrean Conference. These include the collaborating partners, the conference organizing committee, sponsors, and The Southwest Border Resources Protection Program of the U.S. National Park Service.

Collaborating Partners

Sky Island Alliance would like to acknowledge the special contributions of a wide host of collaborating partners and contributors that have made this conference possible, including:

Alfonso Villaseñor and his interpretation staff, Mexican Consulate in Tucson and the Cultural Institute of Mexico

Next Generation of Sonoran Desert Researchers

Southwest Climate Science Center

Southwest Fire Consortium

US Geological Survey

USDA Forest Service Rocky Mountain Research Station

NOTE: Abstracts and translations used in this document came directly out of the conference program, and were formatted for the General Technical Report. They have also been edited for spelling, consistency, and use of scientific measurement units. Full papers have been reviewed and edited.

Conference Organizing Committee

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Dale Turner, The Nature Conservancy, Committee Co-Chair
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Tahnee Robertson, Cross-watershed Network
Chris Thiel, USDA Forest Service, Coronado National Forest

The Southwest Border Resources Protection Program of the U.S. National Park Service

The organizing committee for the Madrean Conference IV would like to specially thank (Un agradecimiento especial a) the Southwest Border Resources Protection Program of the U.S. National Park Service for its significant contributions to cross-border collaboration and resource protection in the Madrean Archipelago. For a variety of reasons, many National Park Service units on and near the border have experienced natural and cultural resource damage. To address these challenges, the Southwest Border Resource Protection Program provides financial and technical assistance to U.S. national parks and their partners to support research, inventory and monitoring, and other projects that preserve and restore threatened natural and cultural resources. The Program seeks to mitigate impacts on cultural and natural resources and to further collaboration between Mexican and American land managers and their partners. Because education is key to every initiative, the program also provides coordination and funding for conferences that bring resource managers together to focus on critical resource issues that the United States and Mexico share. The program office works with park staff and their Mexican counterparts, as well as educational institutions, nonprofit organizations, and local, state, tribal and federal agencies to improve resource stewardship and to achieve international cooperation. The program supports the informal system of “sister parks” established by several U.S. national parks with federally protected areas in Mexico. Sister parks foster sharing of information and regular, direct park-to-park contact to address mutual interests and concerns. Grant funding from the Southwest Border Resource Protection Program provided travel support, interpretation and translation services, and contributed to staff time available to organize the conference. This support was crucial to making this a binational conference with materials and talks provide in Spanish and English, and to ensure robust participation from Mexican partners. We thank the Southwest Border Resource Protection Program for making this conference possible and for their contributions to cross-border collaboration and resource protection in the Madrean Archipelago.

El comité organizador de la Conferencia Madrean IV desea reconocer especialmente el Programa de Protección de los Recursos del Suroeste del Servicio de Parques Nacionales de los Estados Unidos por sus importantes contribuciones a la colaboración transfronteriza y la protección de recursos en el Archipiélago Maduro. Por una variedad de razones, muchas unidades del Servicio de Parques Nacionales en y cerca de la frontera han sufrido daños a recursos naturales y culturales. Para enfrentar estos desafíos, el Programa de Protección de Recursos del Suroeste proporciona asistencia financiera y técnica a los parques nacionales de EE. UU. y sus socios para apoyar la investigación, el inventario y el monitoreo, y otros proyectos que preservan y restauran los recursos naturales y culturales amenazados. El programa busca mitigar los impactos sobre los recursos culturales y naturales y fomentar la colaboración entre los administradores de la tierra mexicanos y estadounidenses y sus socios. Debido a que la educación es clave para cada iniciativa, el programa también proporciona coordinación y financiamiento para conferencias que reúnen a los administradores de recursos para que se centren en los problemas críticos de recursos que comparten Estados Unidos y México. La oficina del programa trabaja con el personal del parque y sus homólogos mexicanos, así como con instituciones educativas, organizaciones sin fines de lucro y agencias locales, estatales, tribales y federales para mejorar la administración de los recursos y lograr la cooperación internacional. El programa apoya el sistema informal de "parques hermanos" establecido por varios parques nacionales de EE. UU. con áreas federales protegidas en México. Los parques hermanas fomentan el intercambio de información y el contacto regular, directo de un parque a otro, para abordar intereses y preocupaciones mutuas. Los fondos de subvención del proporcionaron servicios de apoyo de viaje, interpretación y traducción, y contribuyeron al tiempo del personal disponible para organizar la conferencia.

Este apoyo fue crucial para hacer de esta una conferencia binacional con materiales y charlas en español e inglés, y para garantizar la sólida participación de los socios mexicanos. Agradecemos al Programa de Protección de Recursos del Borde Sudoeste por hacer posible esta conferencia y por sus contribuciones a la colaboración transfronteriza y la protección de los recursos en el Archipiélago Madrense. Tenga en cuenta: Las opiniones y conclusiones contenidas en este documento son las de los autores y no deben interpretarse como representativas de las opiniones o políticas del gobierno de EE. UU. La mención de nombres comerciales o productos comerciales no constituye su respaldo por parte del gobierno de EE. UU.

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¡Gracias a nuestros patrocinadores de la conferencia!

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Tucson Audubon Society
Tucson Herpetological Society
University of Arizona, School of Natural Resources and the Environment
USDA Forest Service, Rocky Mountain Research Station
Wilburforce Foundation
Wildlife Corridors LLC

Introduction / *Introducion*

The Madrean Archipelago Ecoregion (Omernik, 1987), also known as the "Madrean Sky Islands" or "Sky Islands," occupies an area of nearly 40,536 km^2 (15,651 mi^2) in southeastern Arizona, southwestern New Mexico, and northern Sonora, Mexico (Figure 1). The ecoregion is bordered on the west by the Sonoran Basin and Range Ecoregion, on the east by the Chihuahuan Deserts Ecoregion, and on the north by the Arizona/New Mexico Mountains Ecoregion. It is influenced by California and Rocky Mountain biogeographic regions to the north, the Great Plains to the east, and the Sierra Madrean and Neotropical regions to the south. This biogeographic región contains many unique faunal and floral species stranded in a desert landscape similar to islands in an ocean. The Madrean Archipeligo with its characteristic basin-and-range geomorphology is one of the most biologically diverse in the world (Ruhlman et al. 2012). Although the mountains in the ecoregion bridge the Rocky Mountains to the north and the Sierra Madre Occidental in Mexico to the south, the lower elevations act as an effective barrier to species

dispersal like oceanic islands. The geographic convergence of these major continental mountain ranges and ecoregions, as well as the deserts to the east and the west, forms the foundation for ecological interactions found nowhere else on Earth.

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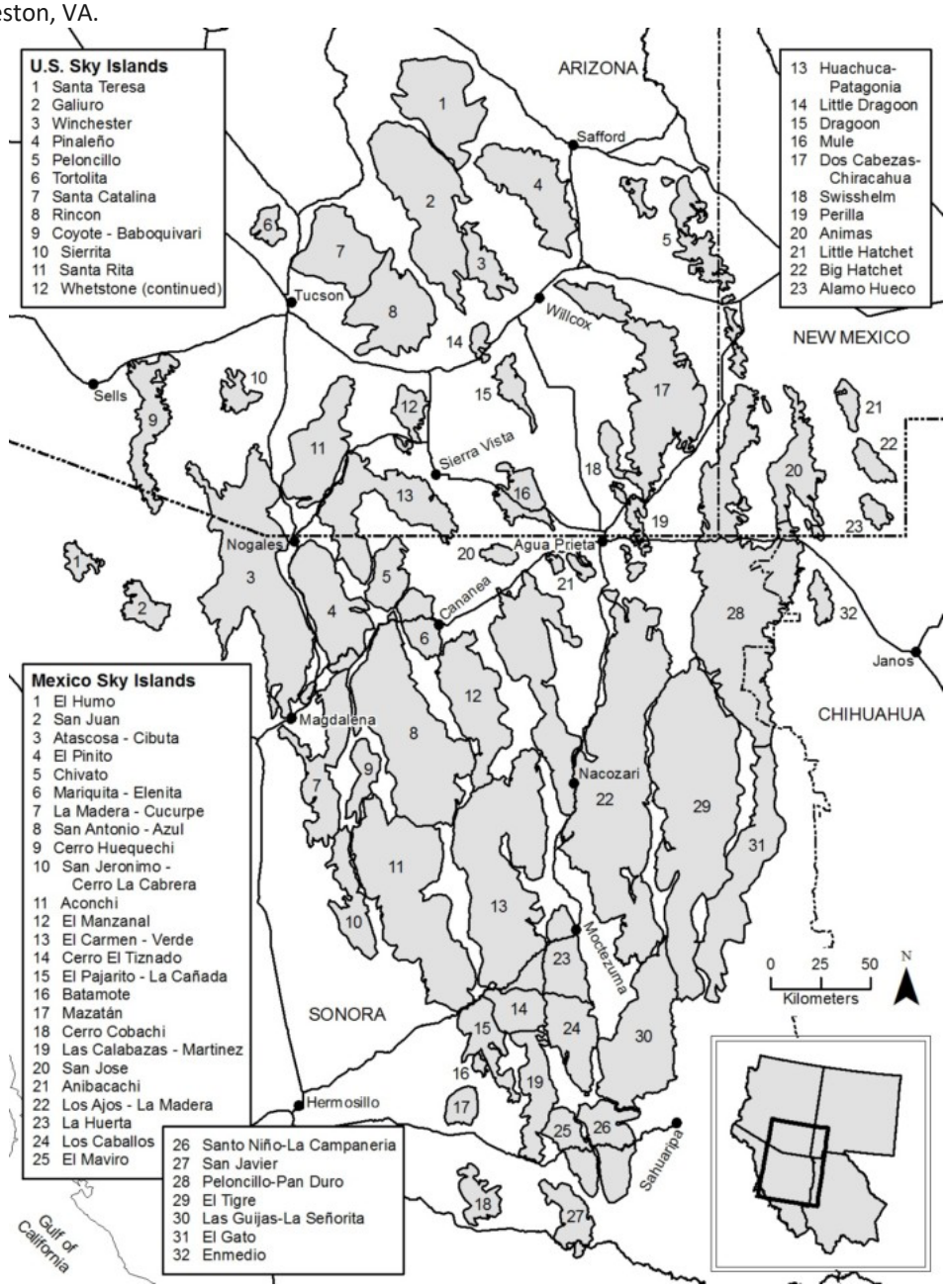

Figure 1. Madrean Archipeligo of the Southwest USA and northern Mexico.

Figure 2. Madrean Archipeligo panoramas.

Sessions / Sesiones

1. **Workshop: Emerging Leaders Roundtable** / Taller: Entrenamiento para Líderes Emergentes
2. **Workshop: Identifying Priority Gaps in Connectivy Knowledge** / Identificación de brechas de prioridad en el conocimiento de conectividad para las Islas Serranas
3. **Workshop: Identifying Priority Gaps in Connectivity Knowledge** / Identificación de brechas de prioridad en el conocimiento **de conectividad para las Islas Serranas**
4. **Workshop: Wildlife Monitoring** / Monitoreo de Vida Silvestre
5. **Workshop: Emerging Leaders Roundtable** / Taller: Entrenamiento para Líderes Emergentes
6. **Workshop: Children Embrace Wildlife Enjoying Puppet Shows** / Los niños aceptan a la vida silvestre disfrutando de espectáculos de títeres
7. **Collection, Production and Harvest of Native Seed and Plant Material for Restoration** / Recolección, producción, y cosecha de semilla native y material vegetal para la restauración
8. **Climate and Pollinators** / Clima y Polinizadores
9. **Workshop: Best Management Practices for Pollinators** / Mejores practices de manejo para polinizadores
10. **Water and Acquatic Ecosystems** / Agua y ecosistemas acuáticos
11. **Workshop: Water for Natural Areas** / Agua para áreas naturales
12. **Workshop: Water for Natural Areas** / Agua para áreas naturales
13. **Mt. Graham Red Squirrel: A Study in Extinction Prevention Part #1** / La Ardilla roja de Mt.Graham: un estudio en prevención de la extinción
14. **Mt. Graham Red Squirrel: A Study in Extinction Prevention Part #2** / La Ardilla roja de Mt.Graham: un estudio en prevención de la extinción
15. **No Session**
16. **Migrant Jaguars Go Both Ways Part #1** / Los jaguares migratorios siguen las dos vías: problemas y perspectivas para la conservación del Jaguar en la región fronteriza
17. **Migrant Jaguars Go Both Ways Part #2** / Los jaguares migratorios siguen las dos vías: problemas y perspectivas para la conservación del Jaguar en la región fronteriza
18. **Migrant Jaguars Go Both Ways: Discussion** / Los jaguares migratorios siguen las dos vías: problemas y perspectivas para la conservación del Jaguar en la región fronteriza
19. **Ecological and Environmental Change Part #1** / Cambio ecológico y ambiental Parte 1
20. **Ecological and Environmental Change Part #2** / Cambio ecológico y ambiental Parte 2
21. **Ecological and Environmental Change Part #3** / Cambio ecológico y ambiental Parte 3
22. **Velvet Mesquite: Riparian Keystone or Grassland Pest?** / Mesquite de terciopelo: ¿especie clave ribereña o plaga de pastizales?
23. **Grasslands** / Pastizales
24. **Mining, Environmental Compliance, Reclamation, and Restoration** / Minería, Cumplimiento Ambiental, Recuperación y Restauración
25. **Engaging Communities** / Atrayendo a las comunidades
26. **Beyond Documenting Trends: Integrating Monitoring Data into Natural Resource Management Decisions** / Más allá de documentar las tendencias: integrar los datos de monitoreo en las decisiones de gestión de recursos naturales
27. **Beyond Documenting Trends: Integrating Monitoring Data into Natural Resource Management Decisions** / Más allá de documentar las tendencias: integrar los datos de monitoreo en las decisiones de gestión de recursos naturales
28. **Invertebrates** / Invertebrados
29. **Plants** / Plantas
30. **Biodiversity** / Biodiversidad
31. **Current Research on Herpetofauna of the Sonoran Desert and Sky Islands Part #1** / Investigación actual sobre la herpetofauna del desierto de Sonora y las Islas Serranas Parte 1

32. **Current Research on Herpetofauna of the Sonoran Desert and Sky Islands Part #2** / Investigación actual sobre la herpetofauna del desierto de Sonora y las Islas Serranas Parte 2
33. **Current Research on Herpetofauna of the Sonoran Desert and Sky Islands Part #3** / Investigación actual sobre la herpetofauna del desierto de Sonora y las Islas Serranas Parte 3
34. **No Session**
35. **Current Research on Herpetofauna of the Sonoran Desert and Sky Islands Part #4** / Investigación actual sobre la herpetofauna del desierto de Sonora y las Islas Serranas Parte 4
36. **Current Research on Herpetofauna of the Sonoran Desert and Sky Islands Part #5** / Investigación actual sobre la herpetofauna del desierto de Sonora y las Islas Serranas Parte 5
37. **Workshop: Nature's NoteBook: A dynamic platform of plant and animal observation** / Cuaderno de la naturaleza: una plataforma dinámica para la observación de plantas y animales
38. **Workshop: The Contemplative Arts in Ecology: Re-enchantment with the natural world /** Taller las artes conservacionistas en ecología: Reencantamiento con el mundo natural
39. **Workshop: Conservation Incentives with the Northern Jaguar Project /** Incentivos de conservación con el Proyecto Jaguar del Norte
40. **Workshop: Nature's NoteBook: A dynamic platform of plant and animal observation** / Cuaderno de la naturaleza: una plataforma dinámica para la observación de plantas y animales
41. **Tracking and Prioritizing Invasive Species Management Treatment** / Seguimiento y priorización del tratamiento de manejo de especies invasivas
42. **Tracking and Prioritizing Invasive Species Management Treatment** / Seguimiento y priorización del tratamiento de manejo de especies invasivas
43. **Mammals Part #1**/ Mamíferos
44. **Mammals Part #2**/ Mamíferos
45. **Workshop: Using Symbiota Software Platform to Collaboratively Manage Collections and Regional Checklists** / Uso de la plataforma de software Symbiota para administrar colaborativamente colecciones y listas de verificación regionals
46. **Plants** / Plantas
47. **Workshop: Sister Parks: Best Practices for Cross-Border Conservation in Parks and Protected Areas** / Parques Hermanos: mejores prácticas para la conservación transfronteriza en parques y áreas protegidas
48. **Invertebrates** / Invertebrados
49. **Citizen Science** / Ciencia Ciudadana
50. **Panel Discussion: Disconnected Waters: What do Cities, Governments, Ecosystems, Native Nations, and the Voiceless have to Say to One Another?** / Desconectado: ¿Qué tienen para decirse las ciudades, los gobiernos, los ecosistemas, las naciones nativas y los sin voz?
51. **Fire** / Incendios
52. **Hydrology** / Hidrología
53. **Connecting and Sustaining the Flow of Transboundary Environmental Goods and Services** / Conexión y mantenimiento del flujo de bienes y servicios ambientales transfronterizos
54. **Springs** / Manantiales
55. Workshop: Landscape Conservation Design / Diseño de conservación del paisaje
56. Workshop: Landscape Conservation Design / Diseño de conservación del paisaje
57. Workshop: Landscape Conservation Design / Diseño de conservación del paisaje

Plenary Speakers / *Oradoras Plenari*

Krista Schlyer

Tuesday May 15 / *Martes 15 de may*

CONTINENTAL DIVIDE: WILDLIFE, PEOPLE AND THE BORDER WALL

DIVISIÓN CONTINENTAL: FAUNA, GENTE Y EL MURO FRONTERIZO

In this slideshow presentation, Krista Schlyer shared readings from her book *Continental Divide: Wildlife, People and the Border Wall* and discussed her 10-year documentary project on the US-Mexico borderlands. In documenting the changes to the ecosystems and human communities along the border while the first segments of wall were being built in 2007, Schlyer catalogued the impacts of border policy on wildlife, landowners, migrants, and border economies–many of which are not fully understood by either policy makers or the general public. This presentation discussed the natural and human history of the borderlands; the history of border policy; the unthinkable human consequences of border militarization; and the current immigration debate as it pertains to borderlands ecosystems, wildlife, and the people who call this region home.

Krista Schlyer is a conservation writer and photographer based in the Washington, DC, area. Her work has appeared internationally in magazines, books and websites including BBC, High Country News, Nature Conservancy, and Audubon. She is a senior fellow in the International League of Conservation Photographers. Her book *Continental Divide: Wildlife, People and the Border Wall* was released in 2012, and has received numerous awards, including the National Outdoor Book Award and the Sierra Club's Ansel Adams Award for conservation photography. Schlyer's newest book, *River of Redemption: Almanac of Life on the Anacostia* will be released in fall 2018.

En esta presentación de diapositivas, Krista Schlyer compartido las lecturas de su libro Continental Divide: Wildlife, People and the Border Wall y discutido su proyecto documental de 10 años en las tierras fronterizas de México y los Estados Unidos. Al documentar los cambios en ecosistemas y comunidades humanas a lo largo de la frontera mientras se construían los primeros segmentos del muro en 2007, Schlyer catalogó los impactos de la política fronteriza en la vida silvestre, propietarios, migrantes y economías fronterizas. Responsables de políticas y el publico en general no logran comprender dichos impactos en plenitud. Esta presentación discutido la historia natural y humana de las tierras fronterizas; la historia de la política fronteriza; las inimaginables consecuencias humanas de la militarización de la frontera; y el debate actual sobre inmigración en lo que respecta a los ecosistemas fronterizos, la vida silvestre y las personas que llaman hogar a esta región. Krista Schlyer es una escritora y fotógrafa conservacionista con sede en el área de Washington, DC. Su trabajo ha aparecido internacionalmente en revistas, libros y sitios web, incluidos BBC, High Country News, Nature Conservancy y Audubon. Ella es miembro senior de la Liga Internacional de Fotógrafos de Conservación. Su libro Continental Divide: Wildlife, People and the Border Wall fue lanzado en 2012, y ha recibido numerosos premios, incluido el National Outdoor Book Award y el Ansel Adams Award de Sierra Club por la fotografía de conservación. El libro más nuevo de Schlyer, River of Redemption: Almanac of Life on the Anacostia se lanzará en el otoño de 2018.

Mary Ellen Hannibal

Thursday May 17 / *Jueves 17 de mayo*

CITIZEN SCIENCE: CONNECTING TIME, PLACE, AND PURPOSE

CIENCIA CIUDADANA: TIEMPO DE CONEXIÓN, LUGAR Y PROPÓSITO

There's more to citizen science than the tech-enabled boom documenting nature. It is a profound tool for revisioning the human place on the landscape and among other creatures. While we are witnessing an unsustainable reduction of animal and plant life, we have the power right now to do something about it. Mary Ellen Hannibal is an award-winning author most recently of *Citizen Scientist: Searching for Heroes and Hope in an Age of Extinction*. It received a Nautilus Book Award and was named a best book of 2016 by the San Francisco Chronicle. Her talk touched on adventures with the Sky Island Alliance in Tucson and Mexico while researching her previous book, *The Spine of the Continent*.

La ciencia ciudadana implica mucho más que el auge de documentar la naturaleza usando la tecnología; la ciencia ciudadana es una herramienta profunda que nos permite reinterpretar el lugar del ser humano en los paisajes y entre otras criaturas. Si bien somos testigos de una reducción insostenible de la vida animal y vegetal, ahora tenemos el poder de hacer algo al respecto. Mary Ellen Hannibal es una autora galardonada quien recientemente escribió Citizen Scientist: Searching Heroes and Hope in a Age of Extinction. Este libro recibió un premio Nautilus Book Award y fue nombrado mejor libro de 2016 por San Francisco Chronicle. Su charla contido aventuras con Sky Island Alliance en Tucson y México mientras investigaba su libro anterior, The Spine of the Continent.

Special Sessions / *Sesiones Especial*

Coronado National Forest, Peloncillo Mountains, Animas Valley, Animas Mountains, New Mexico
(Photo courtesy of the USDA Forest Service, Rocky Mountain Research Station, Photo by Daniel G. Neary)

SESSIONS 11 AND 12: Water for Natural Areas: Developing policy management approaches to secure and steward water for natural areas in Southern Arizona

More than ever, protecting water for natural areas is an urgent matter. In the face of climate change and competing demands on scarce water resources in southern Arizona, the supply of water for human and natural systems is declining and becoming more uncertain. Increased temperatures, along with changes in the timing and amount of precipitation, converge with increased human demand, putting tremendous pressure on the region's water resources. If we do not develop local solutions to protect our streams and springs, we stand to lose some of our most precious natural areas. To preserve our quality of life and the natural systems that enhance it, we must change the way that we relate to water and how it is valued, used, and managed. This session will provide updates on the current statewide and local context for protecting water for natural areas. We will share new ideas and discuss tools and collaborative projects underway seeking to advance the protection of water for natural areas and provide participants with ways to engage directly in this work. Presentations from a diversity of practitioners and experts will address the following topics: the current threats and approaches to protecting water for natural areas; the statewide policy context and opportunity; new ideas and approaches for protecting water for natural areas; special considerations and new tools for securing water at springs; cultural values and considerations for water for natural areas; and innovative collaborative approaches to solve complex problems.

Agua para áreas naturales: Desarrollar enfoques de gestión de políticas para asegurar y administrar agua para áreas naturales en el sur de Arizona

Más que nunca, proteger el agua para áreas naturales es un asunto urgente. Frente al cambio climático y las demandas competitivas sobre los escasos recursos hídricos en el sur de Arizona, el suministro de agua para los sistemas humanos y naturales está disminuyendo y cada vez es más incierto. El aumento de las temperaturas, junto con los cambios en el momento y la cantidad de precipitaciones, convergen con el aumento de la demanda humana, ejerciendo una enorme presión sobre los recursos hídricos de la región. Si no desarrollamos soluciones locales para proteger nuestros arroyos y manantiales, podremos perder algunas de nuestras áreas naturales más preciadas. Para preservar nuestra calidad de vida y los sistemas naturales que la mejoran, debemos cambiar la forma en que nos relacionamos con el agua y cómo se valora, utiliza y gestiona. Esta sesión proporcionará actualizaciones sobre el contexto actual a nivel estatal y local para proteger el agua de las áreas naturales. Compartiremos nuevas ideas y discutiremos las herramientas y proyectos colaborativos en curso que buscan avanzar en la protección del agua para las áreas naturales y proporcionarles a los participantes formas de participar directamente en este trabajo. Las presentaciones de una diversidad de profesionales y expertos abordarán los siguientes temas: las amenazas actuales y los enfoques para proteger el agua para las áreas naturales; el contexto de política estatal y la oportunidad; nuevas ideas y enfoques para proteger el agua para áreas naturales; consideraciones especiales y nuevas herramientas para asegurar el agua en los manantiales; valores culturales y consideraciones para el agua en áreas naturales; y enfoques innovadores de colaboración para resolver problemas complejos.

SESSION 13: Mt. Graham red squirrel: A study in extinction prevention

From June-July 2017, the Frye Fire burned approximately 19,433 ha (48000 ac) in the Pinaleño Mountains in southeastern Arizona, including ~78% of the main portion of the range of the endangered Mount Graham red squirrel (MGRS). Key areas burned at high-severity, which completely removed significant portions of MGRS habitat, but even in areas with low-severity fire MGRS were negatively affected by ground fire that burned the middens (food caches) they use to store their winter food supply. During the September 2017 annual survey, evidence of the Frye Fire was observed in 95% of the surveyed locations, with 80% showing at least some habitat loss, and 44% completely burned. The 2017 population estimate was 35 individuals, down from 252 in 2016, meaning MGRS are now one of the rarest mammals in North America and are emblematic of the challenges that isolated populations face in a changing environment with multiple stressors.

La Ardilla roja de Monte Graham: un estudio en prevención de la extinción

De junio a julio de 2017, el fuego Frye incendió aproximadamente 19,433 ha (48000 ac) en las montañas Pinaleño en el sureste de Arizona, incluyendo ~ 78% de la porción principal del rango de la ardilla roja Mount Graham (MGRS por sus siglas en inglés) en peligro de extinción. Las áreas clave quemadas a alta severidad, que eliminaron completamente partes significativas del hábitat de MGRS, pero incluso en áreas con fuego de baja severidad se vieron afectadas negativamente por fuego de tierra que quemó los basureros (depósitos de alimentos) que utilizan para almacenar su suministro de alimentos de invierno. Durante la encuesta anual de septiembre de 2017, se observó evidencia del fuego Frye en el 95% de los lugares estudiados, donde el 80% mostró al menos alguna pérdida de hábitat y el 44% se quemó por completo. La población estimada para 2017 fue de 35 individuos, frente a 252 en 2016, lo que significa que los MGRS son ahora uno de los mamíferos más raros de América del Norte y son emblemáticos de los desafíos que enfrentan las poblaciones aisladas en un entorno cambiante con múltiples factores de estrés.

SESSIONS 16, 17, & 18: Migrant Jaguars Go Both Ways: Problems and Prospects for Jaguar Conservation in the Borderlands Region

Jaguar is a keystone species in the Sky Island region. As a protected apex predator that regularly moves long distances and faces many threats, including poaching, habitat loss and fragmentation, it has broad implications for a vast area of public and private lands on both sides of the border. The small, vulnerable population in the borderlands region has the potential to expand and recolonize millions of acres of persisting habitat that was historically occupied in the U.S. and Mexico. Efforts to study and conserve jaguar present complex and difficult policy and research challenges. A jaguar session would foster an up-to-date, common understanding of recent research and the current state of policies in place or under development. With a significant increase in jaguar monitoring and conservation work on both sides of the border in recent years and a draft jaguar recovery plan currently under development by U.S. agencies, this topic is very timely and important. Cross-border collaboration will be essential to developing coherent, big-picture strategies for successfully studying and conserving jaguar in the borderlands region. In order for the northern jaguar population to expand, recover and thrive, individuals must be able to access available habitat and other jaguars by moving as freely as possible across the landscape, which includes crossing back and forth over the international boundary. These fundamental concepts should inform jaguar research and conservation going forward, and this session would develop a strong framework of knowledge, opportunities and challenges to inform more in-depth strategizing to follow. Researchers, conservationists, private landowners, government agencies and NGOs could all benefit from this collaborative conversation among diverse voices.

Los jaguares migratorios siguen las dos vías: problemas y perspectivas para la conservación del Jaguar en la región fronteriza

El Jaguar es una especie clave en la región de las Islas Serranas. Como un depredador de ápice protegido que regularmente se desplaza largas distancias y enfrenta muchas amenazas, incluida la caza furtiva, la pérdida de hábitat y la fragmentación, tiene amplias implicaciones para una vasta área de tierras públicas y privadas en ambos lados de la frontera. La población pequeña y vulnerable en la región fronteriza tiene el potencial de expandir y recolonizar millones de acres de hábitat persistente que históricamente estuvo ocupado en los EE UU y México. Los esfuerzos para estudiar y conservar el jaguar presentan desafíos complejos de política e investigación. Una sesión de jaguar fomentaría una comprensión común y actualizada de las investigaciones recientes y el estado actual de las políticas vigentes o en desarrollo. Con un aumento significativo en el trabajo de monitoreo y conservación del jaguar en ambos lados de la frontera en los últimos años y un borrador del plan de recuperación del jaguar actualmente en desarrollo por las agencias de los EE UU, este tema es muy oportuno e importante. La colaboración transfronteriza será esencial para desarrollar estrategias coherentes y de gran formato para estudiar y conservar con éxito el jaguar en la región fronteriza. Para que la población de jaguares del norte se expanda, se recupere y prospere, las personas deben poder acceder al hábitat disponible y a otros jaguares moviéndose con

la mayor libertad posible por el paisaje, lo que incluye cruzar hacia adelante y hacia atrás el límite internacional. Estos conceptos fundamentales deberían informar a la investigación y conservación del jaguar en el futuro, y esta sesión desarrollaría un sólido marco de conocimiento, oportunidades y desafíos para informar estrategias más profundas a seguir. Investigadores, conservacionistas, propietarios privados, agencias gubernamentales y ONG podrían beneficiarse de esta conversación colaborativa entre diversas voces.

SESSIONS 19, 20, & 21: Ecological and Environmental Change in the Madrean Sky Islands Region

This session will focus on understanding both past and anticipated future ecological and environmental change in the Madrean Sky Islands region in the U.S. and Mexico. Ongoing changes in climate, land-use and landcover, wildfire, development along the international border, and other processes pose major threats and unique conservation challenges in this biodiverse region. Understanding the patterns and drivers of past change and forecasting potential future change are essential for developing conservation and management strategies to address ongoing and emerging threats. This session will attempt to bring together Mexican and American scientists, managers, conservation planners, and policy makers working on both sides of the international border to share research results and develop new collaborative partnerships. Presentations will leverage historical and contemporary datasets to address the patterns and drivers of changes in plant and animal populations and communities, ecosystem processes, disturbance, and implications for conservation and management.

Cambio ecológico y ambiental en la región de las Islas Madrean Sky

Esta sesión se enfocará en la comprensión de los cambios ambientales y ecológicos futuros, tanto pasados como anticipados, en la región de las Islas Serranas Madrenses en los Estados Unidos y México. Los cambios continuos en el clima, el uso de la tierra y la cobertura de la tierra, los incendios forestales, el desarrollo a lo largo de la frontera internacional y otros procesos plantean grandes amenazas y desafíos de conservación únicos en esta región biodiversa. Comprender los patrones e impulsores del cambio pasado y pronosticar el cambio futuro potencial es esencial para desarrollar estrategias de conservación y gestión para abordar las amenazas actuales y emergentes. Esta sesión tratará de reunir a científicos, gerentes, planificadores de conservación y legisladores mexicanos y estadounidenses que trabajan en ambos lados de la frontera internacional para compartir resultados de investigación y desarrollar nuevas asociaciones de colaboración. Las presentaciones aprovecharán los conjuntos de datos históricos y contemporáneos para abordar los patrones e impulsores de los cambios en las poblaciones y comunidades de plantas y animales, los procesos del ecosistema, las perturbaciones y las implicaciones para la conservación y la gestión.

SESSION 22: Velvet Mesquite: Riparian Keystone or Grassland Pest?

Velvet mesquite (*Prosopis velutina*) is native to Arizona and Sonora, and is both loved as an important tree and despised as a thorny shrub. It has been the primary subject of both restoration and eradication projects. It has been identified as a keystone for wildlife habitat, a consumer of groundwater resources, and a rangeland invader. The value or threat posed by mesquite can be a subjective judgement, but the ecological and management implications depend heavily on both the landscape context and the goals for a particular site. Understanding that landscape context can help both researchers and managers gain insight, resolve conflicts, understand real tradeoffs, and design effective projects. In this session we will explore the current knowledge about how form and function of one species can vary widely depending on local conditions, how it interacts with other species, and how mesquite management can improve or degrade the landscape.

Mesquite de terciopelo: ¿especie clave ribereña o plaga de pastizales?

El mezquite de terciopelo (Prosopis velutina) es nativo de Arizona y Sonora, y es amado como un árbol importante y despreciado como un arbusto espinoso. Ha sido el tema principal de los proyectos de restauración y erradicación. Se ha identificado como una especie clave para el hábitat de la vida silvestre, un consumidor de recursos de aguas subterráneas y un invasor de pastizales. El valor o la amenaza que representa mezquite puede ser un juicio subjetivo, pero las implicaciones ecológicas y de gestión dependen en gran medida tanto del contexto del paisaje como de los objetivos para un sitio en particular. Comprender ese contexto paisajístico puede ayudar a los investigadores y gerentes a obtener información, resolver conflictos, comprender soluciones de compromiso reales y diseñar proyectos efectivos. En esta sesión exploraremos el conocimiento actual sobre cómo la forma y función de una especie puede variar ampliamente dependiendo de las condiciones locales, cómo interactúa con otras especies y cómo la gestión de mezquite puede mejorar o degradar el paisaje.

SESSION 24: Mining, Environmental Compliance, Reclamation, and Restoration

The binational Madrean region lies within one of the major mineralization belts of the western hemisphere, and mining has been a part of the history, culture, and livelihood of the region beginning with native people and continuing through to the present day. Mining and Madrean ecosystems interact in many ways. It is the goal of this session to report on modern and legacy mines and mining districts and efforts of communities, mining companies, consulting firms, researchers, and other groups with respect to addressing questions of environmental compliance, reclamation, and restoration.

Minería, Cumplimiento Ambiental, Recuperación y Restauración

La región binacional de Madrense se encuentra dentro de uno de los principales cinturones de mineralización del hemisferio occidental, y la minería ha sido parte de la historia, la cultura y el sustento de la región, comenzando por los nativos y hasta el presente. Los ecosistemas mineros y Madrenses interactúan de muchas maneras. El objetivo de esta sesión es informar sobre las minas y los distritos mineros modernos y heredados, y los esfuerzos de las comunidades, compañías mineras, firmas consultoras, investigadores y otros grupos con respecto a abordar cuestiones de cumplimiento ambiental, recuperación y restauración.

SESSIONS 26 & 27: Beyond Documenting Trends: Integrating Monitoring Data into Natural Resource Management Decisions

Long-term monitoring is often touted as a cornerstone of sound natural resource management, but often struggles to maintain momentum, funding and relevance over long time periods. Monitoring programs that are directly linked to management decisions are often considered to be the most successful, yet maintaining this link can be difficult if priorities change. The challenge of sustaining robust and informative monitoring programs will continue to be tested because of ongoing budget shortfalls, ever-looming government shutdowns, and even society's increasing mistrust of science. The monitoring efforts in this session highlight important lessons about the monitoring/management interface and in maintaining relevance with funders, stakeholders, and the general public.

Más allá de documentar las tendencias: integrar los datos de monitoreo en las decisiones de gestión de recursos naturales

El monitoreo a largo plazo a menudo se promociona como una pieza clave de la gestión racional de los recursos naturales, pero a menudo se esfuerza por mantener el impulso, la financiación y la relevancia durante largos períodos de tiempo. Los programas de monitoreo que están directamente relacionados con las decisiones de gestión a menudo se consideran los más exitosos, sin embargo, mantener este vínculo puede ser difícil si cambian las prioridades. El desafío de mantener programas de monitoreo robustos e informativos continuará siendo evaluado debido a las deficiencias presupuestarias en curso, los cierres gubernamentales en auge e incluso la creciente desconfianza de la sociedad en la ciencia. Los esfuerzos de monitoreo en esta sesión resaltan lecciones importantes sobre la interfaz de monitoreo / gestión y el mantenimiento de la relevancia con los financiadores, las partes interesadas y el público en general.

SESSIONS 31, 32, 33, & 36: Current Research on the Herpetofauna of the Sonoran Desert

This full-day session will focus on research and conservation of reptiles and amphibians of the Sky Island and Sonoran Desert region. It is sponsored by the Tucson Herpetological Society, an organization that is committed to research, education, and conservation of herpetofauna in the region. The workshop will include talks on current research with a focus on conservation biology, including a combination of invited speakers and submitted papers. In addition, there will be a kick-off address, keynote speaker, and a poster session. In addition, there will be at least two special sessions, one on declining amphibians and another on conservation education, and an opportunity for networking and conversations on selected conservation topics.

Investigación actual sobre la herpetofauna del desierto de Sonora

Esta sesión de día completo se enfocará en la investigación y conservación de reptiles y anfibios de la región de las Islas Serranas del Desierto de Sonora. Está patrocinado por la Sociedad Herpetológica de Tucson, una organización comprometida con la investigación, la educación y la conservación de la herpetofauna en la región. El taller incluirá charlas sobre investigaciones actuales con un enfoque en la biología de la conservación, incluida una combinación de oradores invitados y documentos presentados. Además, habrá una dirección de inicio, un orador principal y una sesión de carteles. Además, habrá al menos dos sesiones especiales, una sobre disminución de anfibios y otra sobre educación para la conservación, y una oportunidad para establecer contactos y conversaciones sobre temas de conservación seleccionados.

SESSION 50: Panel Discussion - Disconnected: What do cities, governments, ecosystems, Native nations, and the Voiceless have to Say to One another?

ALEJANDRO BÁRCENAS, Public Works City of Nogales
JAMES CALLEGARY, AZ-Sonora Transboundary Aquifer Assessment Program
MARIO CIRETT GÁLAN, Naturalist and Former Manager – Area de Protección de Flora y Fauna Bavispe
JAMES HOPKINS, UA Associate Clinical Professor Indigenous Peoples Law and Policy Program
DENISE MORENO, Coorditor UA Superfund Research Program and Binational Center for Environmental Health Sciences

In the water-scarce Madrean region, there is significant ongoing research, discussion and activity related to water rights, management, and policy, including study of the nexus with energy, the environment, agriculture, and contamination and waste. Seldom are these considered in the same context as biodiversity and land management. This interactive session represents an opportunity to bridge these gaps. It will include presentations and participatory discussions among presenters

and audience members in the hope that new bonds might be forged and creative solutions proposed in what is expected to be a highly multidisciplinary and lively session.

Desconectado: ¿Qué tienen para decirse las ciudades, los gobiernos, los ecosistemas, las naciones nativas y los sin voz?

En la región de Madrean, donde hay escasez de agua, hay una importante investigación, discusión y actividades en curso relacionadas con los derechos, la gestión y la política del agua, incluido el estudio del nexo con la energía, el medio ambiente, la agricultura y la contaminación y el desperdicio. Rara vez se consideran en el mismo contexto que la biodiversidad y la gestión de la tierra. Esta sesión interactiva representa una oportunidad para cerrar estas brechas. Incluirá presentaciones y debates participativos entre los presentadores y los miembros de la audiencia con la esperanza de que se forjen nuevos lazos y se propongan soluciones creativas en lo que se espera sea una sesión altamente multidisciplinaria y animada.

Session 53: Connecting and Sustaining Transboundary Environmental Flows

The focus of this session is research that addresses the importance regional connectivity of resources and ecosystem services in the Madrean ecoregion. The presentations will focus on approaches for sustaining, restoring, or improving transboundary flows and identifying ways to advance landscape-scale, ecoregional resource management. Our goal is to highlight the important environmental flows required to sustain ecosystems and the human livelihoods and well-being that depend on these ecosystems, and identify the socio-cultural-economic barriers that challenge holistic management. Topics may include riparian connectivity and stream restoration, wildlife habitat corridors and refugia, wildfire effects on habitat connectivity, ecological and human health, changes in anthropogenic land uses, climate adaptation or other environmental flows. Presenters are encouraged to describe issues encountered when working across the International Border and solutions for successful cross-border collaboration.

Conexión y mantenimiento de los flujos ambientales transfronterizos

El enfoque de esta sesión es la investigación que aborda la importancia de la conectividad regional de los recursos y servicios ecosistémicos en la ecorregión Madrense. Las presentaciones se enfocarán en enfoques para sostener, restaurar o mejorar los flujos transfronterizos e identificar formas de avanzar en la gestión de recursos ecorregionales a escala de paisaje. Nuestro objetivo es destacar los importantes flujos ambientales necesarios para sostener los ecosistemas y los medios de vida humanos y el bienestar que dependen de estos ecosistemas, e identificar las barreras socio-culturales-económicas que desafían la gestión holística. Los temas pueden incluir conectividad ribereña y restauración de riachuelos, corredores de hábitats de vida silvestre y refugios, efectos de incendios forestales en la conectividad de hábitats, salud ecológica y humana, cambios en los usos de la tierra antropogénica, adaptación climática u otros flujos ambientales. Se alienta a los presentadores a que describan los problemas que surgen cuando se trabaja en el otro lado de la frontera internacional y las soluciones para una colaboración transfronteriza exitosa.

SESSION 54: Springs

Starting with the 2010-13 workshops organized by Louise Misztal at Sky Island Alliance, conservation partners in the Sky Island Region began to focus on understanding springs in the region. Springs provide habitat for a host of flora and fauna, free water for wildlife, and are likely to be crucial locations for species adapting to climate change. They are also threatened by climate change. After 5 years surveying springs, let's get together and discuss outcomes of our work and examine the progress we've

made in learning about Sky Island springs. Partners already working on springs, as well as those interested in beginning to should benefit from this session. This should help to coordinate efforts across the region and identify new approaches partners should take.

Manantiales

Comenzando con los talleres de 2010-13 organizados por Louise Misztal en Sky Island Alliance, los socios de conservación en la región de Sky Island comenzaron a enfocarse en comprender los manantiales en la región. Los manantiales proporcionan un hábitat para una gran cantidad de flora y fauna, agua libre para la vida silvestre, y es probable que sean lugares cruciales para que las especies se adapten al cambio climático. También están amenazados por el cambio climático. Después de 5 años investigando los resortes, reunámonos y analicemos los resultados de nuestro trabajo y examinemos el progreso que hemos logrado en aprender sobre los manantiales de Sky Island. Los socios que ya están trabajando en manantiales, así como aquellos interesados en comenzar, deberían beneficiarse de esta sesión. Esto debería ayudar a coordinar los esfuerzos en toda la región e identificar nuevos enfoques que los socios deberían tomar.

SESSION 56: Plan Globally, Implement Regionally, Work Locally: Large Landscape Conservation in the Transboundary Madrean Watersheds

The Transboundary Madrean Watersheds initiative is a large landscape, international effort to maintain and enhance the interconnected system of mountains, grasslands, deserts and waters that supports species diversity, promotes healthy watersheds, and maintains the overall ecosystem integrity that enriches the lives of human communities. Large-scale stressors such as climate change require large-scale conservation planning to understand where to prioritize resources and implement conservation and restoration actions.

Within the Transboundary Madrean Watersheds, the Desert Landscape Conservation Cooperative initiated development of a Landscape Conservation Design by working with diverse partners to develop a shared conservation vision and enhance understanding of priority resources and current threats. The initiative is combining geospatial data, biological information, and partner input to identify opportunities to protect species, habitats, and environmental processes across the entire landscape. This requires a collaborative structure of engaged partners to implement local projects that contribute to achieving the conservation vision. Together we can solve problems that are too big for any one organization to solve alone.

This session will cover components of large-landscape conservation in the region including: binational coordination opportunities and challenges, partner-driven synthesis and science products, spatial analysis of the state of ecosystems and potential future conditions, development of indicators, watershed-scale project planning, adaptation case studies, a regional connectivity analysis, strategies for adapting to climate change, scenario planning and an in-depth case study of local work. We will share new information and products developed for the Transboundary Madrean Watersheds and engage participants in discussion of how best to continue this critical cross-border work into the future.

Planificar globalmente, Implementar a nivel regional, Trabajar a nivel local: Conservación de paisajes grandes en las cuencas hidrográficas transfronterizas Madrenses

La iniciativa Transfronteriza de Cuencas Madrenses es un gran esfuerzo internacional para mantener y mejorar el sistema interconectado de montañas, pastizales, desiertos y aguas que respalda la diversidad de especies, promueve cuencas hidrográficas saludables y mantiene la integridad global del ecosistema que enriquece las vidas de las comunidades humanas.

Los factores estresantes a gran escala, como el cambio climático, requieren una planificación de la conservación a gran escala para comprender dónde priorizar los recursos e implementar acciones de conservación y restauración.

Dentro de las cuencas hidrográficas transfronterizas Madrenses, la cooperativa de conservación del paisaje del desierto inició el desarrollo de un diseño de conservación del paisaje trabajando con diversos socios para desarrollar una visión de conservación compartida y mejorar la comprensión de los recursos prioritarios y las amenazas actuales. La iniciativa combina datos geoespaciales, información biológica y aportes de los socios para identificar oportunidades para proteger especies, hábitats y procesos ambientales en todo el paisaje. Esto requiere una estructura colaborativa de socios comprometidos para implementar proyectos locales que contribuyan a lograr la visión de conservación. Juntos podemos resolver problemas que son demasiado grandes para que una sola organización los resuelva solo.

Esta sesión cubrirá los componentes de la conservación de paisajes grandes en la región, incluyendo: oportunidades y desafíos de coordinación binacional, síntesis y productos científicos impulsados por socios, análisis espacial del estado de los ecosistemas y posibles condiciones futuras, desarrollo de indicadores, planificación de proyectos a escala de cuenca , estudios de casos de adaptación, un análisis de conectividad regional, estrategias para adaptarse al cambio climático, planificación de escenarios y un estudio de caso profundo del trabajo local. Compartiremos nueva información y productos desarrollados para las Cuencas Hidrográficas Transfronterizas Madrenses e involucraremos a los participantes en la discusión sobre la mejor manera de continuar este trabajo transfronterizo crítico en el futuro.

Workshops / *Talleres*

Peloncillo Mountains Prescribed Fire, Coronado National Forest
(Photo courtesy of the USDA Forest Service, Rocky Mountain Research Station)

Abstracts
Robertson: Sessions 1 & 5
Bravo: Sessions 2 & 3
Wilbor: Session 4
Bernal: Session 6
Campbell: Session 9
Posthmus: Session 40
Rowe: Sessions 41 & 42
Franz: Session 45
Swann: Session 47
Wilbor: Sessions 56 & 57

SESSIONS 1 & 5: Emerging Leaders Roundtable

TAHNEE ROBERTSON ROBERTSON, Colleen Whitaker, Julia Sittig, Abby Fullem, Larry Fisher, Ben Wilder

Monday 10-noon and 1:40-3:00p (afternoon session is optional): This session is geared to emerging leaders (under 30) in the conservation and natural resources community. Collaborative leadership, facilitation, cross boundary collaboration, working with diverse stakeholders and complex issues, and related topics will be covered through presentation, dialogue and small group activities. This mini-workshop is one of three linked emerging leaders opportunities that also include a Thursday evening mixer and Friday morning panel to kick off our Shaping the Future of the Sky Island Region plenary session.

Entrenamiento para Líderes Emergentes

Lunes 10-mediodía y 1: 40-3: 00p (la sesión de la tarde es opcional): esta sesión está dirigida a líderes emergentes (menores de 30 años de edad) en la comunidad de conservación y recursos naturales. El liderazgo colaborativo, la facilitación, la colaboración transfronteriza, el trabajo con partes interesadas diversas y temas complejos, y los temas relacionados serán cubiertos a través de presentaciones, diálogos y actividades en grupos pequeños. Este mini taller es una de las tres oportunidades vinculadas de líderes emergentes que también incluyen un convivio el jueves por la noche y un panel de viernes por la mañana para dar inicio a nuestra sesión plenaria de Shaping the Future of the Sky Island Region.

NOTE: A manuscript was not submitted to accompany this presentation.

SESSIONS 2 & 3: Identifying priority gaps in connectivity knowledge for the Sky Islands

JUAN CARLOS BRAVO

Recent progress has been made towards understanding and modeling habitat connectivity in the Madrean Sky Islands, yet much of the work has been limited to the U.S. The few transboundary connectivity models available to conservation practitioners and land use planners focus on the jaguar. While the practice of Conservation Planning necessitates emphasis on a manageable number of species, a single species understanding of transboundary connectivity is insufficient to address the needs of the whole diversity of life in a region so topographically complex and biologically rich. We will host a workshop with the specific goal of identifying priority gaps in our knowledge of connectivity in the Madrean Sky Islands Region with an emphasis on transboundary corridors and connectivity in the Mexican portion of the region. We'll encourage participants to come up with ways in which we can take advantage of advances in digital mapping, which have produced datasets that, for the first time, incorporate a single resolution and consistent nomenclatures across the U.S.-Mexico border. We will also seek to reach a common understanding of the current state of the Border Wall as a series of obstacles to wildlife mobility and to identify, areas of critical importance and strategies for continued monitoring that can provide long-term data of its impacts. We will supply live-GIS viewing and basic mapping to create a preliminary collection of shape layers that place the gaps and opportunities identified by participants. This will also provide regional context and real-time feedback for participants while eliminating intermediary steps in interpreting and sharing their input. Resulting layers will be uploaded to Data Basin. We will reach out to key experts of both countries with individual invitations and pre-workshop questions.

Identificación de brechas de prioridad en el conocimiento de conectividad para las Islas Serranas

Se han realizado progresos recientes para comprender y modelar la conectividad del hábitat en las Islas Serranas Madrenses, pero gran parte del trabajo se ha limitado a los Estados Unidos. Los pocos modelos de conectividad transfronteriza disponibles

para los profesionales de la conservación y los planificadores del uso de la tierra se centran en el jaguar. Si bien la práctica de la Planificación de la Conservación requiere énfasis en un número manejable de especies, la comprensión de una sola especie de la conectividad transfronteriza es insuficiente para abordar las necesidades de toda la diversidad de la vida en una región tan topográficamente compleja y biológicamente rica. Organizaremos un taller con el objetivo específico de identificar las brechas prioritarias en nuestro conocimiento de conectividad en la región de Isla Serrana Marshall con énfasis en los corredores transfronterizos y la conectividad en la porción mexicana de la región. Alentaremos a los participantes a encontrar formas en las que podamos aprovechar los avances en el mapeo digital, que han.

NOTE: A manuscript was not submitted to accompany this presentation.

SESSION 4: Wildlife Monitoring in the Sky Islands Workshop

SCOTT WILBOR, Mirna Manteca

Sky Island Alliance hosts a "Wildlife Monitoring in the Sky Islands Workshop" at the Madrean Conference 2018. The goal of this workshop is to share the knowledge of regional wildlife monitoring projects and explore the potential benefits of greater collaboration over time. An explosion of remote wildlife camera monitoring programs, as well as other types of wildlife monitoring, has occurred in the last decade plus in the Madrean Sky Island Region. It is our intention to gather those agencies/organizations pursuing wildlife monitoring and facilitate the exchange of information leading to greater knowledge, collaboration, and potentially cooperation in design, data collection, analysis, and application of data collected to land management.

The Workshop will allow each participating entity to present their program/project, providing: 1) goals, 2) region of interest, 3) species of focus, 4) habitats or landscape elements of interest, 5) current project status (number of active monitoring sites and geographic distribution), 6) plans for the future, and 7) desired outcomes for wildlife monitoring and conservation application in the region. We anticipate at least seven large-scale wildlife monitoring programs of the region to present at the workshop, i.e., Sky Island Alliance, Arizona Game and Fish Department, U.S. Fish and Wildlife Service, National Park Service, Arizona Center for Nature Conservation, University of Arizona Wild Cat Research & Conservation Center, and Naturalia. The University of Arizona and Wildlife Insights (Conservation International) will present their web-based wildlife image management systems development to date. Presentations will be followed by a facilitated panel discussion among presenters with the engagement of other workshop participants (some representing their own wildlife projects), on the options for future greater communication, information/data sharing, cooperation, and collaboration for improved wildlife monitoring and conservation in the Madrean Region.

Monitoreo de Vida Silvestre en el Taller de Sky Islands

Sky Island Alliance organiza un "Taller de Monitoreo de Vida Silvestre en las Islas Serranas" en el Congreso Madrense 2018. El objetivo de este taller es compartir el conocimiento de los proyectos regionales de monitoreo de vida silvestre y explorar los beneficios potenciales de una mayor colaboración al pasar del tiempo. En la última década se ha producido una explosión de programas remotos de monitoreo de cámaras de vida silvestre, así como otros tipos de monitoreo de la vida silvestre, en la región de las Islas Serranas Madrenses. Es nuestra intención reunir a aquellas agencias u organizaciones que persiguen el monitoreo de la vida silvestre y facilitar el intercambio de información que conduzca a un mayor conocimiento, colaboración y cooperación potencial en el diseño, recopilación de datos, análisis y aplicación de los datos recopilados para la gestión de la tierra. El Taller permitirá que cada entidad participante presente su programa / proyecto, proporcionando: 1) objetivos, 2) región de interés, 3) especies de enfoque, 4) hábitats o elementos de paisaje de interés, 5) estado actual del proyecto (número de activos sitios de monitoreo y distribución geográfica), 6) planes para el futuro, y 7) resultados deseados para el monitoreo de la vida silvestre y la aplicación de conservación en la región. Anticipamos al menos siete programas de monitoreo de vida silvestre a gran escala de la región para presentar en el taller, es

decir, Sky Island Alliance, Arizona Game and Fish Department, Servicio de Pesca y Vida Silvestre de los Estados Unidos, National Park Service, Arizona Center for Nature Conservation, University of Centro de Investigación y Conservación del Gato Salvaje de Arizona y Naturalia. La Universidad de Arizona y Wildlife Insights (Conservation International) presentarán su desarrollo de sistemas de gestión de imágenes de vida silvestre basado en la web hasta la fecha. Las presentaciones serán seguidas por una mesa redonda facilitada entre los presentadores con la participación de otros participantes del taller (algunos representantes de sus propios proyectos de vida silvestre), las opciones para una mayor comunicación futura, intercambio de información / datos, cooperación y colaboración para mejorar el monitoreo y conservación de la vida silvestre en la región de Madrense.

NOTE: A manuscript was not submitted to accompany this presentation.

SESSION 6: Children embrace wildlife enjoying puppet shows

EMMANUEL BERNAL, Ailín Ruiz, Gerardo Carreón

Naturalia A.C., L'ormiga títeres, Naturalia A.C.
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Getting away from nature is a generalized trend in the globalized world, people generally do not think of wildlife as an essential part of their lives, and that generates problems when working with nature conservation; This lack of concern, knowledge and interest in flora and fauna is a cultural problem, in which children often do not learn about the importance of the living organisms from their parents or their teachers, the two main voices of authority a child has. On the other hand, children would rather listen to the voice of a puppet than the voice of a stranger; therefore, combining this art with the arguments of conservation biology generates a powerful educational tool, which is fun, persuasive, sincere and practical. We developed a puppet show called “El Regreso del Rey Jaguaripa”, which it is about the problem of wildlife hunting, emphasizing jaguars, and we showed it to almost 1000 children from several municipalities of Sonora, especially in rural areas, in 2017. The response of the audience to the play was much better than to any conference about the importance of wildlife. Currently, we are working on evaluations which measure if there is an increase on knowledge of the species, and on skills and motivation to conserve the wildlife among children. We will present the play to the participants of the session, we will offer a workshop about puppets for conservation, and finally we will organize a discussion forum about ways to evaluate the results of this kind of educational activities.

Los niños aceptan a la vida silvestre disfrutando de espectáculos de títeres (Herramientas)

Alejarse de la naturaleza es una tendencia compartida en el mundo globalizado, las personas generalmente no piensan en la vida silvestre como una parte esencial de sus vidas, y eso genera problemas al trabajar en la conservación de la naturaleza; Esta falta de preocupación, conocimiento e interés en la flora y la fauna es un problema cultural, en el cual los niños a menudo no aprenden directamente de sus padres o de sus maestros, las dos voces principales de autoridad, sobre la importancia de los organismos vivos. Por otro lado, los niños prefieren escuchar la voz de un títere a la voz de un extraño; por lo tanto, la combinación de este arte con los argumentos de la conservación biológica genera una poderosa herramienta educativa, que es divertida, persuasiva, sincera y práctica. Desarrollamos un espectáculo de títeres llamado "El Regreso del Rey Jaguaripa", que trata sobre el problema de la caza de vida silvestre, haciendo hincapié en los jaguares, y se lo enseñamos a casi 1000 niños de varios municipios de Sonora, especialmente en áreas rurales, en el 2017. La respuesta de la audiencia a la obra sobre la importancia de la vida silvestre fue mucho mejor que en cualquier conferencia. Actualmente, estamos trabajando en evaluaciones que miden si hay un aumento en el conocimiento de la especie, y en las habilidades y la motivación para conservar la vida silvestre entre los niños. Presentaremos la obra a los participantes de la sesión, ofreceremos un taller sobre

títeres para la conservación, y finalmente organizaremos un foro de discusión sobre las formas de evaluar los resultados de este tipo de actividades educativas. Producido conjuntos de datos que, por primera vez, incorporan una única resolución y nomenclaturas uniformes en todo el territorio de la frontera entre México y los EE. UU. También buscaremos llegar a un entendimiento común del estado actual del Muro Fronterizo como una serie de obstáculos a la movilidad de la vida silvestre e identificar áreas de importancia crítica y estrategias para un monitoreo continuo que pueda proporcionar datos a largo plazo de sus impactos. Proporcionaremos visualización de SIG en vivo y mapeo básico para crear una colección preliminar de capas de forma que coloque las lagunas y oportunidades identificadas por los participantes. Esto también proporcionará un contexto regional y retroalimentación en tiempo real para los participantes, al tiempo que eliminará los pasos intermedios en la interpretación y el intercambio de sus comentarios. Las capas resultantes se cargarán en Data Basin. Nos comunicaremos con expertos clave de ambos países con invitaciones individuales y preguntas previas al taller.

NOTE: A manuscript was not submitted to accompany this presentation.

SESSION 9: Best Management Practices for Pollinators

CARIANNE CAMPBELL and Elise Gornish

The Sky Island Region is nestled in the heart of continental migratory corridors for pollinators and other wildlife. Local corridors within the region span elevational gradients from the desert floor at 2,500 ft. elevation to more than 10,000 ft. Winter precipitation and spring temperatures are changing at more extreme rates than in any other season, which threatens the phenological coupling of food resources and species that depend on them. A 2016 analysis of temperature trends by season since 1960 found Arizona to be first in the nation for spring warming, with southeastern Arizona experiencing an average increase of .88 degree F per decade. Annual average daily maximum temperatures have increased as much as 5.4 degrees F in some areas (Overpeck et al. 2013), and winter precipitation has become much more variable, with a trend toward increasing frequency of both extremely dry and extremely wet winters (Karl et al. 2009). This is already changing the timing of plant life cycles, which has significant consequences for pollinators and other wildlife, and is rendering traditional ecosystem restoration approaches less viable. Loss of functionality along continental and elevational corridors combined with phenological decoupling of resources and species will decrease adaptive capacity. Restoration and enhancement of diverse native plant communities in strategic locations will be critically important for maintaining insect diversity and providing corridors for migratory birds, pollinating insects and bats. During this workshop, participants will collaboratively draft and commit to best management practices for binational pollinator conservation to support the function and transition of pollinator species and ecosystems of the Sky Island region as the region's climate continues to change rapidly.

Mejores prácticas de manejo para polinizadores

La región de la Isla Serranas se encuentra en el corazón de los corredores migratorios continentales para los polinizadores y otros animales salvajes. Los corredores locales dentro de la región abarcan gradientes altitudinales desde el suelo del desierto a una elevación de 2.500 pies a más de 10.000 pies. Las precipitaciones invernales y las temperaturas primaverales están cambiando a tasas más extremas que en cualquier otra temporada, lo que amenaza el acoplamiento fenológico de recursos y especies alimenticias que dependen de ellos. Un análisis del 2016 de las tendencias de temperatura por estación desde 1960 encontró que Arizona es el primero en la nación para el calentamiento de la primavera, con el sudeste de Arizona experimentando un aumento promedio de .88 grados F por década. Las temperaturas máximas diarias promedio anuales han aumentado hasta 5.4 grados F en algunas áreas (Overpeck et al., 2013), y la precipitación invernal se ha vuelto mucho más variable, con una tendencia hacia una mayor frecuencia de inviernos extremadamente secos y extremadamente húmedos (Karl et al. al. 2009). Esto ya está cambiando el calendario de los ciclos de vida de las plantas, lo que tiene consecuencias importantes para los polinizadores y otros animales salvajes, y está haciendo que los enfoques tradicionales de restauración de los ecosistemas sean menos viables. La pérdida de funcionalidad a lo largo de los corredores continentales y altitudinales combinada con el desacoplamiento fenológico de recursos y especies disminuirá la capacidad de adaptación. La restauración

y la mejora de diversas comunidades de plantas nativas en lugares estratégicos serán de importancia crítica para mantener la diversidad de insectos y proporcionar corredores para aves migratorias, insectos polinizadores y murciélagos. Durante este taller, los participantes redactarán y se comprometerán en colaboración con las mejores prácticas de gestión para la conservación binacional de polinizadores para respaldar la función y la transición de las especies de polinizadores y los ecosistemas de la región de las Islas Serranas a medida que el clima de la región continúe cambiando rápidamente.

NOTE: A manuscript was not submitted to accompany this presentation.

SESSION 38: The Contemplative Arts in Ecology: Re-enchantment With the Natural World (No Abstract Provided)

SESSION 39: Conservation Incentive with the Northern Jaguar Project (No Abstract Provided)

SESSION 40: Nature's Notebook: A dynamic platform for plant and animal observation

ERIN POSTHMUS

Does your organization collect or use data related to the life cycle events of plants, animals, or their habitats? By tapping into the resources of the USA National Phenology Network (USA-NPN), you can leverage a comprehensive data management platform, a database of over 12 million phenological records, and tools for data summary and visualization. Phenology has been recognized as one of the most sensitive indicators of biological response to environmental change. It is easy for scientists and non-scientists alike to observe. The USA-NPN is a federally-funded, national-scale science and monitoring initiative that seeks to partner with organizations to inform decisions related to phenology in a diversity of realms. The Network provides a platform for data collection and delivers freely available quality-controlled data and products to improve decision-making at local to regional to continental scales. In this workshop, you will learn about how to use the USA-NPN's Nature's Notebook plant and animal observation program to meet your existing needs for phenology data collection and storage. You will also learn about the data already available from ecosystems across the Southwest US and beyond. We'll explore the data visualization and summary tools on the USA-NPN website which can help you answer questions about species presence, abundance, and the timing of their life cycle events. If you are looking for a way to engage members of your organization or volunteers in collection of meaningful scientific data, you will learn about local observational campaigns including the flowering phenology of forage species of the lesser long-nosed bats, flowering of nectar species important to monarchs and other pollinators, and leafing, flowering and fruiting phenology of local grass and shrub species.

Cuaderno de la naturaleza: una plataforma dinámica para la observación de plantas y animales

¿Su organización recopila o usa datos relacionados con los eventos del ciclo de vida de plantas, animales o sus hábitats? Al aprovechar los recursos de la Red Nacional de Fenología de EE. UU. (EE. UU.-NPN), puede aprovechar una plataforma de gestión de datos integral, una base de datos de más de 12 millones de registros fenológicos y herramientas para el resumen

y la visualización de datos. La fenología ha sido reconocida como uno de los indicadores más sensibles de la respuesta biológica al cambio ambiental. Es fácil de observar para científicos y no científicos. USA-NPN es una iniciativa de monitoreo y ciencia financiada con fondos federales que busca asociarse con organizaciones para informar decisiones relacionadas con la fenología en una diversidad de ámbitos. La red proporciona una plataforma para la recopilación de datos y ofrece datos y productos de control de calidad de libre acceso para mejorar la toma de decisiones a escalas locales, regionales y continentales. En este taller, aprenderá cómo utilizar el programa de observación de animales y plantas Nature's Notebook de USA-NPN para satisfacer sus necesidades existentes de recopilación y almacenamiento de datos fenológicos. También aprenderá sobre los datos ya disponibles de los ecosistemas en el sudoeste de los EE. UU. y más allá. Exploraremos la visualización de datos y las herramientas de resumen en el sitio web de USA-NPN que pueden ayudarlo a responder preguntas sobre la presencia de especies, la abundancia y el momento de los eventos de su ciclo de vida. Si está buscando la manera de involucrar a los miembros de su organización o voluntarios en la recopilación de datos científicos significativos, aprenderá sobre las campañas de observación locales, incluida la fenología de floración de las especies forrajeras de los murciélagos de nariz larga, la floración de especies de néctar importantes para monarcas y otros polinizadores, y fenología de hojeado, floración y fructificación de especies locales de hierbas y arbustos.

NOTE: A manuscript was not submitted to accompany this presentation.

SESSIONS 40 & 41: Tracking and Prioritizing Invasive Species Management Treatment

JULIA ROWE and Madeline Ryder

Invasive species management (ISM) is an incredibly important, universal, and relatively controversial topic in natural resources management worldwide. The Madrean Archipelago is no exception to this, and we as scientists, managers, and on-the-ground practitioners in this region are addressing the ecological, social, and economic impacts of invasive species encroachment with a spectrum of approaches and knowledge. This workshop aims to bring together the key players on this issue for a thoughtful, iterative, self-analysis of what has worked so far, what hasn't, where we need to go, and even what we're willing to leave behind. Beyond that, we hope to bring the new and emerging science on the issue to the community at large – those with the ability or interest to continue a concerted and coordinated ISM effort. Are there connections to be made (or existing ones to be identified) between researchers, practitioners, and citizens? How can these connections be fostered and encouraged to expand or improve our collective efforts? A panel representing these key stakeholder groups will present on their work, including successes and challenges. Afterwards: the panel will be open for questions and a lead discussion will follow. Questions that may be discussed include, but are not limited to:
1) What are the current controversies surrounding ISM (i.e., ecology, control methods, perceived futility of efforts)? What messages can we develop and present to counter these controversies?
2) How can ISM be implemented at different scales, from private property to national forests? How do strategies adapt to scale differently?
3) When is triage necessary? When it is used, how do we decide what to value, and how will continued changes in climate affect this?
Is there any practicality in adapting to invasive species? Why or why not?

Seguimiento y priorización del tratamiento de manejo de especies invasivas

El manejo de especies invasivas (MIS) es un tema increíblemente importante, universal y relativamente controvertido en la gestión de los recursos naturales en todo el mundo. El Archipiélago Madrense no es una excepción a esto, y nosotros, como científicos, administradores y practicantes sobre el terreno en esta región estamos abordando los impactos ecológicos, sociales y económicos de la invasión de especies invasoras con un espectro de enfoques y conocimiento. Este taller tiene como objetivo reunir a los principales actores en este tema para un autoanálisis reflexivo, iterativo, de lo que ha funcionado hasta ahora, lo que no tiene, a dónde tenemos que ir, e incluso lo que estamos dispuestos a dejar atrás. Más allá de eso,

esperamos acercar la ciencia nueva y emergente sobre el tema a la comunidad en general, aquellos con la capacidad o el interés de continuar un esfuerzo MIS concertado y coordinado. ¿Se deben establecer conexiones (o identificar las existentes) entre investigadores, profesionales y ciudadanos? ¿Cómo se pueden fomentar y alentar estas conexiones para expandir o mejorar nuestros esfuerzos colectivos? Un panel que represente a estos grupos clave de partes interesadas presentará en su trabajo, incluidos los éxitos y desafíos. Después: el panel estará abierto para preguntas y se realizará una discusión principal. Las preguntas que pueden discutirse incluyen, pero no se limitan a: 1) ¿Cuáles son las controversias actuales en torno al ISM (es decir, ecología, métodos de control, inutilidad percibida de los esfuerzos)? ¿Qué mensajes podemos desarrollar y presentar para contrarrestar estas controversias? 2) ¿Cómo se puede implementar el ISM a diferentes escalas, desde la propiedad privada hasta los bosques nacionales? ¿Cómo se adaptan las estrategias a la escala de manera diferente? 3) ¿Cuándo es necesario el triage? Cuando se usa, ¿cómo decidimos qué valorar y cómo los cambios continuos en el clima afectarán esto? ¿Hay alguna posibilidad práctica de adaptarse a las especies invasoras? ¿Por qué o por qué no?

Note: Full Paper Follows

Madrean Conference 2018: Tracking and Prioritizing Invasive Species Management and Treatment Workshop

Facilitators: Julia Rowe[1], and Madeline Ryder[2],

Arizona Sonora Desert Museum[1], Sky Island Alliance[2]

Abstract--*Invasive species management (ISM) is an incredibly important, universal, and relatively controversial topic in natural resources management worldwide. The Madrean Archipelago is no exception to this, and we as scientists, managers, and on-the-ground practitioners in this region are addressing the ecological, social, and economic impacts of invasive species encroachment with a spectrum of approaches and knowledge. This workshop aims to bring together the key players on this issue for a thoughtful, iterative, self-analysis of what has worked so far, what hasn't, where we need to go, and even what we're willing to leave behind. Beyond that, we hope to bring the new and emerging science on the issue to the community at large – those with the ability or interest to continue a concerted and coordinated ISM effort. Are there connections to be made (or existing ones to be identified) between researchers, practitioners, and citizens? How can these connections be fostered and encouraged to expand or improve our collective efforts? A panel representing these key stakeholder groups will present on their work, including successes and challenges. Afterwards: the panel will be open for questions and a lead discussion will follow. Questions that may be discussed include, but are not limited to:*

1) What are the current controversies surrounding ISM (i.e., ecology, control methods, perceived futility of efforts)? What messages can we develop and present to counter these controversies?

2) How can ISM be implemented at different scales, from private property to national forests? How do strategies adapt to scale differently?

3) When is triage necessary? When it is used? How do we decide what to value? How will continued changes in climate affect this?

Is there any practicality in adapting to invasive species? Why or why not?

Presentations

1. Tackling Invasive Species on Public Lands: A U.S. Geological Survey Perspective

Dr. Kathryn Thomas,

US Geological Survey

Definition of invasive species

'Invasive species' means, with regard to a particular ecosystem, a non-native organism whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health (Executive order 13751, 2016). There are many invasives in Arizona, but not all are plants. Arizona Game & Fish Department's (AGFD) list of 10 includes:

- Invertebrates — Quagga mussel, New Zealand mud snail, Red imported fire ants, Asian tiger mosquito, Northern crayfish
- Plants — Buffelgrass, Yellow star thistle, Red brome grass, Giant salvinia
- Vertebrates — Silver carp.

Role of the USGS in invasive species management

The USGS is involved in invasive plant species control. Its parent entity, the Department of Interior (DOI), provides management of about 80% of all land in the western United States. The U.S. Geological Survey (USGS) is the one Bureau within the DOI with the mission to provide science and technical support to managers of public land, such as the National Park Service, Bureau of Land Management, and U.S. Fish and Wildlife Service.

The USGS coordinates with the National Invasive Species Council (NISC) on one of its current focal areas: early detection and rapid response. Currently, the National Invasive Species Council is identifying actions needed to promote four approaches to invasive species problems:

- prevention,
- eradication,
- control, and
- ecosystem restoration.

Oftentimes, invasive species issues are best addressed with integrated approaches that include private landowners, citizen scientists, universities (particularly extension), tribal nations, and state agency contributors as well as federal land managers and scientists. Current research by the USGS Southwest Biological Science Center in Tucson focuses on buffelgrass, *Salsola ssp.*, tamarisk, and several aquatic species. USGS has previously collaborated with groups across the state that formed Cooperative Weed Management Areas (CWMA), as well as contributed to efforts with the Arizona Wildlands Invasive Plant Working Group to develop a categorized list of invasive plants in 2005. As part of collaboration and outreach, CWMAs highlight tools for citizens and agencies to use (like iNaturalist and iMapInvasives) to help get information on the spread of major invasive plants.

2. Research and Control Efforts Against Buffelgrass in Saguaro National Park

Perry Grissom

US National Park Service

A brief history of buffelgrass at Saguaro National Park (SNP)

Buffelgrass was found in SNP in 1989, with pulling efforts initiated in 1993 after buffelgrass was found to be able to successfully push out native species. When buffelgrass was first discovered, there were not many case studies to rely on for management decisions. Herbicides were first used in 2003 with patchy success; south-facing slopes were most difficult to treat due to terrain. Buffelgrass population dynamics mimic a classic S-curve, with stages of Introduction (low spread rate); Colonization (accelerating spread rate); Expansion (spread rate which begins to decline); and Saturation (spread rate levels off). SNP is currently believed to be near the tip of the Expansion stage by park managers.

Research to address growing questions and concerns

Glyphosate was found to be the most successful herbicide treatment for addressing buffelgrass invasions. Aerial spraying began in 2014 in buffelgrass monoculture stands after a decade of ground treatments, with monitoring via hand-held greenness monitors. Treatment sites showed the ability of the desert to bounce back from buffelgrass invasion and herbicide applications. Many desert plant species have long-lived, hardy seeds due to adaptation to extreme habitat, or strong mobility traits, which aid them in them recovery process.

SNP funded studies of controlled burns to produce a predictive fire model for the park. Concerns of creating more fuel through herbicide treatments were alleviated from studies of reduced post-treatment biomass. Risk of wildlife mortality increased with increased fire intensity and range. Many burned vertebrates and invertebrates were documented post-fire.

Tortoises were found in worse condition in areas of high buffelgrass due to less native food availability. However, tortoise abundance has remained unchanged.

3. The Buffelgrass (BG) Issue in Mexico: Ecological, Political, and Social

Carlos Hugo Alcalá Galvan

Departamento de Investigaciones Científicas y Tecnológicas – La Universidad de Sonora (DICTUS-UNISON)

The introduction and proliferation of BG in México (MX)

Private land accounts for 95% of land ownership in Sonora, MX, with a different political context for BG management, mainly focused on cattle and livestock production. In the 1950s–60s, Mexican ranchers visiting Texas identified BG as a potential forage crop; native vegetation was commonly clear-cut, soil was levelled, and some soil was fertilized for BG proliferation. BG increased forage production by 800%, even resulting in more forage than necessary for cattle in some areas. By 1990, 300,000 ha of buffelgrass existed in Sonora through anthropogenic and natural propagation. The federal government subsidized BG growth as well, with the mindset that BG should be seeded on all available lands, excluding roads.

Personal work of Dr. Alcalá on mitigating negative buffelgrass impacts

Dr. Alcalá worked as a member of a group of federal researchers with the underlying goal of supporting ranchers (and their efforts at furthering the use of BG) for cattle production). During his time in the group, Dr. Alcalá advocated against the practice of clear-cutting for BG propagation. Evidence suggests that only 10% of land devoted to BG production is needed to maintain existing economic function for ranches. Government regulations surrounding the use of BG exist, but there is no enforcement. There are now incentives to promote native species on ranchland that have come from the selling of federal hunting permits on private land. These incentives have had a greater impact than BG. For example, ranchers can get the economic equivalent of selling 10 cows from one mule deer permit sale; this encourages them to provide the habitat necessary to allow mule deer and other game animals to flourish.

4. Managing Invasive Species in an Area of Social and Environmental Change

Kim Franklin

Arizona-Sonora Desert Museum

Buffelgrass (BG) is the most impactful invasive species in the Sonoran Desert. There are not many success stories, so Dr. Franklin urged the audience to create one here.

Effects of buffelgrass on Tucson Basin ecology

The Tucson Basin is the wheelhouse of BG. It's heading east rapidly, but only slowly heading west. Saguaro and palo verde forests are being converted by BG into grassland, due to the increasing fuel load and severity of fires. The fire on A Mountain last year (2017) is a prime example of this trend. It left slopes completely burned, and after the first subsequent rain, BG was the first plant to reestablish. The Santa Catalina Mountains have somewhere between 3,048 – 3,657 ha (10,000-12,000ac) BG. Many vacant lots and lawns in town are covered in the plant.

Community responses to BG invasion

Arizona added BG to the state noxious weed list, which was not an easy task (the list is more focused on agricultural pests instead of invasive species). The Wildlands Fire Resilient Landscapes Program supported cross-jurisdictional coordination and action on BG. The Southern Arizona Buffelgrass Coordination Center (SABCC) was created to coordinate the BG effort in southern AZ. SABCC obtained a Federal Emergency Management Agency (FEMA) grant to control BG around the Tucson

airport, and BG was recognized as an urban threat as well as wildland threat. SABCC dissolved recently (2015) and their work is continued by the Arizona-Sonora Desert Museum. Messaging has changed from "beat back buffelgrass" to "save our saguaros" to focus on what we are trying to protect. As federal funding decreases and as the problem proliferates, "glue" organizations are needed to hold together large, cross-jurisdictional conservation efforts, as well as to link scientists and managers.

Small Group Discussions

Gaps & Opportunities in Knowledge & Tools

This group discussed mapping and went over the existing databases and discussed the challenges of pulling together all of this data into a single database. The Western Governors Association recently put together a list of the worst 50 invasives in the west. The Association is calling for coordinated invasive species management including early detection and rapid response programs to ensure that actions result in more on-the-ground prevention, management and eradication. Governors also call for increased accountability and oversight of federal invasive species programs and support the creation of a west-wide species inventory, including the development of data management standards, formats and protocols (Invasive Species Data Management Project).

iMap Invasives continues to be a good source of regional data on BG occurrence. Another platform, GIS Cloud mapping shows great promise for increasing our ability to detect small populations early. It has been adopted by the Department of Defense, Barry Goldwater Airforce Base. Check out the map created by Jim Malusa, with data collected by servicemen and women, as well as Jim Malusa and Max Li. (https://editor.giscloud.com/ (search for "sonoran")).

Communication & Collaboration

This group discussed the need to bring the issues of invasive plant species to the public. Even though BG has been a major problem for decades many people in the general public still do not know about it or do not understand the severity of the issue. Media outlets such as radio spots, electronic platforms such as blog posts, web newsletters, Facebook, Twitter, and others all need to be utilized to reach the people that do not self-select to learn about BG. Also, reaching out along with other larger events and activities in town is another way to reach novel audiences.

In the community some ideas to get the info out and people excited include: Evening pub talks and talks at regular neighborhood meetings. There was a lot of enthusiasm for a plant swap that would include people bringing in BG plants in exchange for a native grass or other plant.

Translating Ideas into Action

There are few tools to control BG. There are some folks working to increase available tools. Research on biocontrol involve a local rust (fungus) acts as a biocontrol, but it is not very effective. We will need more tools for long term success beyond mechanical and chemical applications; biocontrol could allow personnel to avoid dangerous areas to treat. Certain neighborhoods won't allow spraying, this could solve that too. There is the economic impact in Sonora, MX to consider because BG is an important economic market there.

Increasing capacity

Where can we get support for greater physical capacity? Certification of landscaping companies to properly remove BG would help people know who to contract and increase awareness among that group of practitioners. City of Tucson and Pima County have separate regulations; the countys could be more effective, but there's no enforcement. The US NPS needs a helicopter, a boom and other tools for greater capacity. Other groups could potentially share large equipment like this for increased efficiency and decreased monetary investment.

Creation of an economic market

There was a company that created paper products with BG, and some people have used BG as a building material in alternative mud style buildings. However, encouraging this may encourage easy-to-access BG production in the valley. There is a federal push to NOT create markets for noxious weeds.

Mapping and interagency crews; a cross-jurisdictional action group

Road corridors are acting as transmission lines for BG. County/city right-of-ways are not regulated for treatment. Some roadways are solid BG stands coming up to park entrances. There is a current FEMA grant for controlling BG in washes. Washington has issued a regulation to notify property owners of the need to treat invasives on private land within certain time. If not done, the state will do it and send a bill. Tucson has a similar regulation, but it seems to not be enforced at this time and it relies on complaint calls to trigger action.

There are not enough people for control, so areas need to be prioritized. Mapping seems to come to the forefront in these discussions. However, we already know BG is here, so this may not be the most important step anymore.

Large Group Discussion

Some interesting ideas to increase the excitement and enthusiasm for BG control were discussed. There could be an incentive for HOAs or neighborhood associations to compete in control of BG, such as prizes or plaques for most BG plants removed, or native plants in exchange. There is a local nursery is already on board. It would be best to keep the scale small, neighborhood scale or smaller and businesses could be tapped to help sponsor the efforts. Other topics for consideration: social justice issues; combining BG with native pollinator plants, bringing in positive things as well as removing negative things; a “Save the Hopbush” campaign, in addition to Save Our Saguaros.

SABCC created a booklet for corporate sponsorship opportunities, but it hasn’t been used since. This could be explored further, with Raytheon, Caterpillar, Monsanto as possibilities. There could also be a county requirement to not allow BG grass to grow onto newly developed properties.

Buffelgrass control efforts need to be sustained. With ample funding and rapid response crews that can take care of spot infestations as they develop. Tucson needs to be a buffelgrass-free zone; with easy access for removal. If the public sees progress, they’ll be more encouraged to help. Some frustrations are that citizens and agencies of Tucson have been doing this for 18 years, and there are a lot of repeat infestations. There are mixed messages on chemicals as well as pulling. A lot of effort, time, and money put into A Mountain and Tumamoc Hill, but regrowth when groups left is discouraging. There is a new effort to push back the BG off of these two symbols of Tucson; hopefully they can be an example of what can be done.

SESSION 45: Using Symbiota Software Platform to Collaboratively Manage Collections and Regional Checklists

NICO FRANZ

I will give an interactive, audience-driven live demonstration of the Symbiota software platform* from the perspective of a biodiversity scientist assembling a regional, occurrence-based biodiversity inventory for a particular region (such as a country's state). Topics to cover include common data search and display interfaces, collection and observation management, and particularly taxonomic and social practices related to accumulating checklist data from diverse information sources. I will touch on the not-well-understood issue of versioning checklists, where potentially different succeeding versions can have different sets of authors and taxonomic views. Because members of Arizona State University's Biodiversity Knowledge Integration Center are actively involved in developing and using Symbiota, and therefore often serve as portal managers or

at least promoters, this workshop can also serve as a starting point for workshop participants to develop their own collections or datasets.

Uso de la plataforma de software Symbiota para administrar colaborativamente colecciones y listas de verificación regionales

*Ofreceré una demostración interactiva, conducida por la audiencia, de la plataforma de software Symbiota * desde la perspectiva de un científico de la biodiversidad que ensamble un inventario regional de biodiversidad basado en la ocurrencia para una región en particular (como el estado de un país). Los temas a cubrir incluyen interfaces comunes de búsqueda y visualización de datos, gestión de la recopilación y observación, y particularmente las prácticas taxonómicas y sociales relacionadas con la acumulación de datos de la lista de verificación de diversas fuentes de información. Voy a tocar el tema no bien comprendido de las listas de control de versiones, donde las versiones sucesivas potencialmente diferentes pueden tener diferentes conjuntos de autores y vistas taxonómicas. Debido a que los miembros del Centro de Integración del Conocimiento de Biodiversidad de la Universidad Estatal de Arizona participan activamente en el desarrollo y uso de Symbiota, y por lo tanto sirven como administradores del portal o promotores, este taller también puede servir como punto de partida para que los participantes desarrollen sus propias colecciones o conjuntos de datos.*

NOTE: A manuscript was not submitted to accompany this presentation.

SESSION 48: Sister Parks: Best Practices for Cross-Border Conservation in Parks and Protected Areas

DON SWANN and Mario Cirett

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Although increasingly separated by physical and political barriers, the lands on either side of the US-Mexico are united by shared ecosystems, watersheds, and conservation issues. Both sides of the border contain numerous protected natural areas, including parks, forests, and wildlife refuges, and some of the national parks in the two countries are designated "sister parks" in a formal program that encourages collaboration and mutual support. This paper, based on a workshop held at the Madrean Conference, explores the many challenges and opportunities in creating on the ground conservation partnerships across the border. An important issue for biologists, park rangers, and other government employees in both the US and Mexico is the difficulty in obtaining permission to cross the international border, so working with non-governmental organizations that provide greater travel flexibility is essential. Other challenges include language barriers that make communication more complicated, staff turnover that can affect established relationships, and barriers to sharing data that would aid conservation of shared wildlife species.

Parques Hermanos: mejores prácticas para la conservación transfronteriza en parques y áreas protegidas

Aunque cada vez más separadas por barreras físicas y políticas, las tierras a ambos lados de los Estados Unidos y México están unidas por ecosistemas, cuencas hidrográficas y problemas de conservación compartidos. Ambos lados de la frontera contienen numerosas áreas naturales protegidas, incluidos parques, bosques y refugios de vida silvestre, y algunos de los parques nacionales de los dos países se designan como "parques hermanos" en un programa formal que fomenta la colaboración y el apoyo mutuo. Este documento, basado en un taller realizado en la Conferencia Madrean, explora los muchos desafíos y oportunidades en la creación de asociaciones de conservación sobre el terreno a través de la frontera. Un tema

importante para los biólogos, guardaparques y otros empleados gubernamentales tanto en los Estados Unidos como en México es la dificultad para obtener permiso para cruzar la frontera internacional, por lo que es esencial trabajar con organizaciones no gubernamentales que brinden una mayor flexibilidad de viaje. Otros desafíos incluyen las barreras del idioma que complican la comunicación, la rotación de personal que puede afectar las relaciones establecidas y las barreras para compartir datos que ayudarían a la conservación de especies de vida silvestre compartidas.

Note: Full Paper Follows

Sister Parks: Challenges and Best Practices for Cross-Border Conservation in Parks and Protected Areas

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***Abstract**--Although increasingly separated by physical and political barriers, the lands on either side of the US-Mexico are united by shared ecosystems, watersheds, and conservation issues. Both sides of the border contain numerous protected natural areas, including parks, forests, and wildlife refuges, and some of the national parks in the two countries are designated "sister parks" in a formal program that encourages collaboration and mutual support. This paper, based on a workshop held at the Madrean Conference, explores the many challenges and opportunities in creating on the ground conservation partnerships across the border. A important issue for biologists, park rangers, and other government employees in both the US and Mexico is the difficulty in obtaining permission to cross the international border, so working with non-governmental organizations that provide greater travel flexibility is essential. Other challenges include language barriers that make communication more complicated, staff turnover that can affect established relationships, and barriers to sharing data that would aid conservation of shared wildlife species. Workshop participants agreed that while maintaining formal US-Mexico sister park and other conservation partnerships is difficult, the work is important and will only become more so. We provide examples of how barriers to cooperative cross-border conservation can be overcome, and highlight a few examples of successful programs, including spring and biodiversity initiatives in sister parks in southeastern Arizona and northern Sonora, and the pronghorn restoration project in the Pinacate-Organ Pipe-Cabeza Prieta region.*

INTRODUCTION

The natural world rarely conforms to political boundaries. This is especially true in the Borderlands region of the United States and Mexico, where both countries share rich biodiversity, migratory wildlife, watersheds, and a host of environmental problems including air and water pollution (Liverman et al. 1999, Varady et al. 1995, Wilder et al. 2010, Scott et al. 2012). The two countries also share a number of threatened and protected species including jaguars (*Panthera onca*) and other felids, Mexican grey wolves (*Canis lupus baileyi*), Sonoran pronghorn (*Antilocapra americana sonoriensis*), desert bighorn sheep (*Ovis canadensis nelsoni*), and others that rely on habitat and cooperation among wildlife managers in both countries to maintain healthy populations (U.S. Fish and Wildlife Service 2018).

Mexico and the US have significant protected natural areas near the border in the states of Texas, New Mexico, Arizona, and California in the US, and Baja California, Sonora, and Chihuahua in Mexico. These include both private and public reserves with a variety of designations and protections. In the Sonoran Desert-Sky Island region, some of the largest areas are national parks that share a contiguous border, such as Organ Pipe Cactus National Monument and Pinacate Biosphere Reserve (El Pinacate y Gran Desierto Altar) in Mexico and are officially referred to as “Sister Parks” in the US and “Brother Parks” (parques hermanos) in Mexico (U.S. National Park Service 2018). The sister park designation is also shared by other parks that are not contiguous but have shared resources, such as Saguaro National Park in Arizona and Parque Nacional Constitución de 1857 and Parque Nacional Sierra de San Pedro Mártir in Baja California, all three of which are located in “sky island” mountain ranges that are surrounded by desert areas, and the southern Arizona national park areas Chiricahua National Monument and Coronado National Memorial, which are linked with Ajos-Bavispe National Forest Reserve and Sierra de Alamos - Rio Cuchujaqui in Sonora (Swann et al. 2016).

Conservation relationships between the US and Mexico have a long history. The first U.S. and Mexico International Park Agreement was signed at an international meeting in El Paso, Texas more than 80 years ago, on November 24, 1935 (Greater Big Bend Coalition 2018). When US President Franklin Roosevelt signed the legislation creating Big Bend National Park in 1944, he expressed in a letter to Mexican president Manual Avila Camacho that “I do not believe that this undertaking in the Big

Bend will be complete until the entire park area in this region on both sides of the Rio Grande forms one great international park." Similarly, when the biosphere reserves were established in Organ Pipe Cactus National Monument (1976) and El Pinacate y Gran Desierto Altar (1993) it was with the goal of international cooperation and support. In the area of wildlife conservation, the two governments have often collaborated, with both signing the Migratory Bird Treaty Act with in 1936 and through creation of the Canada/Mexico/US Trilateral Committee for Wildlife and Ecosystem Conservation and Management (Mumme 2017), which meets annually to consolidate efforts for wildlife and ecosystem conservation and management.

Despite this history of ambitious efforts, maintaining conservation partnerships on the ground has always been challenging. In addition to the economic, cultural, and language differences between the two countries, domestic politics within Mexico and the US often influence the relationships between them (Liverman et al. 1999). In the past two decades immigration into the US from Mexico and smuggling between the two countries, as well as the law enforcement response on the US side, has dramatically impacted the border region (Cohn 2007, Flesch et al. 2010). Beyond the political difficulties between the two countries, there is still significant economic activity and legal travel between the US and Mexico, an active tourist industry, and a widespread belief that the need for shared conservation is greater than ever.

The purpose of this paper, based on a workshop at the Madrean Conference with about 20 participants from both Mexico and the US, is to explore the main challenges in developing shared conservation partnerships and how best to overcome them. Although there is a large literature on keys for creating successful private-partnerships and some papers on conservation partnerships, here we focus on the more specific question of current issues and opportunities in conservation partnerships along the US-Mexico border. In the workshop, we engaged in both one-on-one and group dialogue. We asked participants to share their stories and program examples of what works in helping achieve important shared conservation goals in the Sky Island-Sonoran Desert region and how to move forward in solving problems related to water, wildlife and other environmental issues.

ISSUES AND CHALLENGES

Workshop participants explored a wide range issues and challenges that are common to many partnerships, including the need for consistent funding and the importance of clear goals and consistent leadership. One of the more specific challenges for collaboration in the border area is the difficulty that government officials such as park managers, biologists, and managers have in traveling across the international border, which greatly limits face-to-face meetings and cross border visits to field sites. For examples, park officials from Sonora were unable to attend our session because they could not secure permissions to travel to the Madrean Conference. In 2016, an important meeting involving more than 4 US parks and 8 Mexico parks had to be cancelled at the last minute because National Park Service (NPS) officials were unable to cross the border due to security concerns. In-person meetings in the past have been important for training, developing shared protocols, fire management, and even for practical considerations such as exchanging equipment.

We agreed it is important to continue to work through these challenges and continue to meet wherever possible. Large meetings are more intractable at the present time but smaller trips, planned well in advance, may be possible. In addition, it is possible to use technologies such as Skype to hold virtual meetings across borders. An alternative way that government agencies can address the travel issue is by working with universities and non-governmental non-profit organizations (NGOs), which often have fewer travel restrictions to host or attend meetings, facilitate communication, provide training, and implement on-the-ground projects with the participation of government agencies supported through grants. NGOs such as the Sky Island Alliance (SIA), International Sonoran Desert Alliance, Arizona-Sonora Desert Museum, Greater Big Bend Coalition, and many others often form the core of efforts to achieve specific results in a wide range of restoration, research, and wildlife conservation efforts.

Conservation challenges and solutions can be unique to each nation, but often the needs and goals are similar on both sides of the border. Additional issues identified in the workshop that can affect cross-border conservation include limited financial support, language barriers, and barriers to sharing data among researchers and agencies. On the US side the Sister Parks programs have been financially supported by the Southwest Border Resource Protection Program, not only Arizona and Sonora, but also between Texas and Chihuahua, and between California and Baja California. These funds can be used to support borderlands conservation in parks through cooperative agreements with NGOs. Funding for collaborative projects

often seem the most effective way to overcome shared information gaps or border-related challenges in conservation programs.

Most individuals who work for agencies in Mexico and the US are not fluent in both Spanish and English; although they may speak some of the second language but are reticent about speaking it. We discussed how language barriers may be perceived as more consequential than they need be. We addressed this issue in a humorous way in our workshop by asking everyone to greet and converse with 2-3 people from the other country in their native tongue. However, clearly the most successful meeting and trainings, like the Madrean Conference, try to translate all the content to all participants, and have trained facilitators who are also skilled translators, which NGOs are often able to provide. Non-native language learners can also sometimes find support within their organizations to take additional classes or immersion experiences, but probably the most important step is for organizations in both countries to make the effort to hire more bilingual staff. Some NPS areas have taken steps to do this, hiring from a pool of bilingual returned Peace Corps Volunteers who are eligible for special hiring considerations in the federal government and come to the position with cross-cultural community development experience. At any rate, the language issue is significant but can be overcome with advanced planning and good selection of team members.

Barriers to sharing data are more difficult to address, as sometimes there are legal barriers, especially with sensitive species. However, most species are not sensitive and the tendency to not share data such as wildlife camera data, even within countries, is often more of a problem related to individual reluctance and lack of good systems for managing the data. Other workshops at the conference also discussed this issue and proposed some solutions. Some participants expressed that greater knowledge of mammal distributions on both sides of the border, as is occurring with reptiles and plants, would be an important step in regional wildlife conservation. Recognizing the value of open-source publications, with multinational authors, can also work to address data-sharing needs as many journals now require all data to be archived and accessible.

Finally, there is no way of getting around the significant issues related to politics and security along the US-Mexico border. Although there are great differences in the perceptions about these issues, workshop participants acknowledged that they have real and significant implications for how conservation programs and projects can be accomplished. Beyond travel restrictions, these implications include shifting financial and institutional support for international conservation programs, as well as changes in conservation priorities that may result from changes in border security, infrastructure, and enforcement.

EXAMPLES OF SUCCESSFUL PARTNERSHIPS

The Madrean Conference highlighted many of the best cross-border conservation projects in the region, including large programs such as the biodiversity surveys associated with the Madrean Archipelago Biodiversity Assessment and jaguar conservation projects associated with Naturalia, Northern Jaguar Project and other partners, as well as many smaller projects with literally dozens of partner organizations. In addition, there are some existing conservation partnerships at higher levels in the governments. Besides the Trilateral Committee, a major player is the US Fish and Wildlife Service's Division of International Conservation, which has a Mexico branch dedicated to strengthening Mexico's capacity to conserve its globally important biological resources (U.S. Fish and Wildlife Service 2018). In addition to wildlife conservation, the border region has several conservation projects related to water, especially in the Colorado River delta and the Big Bend/Rio Bravo area.

These programs share many similarities that help make them successful, so and in the remaining part of this paper we'll highlight just a few example projects that were discussed during the workshop that illustrate how these projects have addressed some of the challenges of doing work on both sides of the border.

Sister park project in Arizona, Sonora, and Baja California

During the past decade a project with the SIA, NPS, and Mexico's Comisión Nacional de Áreas Naturales Protegidas (CONANP) worked with Sister Parks in each country to share knowledge relating to conservation and education related to wildlife, pollinators, and springs. SIA has been a natural partner for this work, which is focused on long-term understanding of changes in wildlife populations and water resources within parks and national forests so as to ensure they will be protected for the future, because it has Spanish-speaking staff and a long history of working in Mexico and many existing connections in

Mexico parks and NGOs. Although NPS and CONANP park rangers and biologists are sometimes able to meet in person – in the past, they have shared equipment such as fire engines and even paint colors for park signs – travel between countries has become more difficult in recent years.

SIA has helped the partnership continue by holding trainings for park staff in their own countries including springs assessment workshops in Sonora with the Springs Stewardship Institute, and wildlife tracking workshops in the US for NPS staff. In addition, where travel has been possible, SIA has facilitated visits by CONANP staff to events in the US, such as a Borderlands workshop and bioblitzes at Coronado National Memorial, and facilitated visits by NPS staff to workshops on wildlife tracking and fire management in Área de Protección de Flora y Fauna Bavispe and Parque Nacional Constitución de 1857. An important role for SIA is to help overcome language barriers by facilitating messages between park officials and translations during meetings, including opportunities to speak via Skype at park events where travel is not possible. Over the past few years SIA has also developed partnerships with several key NGOs in Mexico including Naturalia and Cuenca Los Ojos.

One of the best results of the partnership has been the involvement of student-led groups from Mexican universities who have enthusiastically participated and even initiated bioblitzes, spring assessments, and pollinator conservation. These groups include Allianza Mariposa Monarca, a student group at Universidad de Sonora that monitors and carries out educational programs about monarch butterfly conservation; Grupo de Exploración de Manantiales de Sonora (Sonoran Springs Exploration Group) dedicated to search and assess springs in Sonora; and students from Universid de la Sierra, who participate in pollinator blitzes. Through these efforts SIA has been able to expand the Sister Park concept to other organizations engaged in conservation and education work along the border. More importantly, the student groups not only help sustain the Sister Parks program in a time when it might otherwise be impossible, but they are inspiring to work with and bring new energy to the parks. It is extremely hopeful to witness new bonds being forged between future conservation stewards and leaders from either side of the border.

Sonoran pronghorn recovery project in Arizona and Sonora

The partnership to protect, monitor, and restore the Sonoran pronghorn has seen significant successes that would have been impossible without an international partnership of many organizations. This population of pronghorn, an endangered subspecies, is found nowhere else in the world outside of the Organ Pipe-Cabeza Prieta-Pinacate in the Sonoran Desert, was in decline for many years due to habitat loss, fragmentation, and severe drought. The population appears to have hit a low point during the drought of 2002 with only 18 individuals counted in the US (Christianson et al. 2017), with a higher but unknown number of individuals in Mexico.

The on-going effort to restore the pronghorn through captive breeding is a broad partnership that includes the US Fish and Wildlife Service, the Arizona Game and Fish Department, Organ Pipe Cactus National Monument, the US Bureau of Land Management, the US Air Force, the US Marine Corps, Wildlife and Sport Fish Restoration Programing of the US, and El Pinacate Biosphere Reserve and the Instituto del Medio Ambiente y el Desarrollo Sustentable de Estatio de Sonora. Collaboration with both state and federal agencies in Mexico has been essential because stock for captive breeding had to come from Sonora.

Collaboration has been further facilitated through partnerships with the University of Arizona and the University of Idaho to facilitate development of cross-border pronghorn population monitoring efforts and ecological research. Through grants and logistical support from US and Mexican partners, the universities have been able to develop consistent survey protocols and centralize, organize, and distribute data for all partners. Research projects are executed by university staff and students who can regularly cross the border to work with pronghorn biologists in both nations and maintain frequent face-to-face communication with sister park staff. Engaging universities formally in conservation efforts, such as through regular Sonoran Pronghorn Recovery Team meetings, further facilitates information transfer and ensures universities address knowledge gaps important to all stakeholders. We have noticed the universities serving as an important bridge, further linking agencies in the U.S. and Mexico. Like all agencies, international relationships with universities take time to build but can be highly impactful. The University of Arizona boasts several US and Mexican graduate students working on cross-border conservation supported by agencies and NGO’s from both countries.

CONCLUSION

The importance of partnerships is widely recognized in achieving many societal goals, including conservation goals (e.g., McNeeley 1995). Key elements of success in partnerships vary widely depending on the specific needs, but universal elements include the need for: 1.) establishing clear goals; 2.) identifying the key stakeholders; 3.) identifying key risks; and 4.) building public support. A universal element in conservation partnerships is the understanding that federal government organizations alone cannot carry the full responsibility for protecting nature. Support from state and local organizations, and especially NGOs, is essential (McNeeley 1995). For conservation work in the US-Mexico border region, we identified several keys to success:

1. Having a range of partners from government organizations, universities, and NGOs who can bring different elements to help the project succeed, with 1-2 organizations providing leadership;

2. A consistent funding source to sustain the project, but with supplemental funds to add value for research and restoration, such as support for pronghorn water catchments;

3. Several key players who enjoy working in partnerships, are flexible, and can take on a leadership role if another key player leaves his or her position;

4. Spanish-English language capacity to help lead meetings and work easily in both Mexico and the US;

5. Recognizing that there will always be barriers to cross-border conservation, a long-term commitment from the different partners with as much institutional support as possible;

6. Capacity to bring in new individuals, especially students, who can add new value and technology to the project and work into leadership positions; and

7. Developing an open environment of mentorship to pass on experience and lessons learned to new leaders in cross-border conservation.

At the workshop, we were pleased to have the participation of some individuals with a deep history of working on both sides of the US-Mexico border, as well as younger individuals who are only beginning their conservation career. We all agreed that while it may be as difficult as it has ever been to work on conservation projects in both countries, at the same time there are probably more on-the-ground projects and more partner organizations than at any previous time in history. This reflects not only a growing recognition that wildlife and other environmental issues do not recognize the international boundary, but that the need to collaborate on environmental issues is greater than ever.

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SESSIONS 56 & 57: Madrean Landscape Conservation Design: Connectivity Mapping and Participatory Input to Species Use, Threats, Best Management, and Protection Opportunities Workshop

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The Madrean Transboundary Watersheds partners have identified biodiversity, connectivity, socio-ecological services, collaboration, and science and information sharing as priorities for the watersheds. Landscape connectivity conservation is critical to achieve biodiversity conservation in this rapidly developing landscape and under a warmer and drier climate. Wildlife's ability to move in this region is challenged by a landscape of high mountains interspersed desert and grassland valleys, and a region dissected by a few major rivers and their tributaries, and with high levels of human land modification and development along these rivers and tributaries. The connectivity of this region is most impacted by the cross-landscape cutting features, such as border infrastructure and major highways, and other types of infrastructure and development which have the potential to severely fragment landscape connectivity for wide-ranging wildlife species, such as jaguar, ocelot, black bear, mountain lion, and pronghorn antelope. The LCD Core Team, directed by a Madrean Connectivity Work Group, set a goal of identifying connectivity priority areas based on landscape, i.e. "connectivity areas" for wide-ranging wildlife (within a human modified landscape), and developing site-specific management recommendations for these areas. We developed a "core" to "core" connection strategy following a rule set that relied on existing GIS models, other spatial data sets, and aerial imagery for guidance. "Cores" were defined as Madrean montane and intact grassland wildland blocks, which we mapped. Our product is a digitized map of priority high integrity connections among cores that if conserved (along with core habitat integrity) would promote connectivity conservation for wide-ranging wildlife of the region. At this workshop, we will ask participants to review and provide input on our mapped connectivity areas, add missing connections to conserve, address knowledge gaps, and answer a series of questions related to developing a conservation profile and best management strategy for each of these connectivity areas (as well as select "cores" of concern in Mexico). We will ask participants for their input on anticipated future threats to connectivity (e.g., new infrastructure), so that new landscape fragmenting features can be mitigated for, so as not to add greater challenges to wildlife movement within the region. The results of this workshop will be published as spatial and qualitative data in the forthcoming Transboundary Madrean Watersheds conservation blueprint. We will utilize the results of this workshop to engage watershed collaboratives and conservation partners in implementing strategies to conserve priority connectivity areas.

Diseño de conservación del paisaje

Los socios de cuencas hidrográficas transfronterizas Madrenses identificaron la biodiversidad, la conectividad, los servicios socioecológicos, la colaboración y el intercambio de información y ciencia como prioridades para las cuencas hidrográficas. La conservación de la conectividad del paisaje es fundamental para lograr la conservación de la biodiversidad en este paisaje de rápido desarrollo y bajo un clima más cálido y seco. La habilidad de la vida silvestre para moverse en esta región se ve desafiada por un paisaje de valles montañosos y desérticos intercalados, y una región diseccionada por algunos ríos importantes y sus afluentes, y con altos niveles de modificación y desarrollo de la tierra humana a lo largo de estos ríos y afluentes. La conectividad de esta región se ve más impactada por las características de corte transversal del paisaje, como la infraestructura fronteriza y las principales carreteras, y otros tipos de infraestructura y desarrollo que tienen el potencial de fragmentar seriamente la conectividad del paisaje para especies silvestres de gran alcance, como el jaguar, ocelote, oso negro, león de montaña y antílope pronghorn. El Equipo básico de LCD, dirigido por un Grupo de trabajo de conectividad Madrense, estableció el objetivo de identificar áreas prioritarias de conectividad basadas en el paisaje, es decir, "áreas de conectividad" para una amplia variedad de vida silvestre (dentro de un paisaje humano modificado) y desarrollar recomendaciones de manejo específicas del sitio para estas áreas. Desarrollamos una estrategia de conexión de "núcleo" a "núcleo" siguiendo un conjunto de reglas que dependía de modelos SIG existentes, otros conjuntos de datos espaciales e imágenes aéreas para orientación. Los "núcleos" se definieron como bloques silvestres montanos Madrenses e intactos de

pastizales, que mapeamos. Nuestro producto es un mapa digitalizado de conexiones prioritarias de alta integridad entre los núcleos que, si se conservan (junto con la integridad del hábitat central), promovería la conservación de la conectividad para una gran variedad de vida silvestre de la región. En este taller, les pediremos a los participantes que revisen y aportes sobre nuestras áreas de conectividad mapeadas, agreguen conexiones faltantes para conservar, solucionen las lagunas de conocimiento y respondan una serie de preguntas relacionadas con el desarrollo de un perfil de conservación y la mejor estrategia de gestión para cada una de estas conectividad áreas (así como seleccionar "núcleos" de preocupación en México). Solicitaremos a los participantes su opinión sobre las amenazas futuras anticipadas a la conectividad (por ejemplo, nueva infraestructura), de modoque se puedan mitigar las nuevas características de fragmentación del paisaje, para no agregar mayores desafíos al movimiento de vida silvestre dentro de la región. Los resultados de este taller se publicarán como datos espaciales y cualitativos en el próximo anteproyecto de conservación de Cuencas Hidrográficas Transfronterizas Madrenses. Utilizaremos los resultados de este taller para involucrar a colaboradores de cuencas hidrográficas y socios de conservación en la implementación de estrategias para conservar las áreas de conectividad prioritarias vegetales en el Archipiélago Madrense.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 7: Collection, Production, and Harvest of Native Seed and Plant Material for Restoration

Grasslands, Peloncillo Mountains Unit, Coronado National Forest
(Photo by Daniel G. Neary, USDA Forest Service, Rocky Mountain Research Station)

Abstracts and Papers
Conn
Habestich
Hodges
Mount
Perez
Wolfgast

Building a native plant materials program in the Borderlands: Successes and next steps

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Borderlands Restoration Network (BRN) is a non-profit organization centered on community-based ecological restoration in the Madrean Archipelago ecoregion of southern Arizona. BRN highlights and promotes the work of a network of organizations with decades of exerptise in watershed and habitat restoration, rural youth programming, and native plant and seed services spanning both Sonoran and Chihuauan ecotypes. The mission of BRN is to foster ecological and cultural place-based learning and leadership which cultivates a restoration economy in the US-Mexico borderlands. Over the past five years, The Borderlands Restoration Native Plant Nursery and Seed Lab in Patagonia, Arizona have developed a system for providing regional plant and seed genotypes to federal agencies and the general public. These entities comprise the BRN Native Plant Materials Program, providing a unique suite of services in a biologically and culturally unique eco-region. In this presentation we will outline our unique program & discuss how and why we are working internationally to build eco-regional capacity for seed collection, storage, and container plant production. This will encompass an overview of current projects, opportunities for partnerships, and resources for Mexican and American practitioners working with plant materials in the Madrean Archipelago.

Construyendo un programa de materiales de plantas nativas en las tierras fronterizas: éxitos y próximos pasos

Borderlands Restoration Network (BRN) es una organización sin fines de lucro centrada en la restauración ecológica basada en la comunidad en la ecorregión del Archipiélago Madrense del sur de Arizona. BRN destaca y promueve el trabajo de una red de organizaciones con décadas de ejercicio en la restauración de cuencas y hábitats, programación de jóvenes rurales y servicios de semillas y plantas nativas que abarcan ecotipos sonorenses y chihuahuenses. La misión de BRN es fomentar el aprendizaje basado en el lugar ecológico y cultural y el liderazgo que cultiva una economía de restauración en las tierras fronterizas de Estados Unidos y México. En los últimos cinco años, The Borderlands Restoration Native Plant Nursery and Seed Lab en Patagonia, Arizona, ha desarrollado un sistema para proporcionar genotipos de plantas y semillas regionales a las agencias federales y al público en general. Estas entidades comprenden el Programa de Materiales de Plantas Nativas de BRN, que proporciona un conjunto único de servicios en una ecorregión biológica y culturalmente única. En esta presentación describiremos nuestro programa único y discutiremos cómo y por qué estamos trabajando internacionalmente para desarrollar la capacidad ecorregional para la recolección de semillas, el almacenamiento y la producción de plantas de contenedores. Esto abarcará una visión general de los proyectos actuales, oportunidades de asociación y recursos para los profesionales mexicanos y estadounidenses que trabajan con materiales vegetales en el Archipiélago Madrense.

NOTE: A manuscript was not submitted to accompany this presentation.

Putting the right seed in the right place: Challenges, tools, and opportunities in the Sky Islands

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Within the last decade studies have shown increased seeding success when species are selected from within seed transfer zones, based on similarity of environmental conditions and ideally confirmed with genetics. Improved seeding success of native vegetation in disturbed or reclaimed areas reduces overall project costs while improving wildlife habitat. Restoration costs as well as advances in GIS technology and plant genetics are contributing to the development of more localized commercial production of seeds for revegetation across the United States. Yet there is no commercial scale native seed production in the Sky Islands. Historic large-scale seeding efforts in southern Arizona have contributed to a view that seeding is not practical within this region, however it is generally a requirement of any commercial project which disturbs federal or state lands. While there are numerous challenges to developing commercial native seed production, there are many opportunities to utilize current tools and lessons learned from other regions to connect restoration and conservation efforts with commercial scale native seed production to contribute to the Sky Island restoration economy and reduce costs of future projects.

Colocando la semilla correcta en el lugar correcto: Desafíos, herramientas y oportunidades en las Islas Serranas

En la última década, los estudios han demostrado un aumento en el éxito de la siembra cuando las especies se seleccionan dentro de las zonas de transferencia de semillas, según la similitud de las condiciones ambientales e idealmente confirmadas con genética. El éxito de mejor siembra de la vegetación nativa en áreas alteradas o recuperadas reduce los costos generales del proyecto mientras que mejora el hábitat de la vida silvestre. Los costos de restauración, así como los avances en la tecnología SIG y la genética de las plantas están contribuyendo al desarrollo de una producción comercial más localizada de semillas para la revegetación en los Estados Unidos. Sin embargo, no existe una producción de semilla nativa a escala comercial en las Islas Serranas. Los esfuerzos históricos de siembra a gran escala en el sur de Arizona han contribuido a la opinión de que la siembra no es práctica dentro de esta región, sin embargo, generalmente es un requisito de cualquier proyecto comercial que perturbe las tierras federales o estatales. Si bien existen numerosos desafíos para desarrollar la producción comercial de semillas nativas, existen muchas oportunidades para utilizar herramientas actuales y lecciones aprendidas de otras regiones para conectar esfuerzos de restauración y conservación con producción de semillas nativas a escala comercial para contribuir a la economía de restauración de las Islas Serranas y reducir los costos de proyectos futuros.

NOTE: A manuscript was not submitted to accompany this presentation.

Native grass cropping

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For the past half century ranchers, scientists, and land managers have struggled to find practical and economic ways to restore native grasslands of the southwest, price of seed being one of the main obstacles. Today's southwestern farmers face challenges of declining water supplies, increased irrigation costs, and competition from more productive regions. Native grass cropping on marginal farmlands in Arizona and New Mexico could provide many of the solutions, while benefiting wildlife, watersheds, and overall environmental quality. This presentation will go over methods used on The Nature Conservancy's Cobra Ranch. It shows how many traditional farming and ranching strategies can be used to restore grasslands with native grass hay.

Cultivo de pasto nativo

Durante el último medio siglo, ganaderos, científicos y administradores de tierras han luchado por encontrar formas prácticas y económicas de restaurar pastizales nativos del suroeste de los Estados Unidos, siendo el precio de las semillas uno de los principales obstáculos. Los agricultores del sudoeste enfrentan desafíos de disminución de los suministros de agua, mayores costos de riego y competencia de las regiones más productivas. El cultivo de pasto nativo en tierras agrícolas marginales en Arizona y Nuevo México podría proporcionar muchas de las soluciones, mientras que beneficia a la vida silvestre, las cuencas hidrográficas y la calidad ambiental en general. Esta presentación repasará los métodos utilizados en Cobra Ranch de The Nature Conservancy y mostrará cuántas estrategias tradicionales de agricultura y ganadería se pueden utilizar para restaurar pastizales con heno de pasto nativo.

NOTE: A manuscript was not submitted to accompany this presentation.

Utilizing abandoned agricultural production fields for production of native seed: What we've learned, best management practices, and opportunities for expansion

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Many lands purchased for Conservation/Restoration actions were previously in agricultural production. In many instances these lands were purchased to eliminate intensive pumping of groundwater. In some imstances, water rights have been retired but in most cases this has not been possible. In this region, native grass seed is used extensively in restoration, as much of the damage to the landscape has been through the removal of grasses and other ground cover. In periods of good rainfall, the cost of native grass seed is often the largest single cost of a restoration project. When rainfall does not occur in adequate amounts and duration, losses of tens of thousands of dollars are not uncommon. In order to both mitigate the expense of native grass seed and the uncertainty of weather, while utilizing abandoned agricultural fields, several organizations are turning to native seed and hay production. A primary assumption is the cultivation of native grass seed would require less irrigation than traditional crops. This was a major assumption that we wanted to explore during this project. This talk will look at lessons learned, best management practices, and opportunities for expansion.

Utilizando campos de producción agrícola abandonados para la producción de semilla nativa: Lo que hemos aprendido, las mejores prácticas de gestión y las oportunidades de expansión.

Muchas tierras adquiridas para acciones de Conservación / Restauración se encontraban anteriormente en producción agrícola. En muchos casos, estas tierras se compraron para eliminar el bombeo intensivo de aguas subterráneas. En algunos casos, los derechos de agua han sido retirados, pero en la mayoría de los casos esto no ha sido posible. En esta región, las semillas de pasto nativas se usan ampliamente en la restauración, ya que gran parte del daño al paisaje se ha debido a la eliminación de pastos y otras capas de suelo. En períodos de buenas precipitaciones, el costo de las semillas de pasto nativas a menudo es el mayor costo individual de un proyecto de restauración. Cuando la lluvia no se produce en cantidades y duración adecuadas, las pérdidas de decenas de miles de dólares no son infrecuentes. Como un medio para mitigar el gasto de semillas de pasto nativas y la incertidumbre del clima, mientras se utilizan los campos agrícolas abandonados, varias organizaciones están recurriendo a la producción de semilla nativa y heno. Una suposición principal es que el cultivo de semilla de pasto nativo requeriría menos riego que los cultivos tradicionales. Esta fue una suposición

importante que queríamos explorar durante este proyecto. Esta charla analizará las lecciones aprendidas, las mejores prácticas de gestión y las oportunidades de expansión.

NOTE: A manuscript was not submitted to accompany this presentation.

Experiences of Cuenca Los Ojos on the establishment and production of native grasses on their properties in Sonora Mexico

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The use of native grass seeds is of paramount importance in any ecological restoration practice. These seeds can accelerate the natural regeneration process, guaranteeing better results and preventing invasive species to establish where the work was done. With a strong need for native grass seeds in restoration projects, Cuenca Los Ojos (CLO) began the production of native seeds in 2012, on formerly abandoned agriculture fields. Additionally, because the number of producers in the region who commercialize this type of seed is very limited, there is a great opportunity to generate income for the operation of CLO when marketing the seeds. Currently, we are producing eight species of native grasses that were establish in Ranchos San Bernardino and Las Anitas. This process has been complicated but the production of seeds has been achieved by adapting different techniques of soil restoration, and with the use of different irrigation techniques. The harvest and processing of this seed has been done manually to date, which allowed us to learn from this process. With this experience, we will, in the future, have greater production, mechanize production processes and harvest, improve our system's irrigation for greater efficiency of water use, while reducing costs and diversifying CLO's income.

Experiencias de Cuenca Los Ojos sobre el establecimiento y la producción de hierbas nativas en sus propiedades en Sonora México

El uso de semillas de pasto nativo es de suma importancia en cualquier práctica de restauración ecológica. Estas semillas pueden acelerar el proceso de regeneración natural, garantizando mejores resultados y evitando que las especies invasoras se establezcan dónde se realizó el trabajo. Con una gran necesidad de semillas de pasto nativo en proyectos de restauración, Cuenca Los Ojos (CLO) comenzó la producción de semillas nativas en 2012, en campos agrícolas anteriormente abandonados. Además, debido a que el número de productores en la región que comercializan este tipo de semilla es muy limitado, existe una gran oportunidad de generar ingresos para la operación de CLO al comercializar las semillas. Actualmente, estamos produciendo ocho especies de pastos nativos que se establecieron en Ranchos San Bernardino y Las Anitas. Este proceso ha sido complicado, pero la producción de semillas se ha logrado adaptando diferentes técnicas de restauración del suelo y con el uso de diferentes técnicas de riego. La cosecha y el procesamiento de esta semilla se han realizado manualmente hasta la fecha, lo que nos permitió aprender de este proceso. Con esta experiencia, en el futuro tendremos una mayor producción, mecanizamos los procesos de producción y la cosecha, mejoramos el riego de nuestro sistema para una mayor eficiencia en el uso del agua, a la vez que reducimos los costos y diversificamos los ingresos de CLO.

NOTE: A manuscript was not submitted to accompany this presentation.

What are we doing with old farm fields?

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The Nature Conservancy (TNC) has a well-established habit of purchasing farms whose value for agriculture has waned. This stands to reason – agricultural lands generally have associated water rights, making them prime candidates for irrigation retirement or sever-and-transfer of surface water rights to instream flow. But what does one do with all that dirt once most or all of the pumps are turned off? The answer tends to be some sort of restoration, either active or passive, or some combination thereof. This presentation will be a tour of six sites where The Nature Conservancy staff and partners have tried various sorts of restoration projects on old farm fields, with a discussion restoration goals, successes, failures, challenges, and long-term maintenance issues.

¿Qué estamos haciendo con los viejos campos de cultivo?

The Nature Conservancy (TNC) tiene un hábito bien establecido de comprar granjas cuyo valor para la agricultura ha disminuido. Esto es lógico: las tierras agrícolas generalmente tienen derechos de agua asociados, lo que los convierte en los principales candidatos para la jubilación por irrigación o la transferencia de los derechos de aguas superficiales al flujo de agua corriente. ¿Pero, qué hace uno con toda esa tierra una vez que la mayoría o todas las bombas están apagadas? La respuesta tiende a ser algún tipo de restauración, ya sea activa o pasiva, o alguna combinación de las mismas. Esta presentación será un recorrido por seis sitios donde el personal y los socios de The Nature Conservancy han probado diversos tipos de proyectos de restauración en campos agrícolas antiguos, con objetivos de restauración, éxitos, fracasos, desafíos y problemas de mantenimiento a largo plazo.

NOTE: A manuscript was not submitted to accompany this presentation.

Session 8: Climate and Pollinators

Coronado National Forest, Peloncillo Mountains Prescribed Fire
(Photo courtesy of the USDA Forest Service, Rocky Mountain Research Station)

Abstracts and Papers
Campbell
Claverie
Winterbottom

Creating restoration planting palettes to support pollinators in a changing climate

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The diverse ecosystems of the Sky Islands of southeastern Arizona support an incredible species-richness, including over 4,000 species of native plants and impressive numbers of associated pollinating animals such as bees, flies, butterflies, moths, ants, birds, and bats. Changes in winter precipitation and accelerated spring warming have affected when, and at what elevation, many plant species are blooming, which will likely have implications for pollinator populations. Restoration of plant diversity and floral resources for pollinators and wildlife is critical to support adaptation in areas dominated by invasive species or unable to support mid-story pollinator plants due to lack of infiltration of water. We are conducting restoration projects along riparian corridors in southeastern Arizona and have made several adjustments to the standard restoration process to account for current and future climate conditions. An important first step in this process has been developing a process for building site-specific planting palettes that are climate smart and geared toward providing resources for pollinators now and into the future.

Creando paletas de plantación de restauración para apoyar a los polinizadores en un clima cambiante

Los diversos ecosistemas de las Islas Serranas del sudeste de Arizona respaldan una increíble riqueza de especies, que incluye más de 4,000 especies de plantas nativas e impresionantes cantidades de animales asociados a la polinización como abejas, moscas, mariposas, polillas, hormigas, pájaros y murciélagos. Los cambios en la precipitación invernal y el calentamiento acelerado de la primavera han afectado cuándo y a qué altura están floreciendo muchas especies de plantas, lo que probablemente tendrá implicaciones para las poblaciones de polinizadores. La restauración de la diversidad vegetal y los recursos florales para los polinizadores y la vida silvestre es fundamental para apoyar la adaptación en áreas dominadas por especies invasoras o que no pueden sostener plantas de polinizadores de mediana altura debido a la falta de infiltración de agua. Estamos llevando a cabo proyectos de restauración a lo largo de corredores ribereños en el sudeste de Arizona, y hemos realizado varios ajustes al proceso de restauración estándar para tener en cuenta las condiciones climáticas actuales y futuras. Un importante primer paso en este proceso ha sido el desarrollo de un proceso para construir paletas de plantación específicas para el clima que sean climáticamente inteligentes y estén orientadas a proporcionar recursos para los polinizadores ahora y en el futuro.

NOTE: A manuscript was not submitted to accompany this presentation.

Feeding pollinators with native plantings: Species palettes, nectar gaps, and plant materials sourcing

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Borderlands Restoration's Native Plant Materials Program's (BRNPM) mission is to promote biodiversity by providing access to restoration quality plant materials and guidance for effective use. BRNPM is based in Patagonia, AZ and began six years ago with locally sourced plant propagation for a hummingbird habitat restoration project to supplement nectar sources for hummingbirds abandoning their nests in early summer. Since its conception BRNPM has worked with

hundreds of pollinator species for support of moths, butterflies, bees, birds, and bats, and has delved into seed and plant material collection, container nursery production, seed production, and consultation for species lists and production of regional plants of the Madrean Archipelago and beyond. BRNPM encourages locally sourced and adapted plant materials for restoration. It attempts to demystify plant materials access and use in restoration. BRNPM is proud to partner with so many organizations in the area and engage volunteers and youth in our pollinator efforts. The plant diversity of the Madrean Archipelago region is unparalleled and there are so many fun botanical options to support the myriad and wide diversity of pollinators of our area. Regardless of the habitat, there is an exciting pollinator supporting plant palette for all areas!

Alimentación de polinizadores con plantaciones nativas: paletas de especies, brechas de néctar y abastecimiento de materiales vegetales

La misión del Programa de Materiales de Plantas Nativas de la Restauración de Borderlands (BRNPM) es promover la biodiversidad brindando acceso a materiales de plantas de calidad para la restauración y orientación para un uso efectivo. BRNPM tiene su sede en Patagonia, AZ, y comenzó hace seis años con la propagación de plantas de origen local para un proyecto de restauración del hábitat de colibríes para complementar las fuentes de néctar para los colibríes que abandonan sus nidos a principios del verano. Desde su concepción, BRNPM ha trabajado con cientos de especies de polinizadores para apoyar polillas, mariposas, abejas, pájaros y murciélagos, y ha profundizado en la recolección de semillas y plantas, producción de viveros en contenedores, producción de semillas y consultas para listas de especies y producción de plantas regionales del archipiélago de Madrense y más allá. BRNPM fomenta la restauración de materiales vegetales locales y adaptados, y trata de desmitificar el acceso y el uso de materiales vegetales en la restauración. BRNPM se enorgullece de asociarse con tantas organizaciones en el área e involucrar a voluntarios y jóvenes en nuestros esfuerzos de polinizadores. La diversidad de plantas de la región del Archipiélago Madrense no tiene paralelo y hay tantas opciones botánicas divertidas para apoyar la gran diversidad de polinizadores de nuestra área. ¡Independientemente del hábitat, hay un emocionante polinizador que apoya la paleta de plantas para todas las áreas!

NOTE: A manuscript was not submitted to accompany this presentation.

Informing Sonoran Desert restoration through mutualism ecology

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Ecological restoration is beginning to play an increasingly important role as ecosystems degrade worldwide. A better understanding of these systems and their ecological interactions is necessary for us to facilitate effective management and restoration. Many of these restoration efforts look primarily at the aboveground interactions that occur, and do not consider the soil microorganisms present. In planning a restoration project, it is critical that researchers consider the full suite of interactions that could potentially influence the success of a given system. This study is set in the Sonoran Desert outside of Tucson, AZ. The five focal species chosen are important resources for pollinating insects. The relationship between these species and the symbiotic arbuscular mycorrhizal fungi (AMF) with which they interact has not been well studied. This project provides a better understanding of the benefit that AM fungi provide these Sonoran Desert perennials. A greater knowledge of these mutualistic relationships will help in the conservation of these species and their pollinators moving forward.

Informar sobre la restauración del desierto de Sonora a través de la ecología del mutualismo

La restauración ecológica está comenzando a desempeñar un papel cada vez más importante a medida que los ecosistemas se degradan en todo el mundo. Es necesario que comprendamos mejor estos sistemas y sus interacciones ecológicas para facilitar una gestión y restauración efectivas. Muchos de estos esfuerzos de restauración se enfocan principalmente en las interacciones aéreas que ocurren, y no consideran los microorganismos presentes en el suelo. Al planificar un proyecto de restauración, es fundamental que los investigadores consideren el conjunto completo de interacciones que podrían influir en el éxito de un sistema dado. Este estudio se desarrolla en el desierto de Sonora en las afueras de Tucson, AZ. Las cinco especies focales elegidas son recursos importantes para la polinización de insectos. La relación entre estas especies y los hongos micorrízicos arbusculares simbióticos (HMA) con los que interactúan no ha sido bien estudiada. Este proyecto proporciona una mejor comprensión del beneficio que los hongos AM brindan a estas plantas perennes del desierto de Sonora. Un mayor conocimiento de estas relaciones mutualistas ayudará en la conservación de estas especies y sus polinizadores en el futuro.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 10: Water and Aquatic Ecosystems

San Pedro River, Arizona
(Photo by Daniel G. Neary USDA Forest Service, Rocky Mountain Research Station)

Abstracts and Papers
Beauregard
Clark
Cornejo
Duncan
Minckley
Sharma
Sharma

Western yellow-billed cuckoos in the Sky Islands of southeast Arizona: What we know and what we still have to learn

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The western distinct population segment of the Yellow-billed Cuckoo (*Coccyzus americanus*) was federally listed as threatened in 2014, with declines across western states attributed to loss and fragmentation of riparian habitat. Although most western Yellow-billed Cuckoos occur in riparian areas, they have recently been reported during the breeding season in drainages dominated by Madrean-evergreen woodlands in the Sky Islands of southeastern Arizona. If cuckoos are commonly breeding in this atypical habitat, this region may represent a previously unknown population which may have implications for species recovery. This research aims to confirm the breeding status and distribution of cuckoos in the Sky Islands and determine the habitat characteristics associated with breeding and occupancy. Existing survey data indicate that western Yellow-billed Cuckoos may be common in the Sky Islands. More than half (n=56) of drainages surveyed between 2013 and 2017 were occupied, and more than one quarter (n=29) have probable or confirmed breeding, as defined by the US Fish & Wildlife Service amp; Wildlife protocol. Furthermore, we are evaluating the use of autonomous recording units (ARUs) to monitor cuckoos, as pilot studies in Arizona have suggested their potential to study this cryptic species. Field work is planned for 2018 and 2019 to follow up on these results with additional surveys, nest searching, and deployment of ARUs. Summary and implications of survey data are discussed along with methodologies for future research.

Cuclillo de pico amarillo en las Islas Serranas del sudeste de Arizona; Lo que sabemos y lo que aún tenemos que aprender

El segmento occidental de población distinta del cuclillo de pico amarillo (Coccyzus americanus) fue incluido en la lista federal como amenazado en 2014, con disminuciones en todos los estados del oeste atribuidas a la pérdida y fragmentación del hábitat ribereño. Aunque la mayoría de los cuclillos de pico amarillo occidentales se encuentran en áreas ribereñas, recientemente durante la temporada de cría han sido reportados en drenajes dominados por bosques maduros de hoja perenne en las Islas Serranas del sudeste de Arizona. Si los cuclillos son comúnmente reproducidos en este hábitat atípico, esta región puede representar una población previamente desconocida que puede tener implicaciones para la recuperación de la especie. Esta investigación tiene como objetivo confirmar el estado de cría y la distribución de cuclillos en las Islas Serranas y determinar las características del hábitat asociadas con la cría y la ocupación. Los datos de la encuesta existente indican que los cuclillos de pico amarillo occidentales pueden ser comunes en las Islas Serranas. Más de la mitad (n = 56) de los drenajes encuestados entre 2013 y 2017 fueron ocupados, y más de una cuarta parte (n = 29) tienen crianza probable o confirmada, según lo definido por US Fish & Wildlife Service amp; Protocolo de vida silvestre. Además, estamos evaluando el uso de unidades autónomas de registro (ARU) para monitorear cuclillos, ya que los estudios piloto en Arizona han sugerido su potencial para estudiar esta críptica especie. El trabajo de campo está planificado para 2018 y 2019 para dar seguimiento a estos resultados con encuestas adicionales, búsqueda de nidos y despliegue de ARU. Resumen y las implicaciones de los datos de la encuesta se discuten junto con las metodologías para la investigación futura.

NOTE: A manuscript was not submitted to accompany this presentation.

35 years of experience restoring water in the Sky Islands

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CLO has developed a model on the ground to show how to restore water to washes and streams in areas that have become dry and eroded over time. We collaborate with agencies, university students, landowners, researchers, and others by bringing them to see examples of how our restoration techniques are working and to give them pointers as to how best to do the work on their own. Thirty years of work in the Sky Islands improving water and vegetation conditions has brought an increase in biodiversity and wildlife.

35 años de experiencia restaurando agua en las Islas Serranas

CLO ha desarrollado un modelo sobre el terreno para mostrar cómo restaurar el agua a los arroyos en áreas que se han secado y erosionado con el tiempo. Colaboramos con agencias, estudiantes universitarios, propietarios de tierras, investigadores y otros, mostrándoles ejemplos de cómo están funcionando nuestras técnicas de restauración y dándoles consejos sobre cómo hacer el trabajo por sí mismos. Treinta años de trabajo en las Islas Serranas mejorando las condiciones del agua y la vegetación han traído un aumento en la biodiversidad y la vida silvestre.

NOTE: A manuscript was not submitted to accompany this presentation.

Flying over the San Miguel River: Exploring the riparian vegetation through drones and satellites

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The San Miguel River is located in the central part of the state of Sonora and along its route it crosses sierras, plains and valleys. The riparian vegetation of the basin has a reduced extension, however, it is of great ecological and economic importance for the region, because it provides diverse ecosystem services that maintain most of the activities (economic and social) present in the basin. A practical way to obtain information about the ecological status of riparian vegetation is by using remote sensors, such as unmanned aerial platforms and satellites. Currently, for the northwest of Mexico, there is little information about the ecological dynamics of the riparian vegetation and, even less, about the use of remote sensing platforms for their study. Therefore, the present work explores various techniques of remote sensing and field work to: 1) describe the composition, structure and distribution of riparian vegetation, and 2) analyze the variability between the productivity of riparian vegetation and desert vegetation adjacent. Additionally, an index was developed to assess the disturbance and categorize the study sites, in the context of the different human activities developed in the area. The sites showed differences in composition as well as a significant variation between the productivity of two riparian classes (riparian and riparian mesquital vegetation), suggesting that the exchanges between obligate and facultative riparian vegetation can lead to a potential loss of productivity. Finally, the results suggest that sites with greater disturbance have less photosynthetic activity.

Volando sobre el río San Miguel: explorando la vegetación ribereña a través de drones y satélites

El río San Miguel se encuentra en la parte central del estado de Sonora y lo largo de su recorrido atraviesa por sierras, llanuras y valles. La vegetación ribereña de la cuenca tiene una extensión reducida, sin embargo, es de gran importancia ecológica y económica para la región, pues provee diversos servicios ecosistémicos que mantienen la mayoría de las actividades (económicas y sociales) presentes en la cuenca. Una manera práctica de obtener información acerca del estado ecológico de la vegetación ribereña es utilizando sensores remotos, tales como plataformas aéreas no tripuladas y satélites. Actualmente, para el noroeste de México, se tiene poca información acerca de la dinámica ecológica de la vegetación ribereña y, aun menos, acerca del uso de plataformas de sensores remotos para su estudio. Por lo anterior, el presente trabajo explora diversas técnicas de percepción remota y trabajo de campo para: 1) describir la composición, estructura y distribución de la vegetación ribereña, y 2) analizar la variabilidad entre la productividad de la vegetación ribereña y la vegetación desértica adyacente. Adicionalmente se desarrolló un índice para evaluar la perturbación y categorizar los sitios de estudio, en el contexto de las diferentes actividades humanas desarrolladas en la zona. Los sitios presentaron diferencias en composición así como una variación importante entre la productividad de dos clases ribereñas (vegetación ribereña y mezquital ribereño), sugiriendo que los intercambios entre vegetación ribereña obligada y facultativa pueden conllevar una potencial pérdida de productividad. Finalmente, los resultados sugieren que los sitios con mayor perturbación tienen menor actividad fotosintética.

NOTE: A manuscript was not submitted to accompany this presentation.

The status and conservation of the Gila Topminnow

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The Gila Topminnow, *Poeciliopsis occidentalis*, was listed as endangered in 1967 due to the well-known and extensively documented threats of habitat desiccation and the release of exotic and nonnative fishes. Status of the species has improved with recovery actions, but the threats that led to the endangered status of the Gila Topminnow continue. Drought, climate change, and increasing human populations still threaten streams and springs and nonnative and exotic species are still introduced and distributed across the landscape. Work on a revision of the 1983 recovery plan continues. The current conservation program is guided by the current draft revised recovery plan, which is the best-available information on the subject. We hope that the current robust conservation actions for the Gila Topminnow could lead to down-listing in the foreseeable future. One strategy we have contemplated with a down-listing to threatened status is an Endangered Species Act 4d rule that would allow the use of Gila Topminnow for vector control, instead of Western Mosquitofish, *Gambusia affinis*. Gila Topminnow have been released over 200 times into mostly wild habitats, and more than 100 times into captive sites; largely over the last 35 years. The releases have been facilitated by MOUs, Endangered Species Act Section 6 funding, Arizona Heritage Funds, the Topminnow and Pupfish Safe Harbor Agreement, and the Gila River Basin Native Fish Conservation Program. We will discuss the history of Topminnow conservation and what the future may hold for the species and the aquatic systems it depends on.

El estado y la conservación de Gila Topminnow

El Gila Topminnow, Poeciliopsis occidentalis, se incluyó en la lista de especies en peligro de extinción en 1967 debido a las amenazas conocidas y extensamente documentadas de la desecación del hábitat y la liberación de peces exóticos y no nativos. El estado de la especie ha mejorado con acciones de recuperación, pero las amenazas que llevaron al Gila Topminnow a un estado de peligro continúan. La sequía, el cambio climático y el aumento de las poblaciones humanas siguen amenazando las corrientes y los manantiales, y las especies no nativas y exóticas aún se introducen y distribuyen en todo el paisaje. Continúa el trabajo sobre una revisión del plan de recuperación de 1983. El actual programa de

conservación se guía por el borrador del plan de recuperación actualmente revisado, que es la mejor información disponible sobre el tema. Esperamos que las robustas acciones actuales de conservación para el Gila Topminnow resulten en una categoría de amenaza más baja en el futuro cercano. Se ha contemplado que al bajar la categoría en la lista hasta el nivel de Amenazado bajo la regla 4d de la Ley de Especies en Peligro, se permitiría el uso de Gila Topminnow para el control de vectores, en lugar de Western Mosquitofish, Gambusia affinis. En más de 200 ocasiones se han liberado Gila Topminnow en hábitats mayormente silvestres, y más de 100 veces en sitios cautivos; en gran medida en los últimos 35 años. Las liberaciones se han visto facilitadas por memorandos de entendimiento, fondos de la Sección 6 de la Ley de especies en peligro, los fondos del patrimonio de Arizona, el acuerdo de puerto seguro de Topminnow y Pupfish y el programa de conservación de peces nativos de la cuenca del río Gila. Discutiremos la historia de la conservación de Topminnow y lo que puede deparar el futuro para las especies y los sistemas acuáticos de los que depende.

NOTE: A manuscript was not submitted to accompany this presentation.

A review of conservation actions, past and present, for the native fish of the upper Yaqui River drainage, with emphasis on the Yaqui catfish, *Ictalurus pricei*, an imperied endangered species.

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The Yaqui River once supported eight species of native fish. Today, five species remain in the United States, listed as endangered or threatened. In Mexico, six species remain, listed as endangered, threatened, or rare. Of the remaining two, one is common, the other is the endangered Yaqui catfish, which is nearing extinction. This talk presents conservation measures, past, present, and future, implemented or planned to protect Yaqui fishes. It reports on the status of this unique suite of native fish in 2018 and current plans, in respect to the Yaqui catfish in Mexico.

Una revisión de las acciones de conservación, pasadas y presentes, para los peces nativos del drenaje superior del río Yaqui, con énfasis en el bagre yaqui, Ictalurus pricei, una especie en peligro de extinción.

El río Yaqui, una vez soportó ocho especies de peces nativos. Hoy, cinco especies permanecen en los Estados Unidos, enlistadas como en peligro o amenazadas. En México, seis especies permanecen, enlistadas como en peligro de extinción, amenazadas o raras. De los otros dos, uno es común, el otro es el bagre yaqui en peligro de extinción, que está a punto de extinguirse. Esta charla presenta medidas de conservación, pasadas, presentes y futuras, implementadas o planeadas para proteger a los peces yaquis. Informa sobre el estado de esta suite única de peces nativos en 2018 y los planes actuales, con respecto al bagre yaqui en México.

NOTE: A manuscript was not submitted to accompany this presentation.

Aquatic and riparian connectivity of Chiricahua leopard frogs (map)

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The Chiricahua leopard frog is a threatened species of true frogs that were abundantly found in the desert highlands of Arizona, New Mexico, and Northern Mexico. Today, the population and distribution of these frogs has significantly depleted due to habitat loss, predation from introduced species, and disease (Chytridiomycosis) among other pressures. We use a connectivity framework that we developed for aquatic and riparian connectivity in arid landscapes to create indices that support assessment and visualization of connectivity in these focal ecosystems. Using regression analysis, GIS, and expert input, Connectivity Value and Connectivity Risk indices are calculated for connectivity of Chiricahua leopard frogs in the Cienega Creek basin and surrounding regions in Arizona. These indices are mapped to show how connectivity can change for the focal species with changes in landscape characteristics. The connectivity framework and the related indices provide customizable options for stakeholders to assess aquatic and riparian connectivity multidimensionally using readily available data. These tools can be used by stakeholders for exploratory analysis of aquatic and riparian connectivity, especially in arid landscapes.

Conectividad acuática y ribereña de las ranas leopardo Chiricahua (mapa)

La rana leopardo Chiricahua es una especie amenazada de ranas verdaderas que se encontraban abundantemente en las tierras altas del desierto de Arizona, Nuevo México y el norte de México. Hoy en día, la población y distribución de estas ranas se ha agotado significativamente debido a la pérdida de hábitat, la depredación por especies introducidas y la enfermedad (quitridiomicosis), entre otras presiones. Usamos un marco de conectividad que desarrollamos para la conectividad acuática y ribereña en paisajes áridos para crear índices que respalden la evaluación y la visualización de la conectividad en estos ecosistemas focales. Mediante el uso de análisis de regresión, SIG e información de expertos, se calculan los índices de Conectividad y Riesgo de Conectividad para la conectividad de las ranas leopardo Chiricahua en la cuenca del Ciénega Creek y las regiones circundantes en Arizona. Estos índices están mapeados para mostrar cómo la conectividad puede cambiar para las especies focales con cambios en las características del paisaje. El marco de conectividad y los índices relacionados ofrecen opciones personalizables para que las partes interesadas evalúen la conectividad acuática y ribereña de forma multidimensional utilizando datos fácilmente disponibles. Estas herramientas pueden ser utilizadas por los interesados para el análisis exploratorio de la conectividad acuática y ribereña, especialmente en paisajes áridos.

NOTE: A manuscript was not submitted to accompany this presentation.

Aquatic and Riparian Connectivity in Arid Landscapes

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Aquatic and riparian ecosystems are valuable and critical in arid environments, supporting a diverse suite of resident and migratory species over different life stages. Ecological connectivity is an important property in the functioning of these ecosystems, and a significant subject of interest for researchers, managers, practitioners and other stakeholders. Furthermore, a variety of perceptions exists on aquatic and riparian connectivity among stakeholders, and connectivity of aquatic and riparian ecosystems in arid landscapes is a relatively unexplored subject. We focused on these questions

in the US portion of the Madrean archipelago, using a combination of quantitative spatial analysis and qualitative methods, to capture the diversity of perspectives on aquatic and riparian connectivity among experts. We synthesized these perspectives into a connectivity framework that deconstructs aquatic and riparian connectivity in arid landscapes into connectivity components and their dimensions. We applied this framework to a case study of the threatened Chiricahua leopard frog (*Rana chiricahuensis*) in the Cienega Creek basin in Arizona. Using regression analysis and GIS, we created Connectivity Value and Connectivity Risk indices for the focal species based on variables identified in the regression analysis. This connectivity framework and the related indices provide customizable options for stakeholders to assess aquatic and riparian connectivity multidimensionally using readily available data. These tools can be used by stakeholders for exploratory analysis, assessment and visualization of aquatic and riparian connectivity, especially in arid landscapes.

Conectividad acuática y ribereña en paisajes áridos

Los ecosistemas acuáticos y ribereños son valiosos y críticos en los ambientes áridos, y dan soporte a un conjunto diverso de especies residentes y migratorias en diferentes etapas de la vida. La conectividad ecológica es una propiedad importante en el funcionamiento de estos ecosistemas, y un tema importante de interés para investigadores, gerentes, profesionales y otras partes interesadas. Además, existe una variedad de percepciones sobre la conectividad acuática y ribereña entre las partes interesadas, y la conectividad de los ecosistemas acuáticos y ribereños en paisajes áridos es un tema relativamente inexplorado. Nos enfocamos en estas preguntas en la porción estadounidense del archipiélago de Madrense, usando una combinación de análisis espacial cuantitativo y métodos cualitativos, para capturar la diversidad de perspectivas sobre conectividad acuática y ribereña entre los expertos. Sintetizamos estas perspectivas en un marco de conectividad que deconstruye la conectividad acuática y ribereña en paisajes áridos en componentes de conectividad y sus dimensiones. Aplicamos este marco a un estudio de caso de la amenazada rana leopardo Chiricahua (Rana chiricahuensis) en la cuenca de Cienega Creek en Arizona. Utilizando el análisis de regresión y el SIG, creamos los índices de Conectividad de Valor y Riesgo de Conectividad para las especies focales en base a las variables identificadas en el análisis de regresión. Este marco de conectividad y los índices relacionados brindan opciones personalizables para que los interesados evalúen la conectividad acuática y ribereña de forma multidimensional utilizando datos fácilmente disponibles. Estas herramientas pueden ser utilizadas por los interesados para el análisis exploratorio, la evaluación y la visualización de la conectividad acuática y ribereña, especialmente en paisajes áridos.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Sessions 11 & 12: Water for Natural Areas

H-Flume gaging water flow on one of the Cascabel Watersheds, Coronado National Forest, Peloncillo Mountains. (Photo by Gerald Gottfried, USDA Forest Service, Rocky Mountain Research Station)

Abstracts and Papers
Biggs
Fonseca
Hullinger
McCoy
Misztal
Tapia
Tapia

The Santa Cruz River Heritage Project – An Innovative Approach to Reviving Tucson's Downtown River Corridor

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The City of Tucson has operated a regional reclaimed water sustem since 1984. Traditional end uses have included turf irrigation, light industrial, single-family residential landscaping, and groundwater recharge. Fundamental assumptions that governed Tucson's approach to reclaimed water included: 1) a desire t opreserve groundwater and surface water supplies for potable use; 2) growing total water demand with growing population; 3) increasing effluent generation in the community; 4) a projected "gap" in water supply as early as 2030 under conservative planning assumptions. In early 2016, the utility recognized that of the four key planning assumptions listed above, only the first was still current and valid. The utility embarked on its "rethinking reuse" program to re-chart the future of recycled water in the community. The Santa Cruz River Heritage Project is the outcome of "rethinking reuse" and is a completely new approach to the deployment of the community's reclaimed water that will support our city's most iconic natural area. This project proposes to use excess capacity in the current reclaimed water system to bring recycled water to downtown Tucson for in-channel aquifer recharge and riparian habitat development in the Santa Cruz River, restoration of important historical and cultural sites, and to spark economic development on the west end of downtown. Collectively, these three outcomes satisfy a wide range of stakeholder interests and key components of the City's General Plan – including a strong focus on the natural environment – while pushing the boundaries of how reclaimed water is used in Arizona.

El Proyecto del patrimonio del río Santa Cruz: un enfoque innovador para revivir el corredor del río del centro de Tucson

La Ciudad de Tucson ha operado un sistema regional de agua regenerada desde 1984. Los usos finales tradicionales han incluido el riego de césped, la industria ligera, la jardinería residencial unifamiliar y la recarga de aguas subterráneas. Los supuestos fundamentales que rigen el enfoque de Tucson para el agua regenerada incluyen: 1) el deseo de preservar el agua subterránea y los suministros de agua superficial para el uso potable; 2) crecimiento de la demanda total de agua con una población en crecimiento; 3) aumentar la generación de efluentes en la comunidad; y 4) una "brecha" proyectada en el suministro de agua desde 2030 bajo suposiciones de planificación conservadora. A principios del 2016, la empresa reconoció que de los cuatro supuestos clave de planificación enumerados anteriormente, solo el primero seguía siendo actual y valido. La empresa se embarcó en su programa de "reconsiderando la reutilización" para volver a registrar el futuro del agua reciclada en la comunidad. El Proyecto del Patrimonio del Río Santa Cruz es el resultado de "reconsiderando la reutilización" y es un enfoque completamente nuevo para el despliegue del agua regenerada de la comunidad que apoyará el área natural más emblemática de nuestra ciudad. Este proyecto propone usar excesos de capacidad en el actual sistema de agua regenerada para llevar agua reciclada al centro de Tucson para la recarga de acuíferos en el canal y el desarrollo del hábitat ribereño en el río Santa Cruz, la restauración de sitios históricos y culturales importantes y para impulsar el desarrollo económico en el extremo oeste del centro de la ciudad. Colectivamente, estos tres resultados satisfacen una amplia gama de intereses de las partes interesadas y componentes clave del Plan General de la Ciudad, incluido un fuerte enfoque en el medio ambiente natural, al tiempo que amplían los límintes de cómo se usa el agua regenerada en Arizona.

NOTE: A manuscript was not submitted to accompany this presentation.

The muddy state of Arizona's water protections

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Important decisions affecting Arizona streams and species will be made at the state and national level this year, independent of the drama over the 2015 Clean Water Act rule. Arizona is evaluating water quality standards for over 900 Arizona water bodies used for fishing, wading, agriculture, water supply and other uses. As part of this effort, the state is entertaining a proposal by Canadian mining company Hudbay, to review the designations and rules protecting certain Arizona streams that have exceptional recreational or ecological values. The state legislature is contemplating assuming authority to administer Section 404 of the Clean Water Act, even as the Corps of Engineers is narrowing the scope of its jurisdiction through permit reviews. At the national level, changes are being discussed to make it easier for states to administer Section 404. Some states administer the Clean Water Act with programs that are more stringent than federal standards, but Arizona statutes forbid higher standards. Furthermore, when streams and lakes lose protections under the Clean Water Act, there is no “safety net”. Arizona currently has no program to protect water bodies from pollution outside of the framework provided by the Clean Water Act, and none is proposed as of February 2018. This presentation will update you on this fast-evolving discussion and describe how the changes may affect Pima County.

El estado fangoso de las protecciones de agua de Arizona

Las decisiones importantes que afectan a las corrientes y especies de Arizona se tomarán a nivel estatal y nacional este año, independientemente del drama sobre la regla de la Ley de Agua Limpia de 2015. Arizona está evaluando los estándares de calidad del agua para más de 900 cuerpos de agua de Arizona utilizados para la pesca, el vadeo, la agricultura, el suministro de agua y otros usos. Como parte de este esfuerzo, el estado está entreteniendo una propuesta de la compañía minera canadiense Hudbay, para revisar las designaciones y las reglas que protegen ciertas corrientes de Arizona que tienen valores recreativos o ecológicos excepcionales. La legislatura estatal está considerando asumir la autoridad para administrar la Sección 404 de la Ley de Agua Limpia, incluso cuando el Cuerpo de Ingenieros está reduciendo el alcance de su jurisdicción a través de revisiones de permisos. A nivel nacional, se están discutiendo cambios para facilitar que los estados administren la Sección 404. Algunos estados administran la Ley de Agua Limpia con programas que son más estrictos que los estándares federales, pero los estatutos de Arizona prohíben estándares más altos. Además, cuando las corrientes y lagos pierden protecciones bajo la Ley de Agua Limpia, no existe una "red de seguridad". Actualmente, Arizona no tiene un programa para proteger los cuerpos de agua de la contaminación fuera del marco provisto por la Ley de Agua Limpia, y no se propone ninguno a partir de febrero de 2018. Esta presentación lo pondrá al día sobre este debate en rápida evolución y describirá cómo los cambios pueden afectar a Pima. Condado.

Note: Full Paper Follows

Arizona's Clean Water Act Protections Are In "Jurisdictional Limbo"

Julia Fonseca

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***Abstract**--The jurisdiction of the Clean Water Act over aquatic and riparian habitats in the Western US is continuing to shrink in response to past Supreme Court decisions, leaving a gap in water quality governance for an increasing number of streams in the Western US. Arizona is preparing to remove certain streams, springs, wetlands, and lakes from the state's water quality standards based on these decisions. Arizona also seeks primacy for future determinations of Clean Water Act jurisdiction under Section 404 for non-navigable waters. Transfer of those Clean Water Act responsibilities to the state will remove the need for Endangered Species Act Sectiion 7 consultations and mitigation of a project's effect to federally protected species, unless the project has some other federal nexus.*

BACKGROUND

Congress enacted the Clean Water Act (the "Act") in 1972 to "restore and maintain the chemical, physical, and biological integrity" (33 U.S.C. § 1251(a)) of the nation's water by setting minimum standards for discharge of pollutants. Over the years, local communities began treating their sewage and states began regulating pollution, often with support of Congressional funding (Andreen 2013). Pima County, Arizona, for instance, received over $50 million in federal assistance for the construction of sewage treatment facilities by 1982 (unpublished Pima County data).

The U. S. Environmental Protection Agency (EPA) reviews and approves changes to state-administered programs. The Agency serves as the regulator for the National Pollutant Discharge Elimination System (NPDES) in the few states that have not yet taken on this responsibility. Arizona was one of the last states to take responsibility for NPDES permits. Arizona assumed NPDES permitting responsibility under Section 402 of the Clean Water Act in 2002. This eliminated Endangered Species Act (Section 7) reviews that were required when NPDES permits were federally administered, with particular consequences to taxa like the cactus ferruginous pygmy-owl (*Nat'l Ass'n of Home Builders v. Defenders of Wildlife,* 551 U.S. 644 (2007)).

The U. S. Army Corps of Engineers (Corps) continues to administer dredge and fill permits under Section 404 of the Clean Water Act throughout the Western U.S. Section 404 permits regulate physical modification to streams and wetlands, as opposed to point and non-point source discharges. Because these permits are federal actions, they are subject to endangered species reviews. Species consultations under Section 7 of the Endangered Species Act have been a focus of much litigation in the West.

ARIZONA MOVES TO ASSUME 404 POWERS

Arizona is actively pursuing powers that would allow the state to determine which streams and wetlands will be regulated under Section 404 of the Act unless the stream is a traditionally navigable water in which case the Corps would continue to have jurisdiction over it and adjacent wetlands. Draft legislation (Senate Bill 1493) was introduced in Arizona in February 2018 to assume these powers. New Jersey and Michigan are the only states in the union which currently administer Section 404 for non-navigable waters and their adjacent wetlands, although many others have evaluated state assumption (NACEPT 2017).

State assumption of Clean Water Act Section 404 powers would eliminate the protection of individual Section 7 consultations about effects to species unless a project has some other federal nexus, such as funding or use of federal lands. Even absent a federal nexus, applicants would still be subject to the Endangered Species Act's taking prohibition and anyone who cannot avoid the take of species would be required to apply for authorization under Section 10 of the Act. Section 10 incidental take permits can take years to obtain. Pima County holds Section 10 permits for incidental take of many listed and unlisted species, but it took over a decade to formulate and obtain the permit.

ARIZONA BEGINS TO ALIGN WATER QUALITY STANDARDS

Arizona Department of Environmental Quality (ADEQ) is evaluating water quality standards for over 900 Arizona water bodies used for fishing, wading, agriculture, water supply, and other uses. The objective of ADEQ's review, as expressed in a memorandum to the Governor's Office, is to "realign Arizona's categories of navigable waters, taking into account U. S. Supreme Court decisions of the past ten years." (ADEQ 2016, Appendix 1). An exemption from the Governor's rule-making moratorium authorizes staff to "prepare the necessary studies to withstand EPA's scrutiny and gather information and supporting documentation on stakeholder's views, especially as to aligning how Arizona categorizes Waters of the US (WOTUS)." (ADEQ 2016).

A preliminary classification of WOTUS offered for the Governor's Office proposed removing 47 lakes and 21 streams from Arizona's Clean Water Act list (ADEQ 2017a). The same analysis identified 74 lakes and 336 streams that might not continue to be regarded as protected by federal Clean Water Act authority based on current Corps standards and data available to its staff.

FEDERAL JURISDICTION IS CHANGING

Even without state assumption, federal jurisdiction over discharges to ephemeral streams will continue to shrink through the slow accumulation of project-level decisions by the Corps. Approved jurisdictional determinations (AJDs) by the Corps have reduced the number of Arizona's watercourses and lakes that are protected against water quality degradation under Section 404 of the Act. Until the 2006 *Rapanos* decision, discharges of fill into nearly all ephemeral streams in Arizona were regulated or presumed to be regulated by the Corps. *Rapanos v. United States*, 547 U.S. 715 (2006).

The guidance issued by the Corps and the U.S. Environmental Protection Agency on December 2, 2008 indicates that the agencies will assert jurisdiction over non-navigable tributaries of traditionally navigable water in two instances. First, jurisdiction will be asserted when the tributary is relatively permanent – a water that has a flow that is at least seasonal. Second, jurisdiction will be asserted when the Corps staff establishes, on a case-by-case basis, that a tributary that is not relatively permanent will significantly affect the chemical, physical, or biological integrity of traditionally navigable waters (USEPA & Corps 2008). In performing this task, the agencies indicated that they would consider the volume, duration, and frequency of the flow and its proximity to a traditionally navigable water, based on "any available hydrologic information" and physical characteristics of the tributary (USEPA & Corps 2008). In addition, the agencies agreed to consider the potential of tributaries to carry pollutants and floodwaters to traditional navigable waters. Other relevant factors include the ecological functions performed by the tributary such as the capacity to transfer nutrients and organic carbon downstream, habitat services, sediment trapping and retention, and pollutant trapping and filtration.

ADEQ expressed concerns over the Corps' draft guidance for implementing the significant nexus test. ADEQ estimated that 96% of Arizona's streams are non-perennial, and it predicted that "the jurisdictional determinations made in accordance with the Guidance will affect the ability of our agency to benefit from and to implement all Clean Water Act programs. ...The State has no role in the implementation of the Guidance....If an Arizona water body stands to lose Clean Water Act protections, the State should receive early notice, an opportunity to comment before the agencies make the final decision, and standing to appeal such a decision (ADEQ 2007)". The final guidance (Corps, 2008) did not address these concerns, and the *Oberstar Memorandum* (2008) found that Clean Water Act enforcement declined as a result.

Recent AJDs (SPL-2015-00520; SPL-2011-00160; SPL-2015-00129) based on this guidance have found that a number of dry streams in the mining districts south of Tucson have no "significant nexus" to the traditionally navigable Santa Cruz River located downstream (Figure 1). Under the 2008 guidance document, the Corps must have a "more

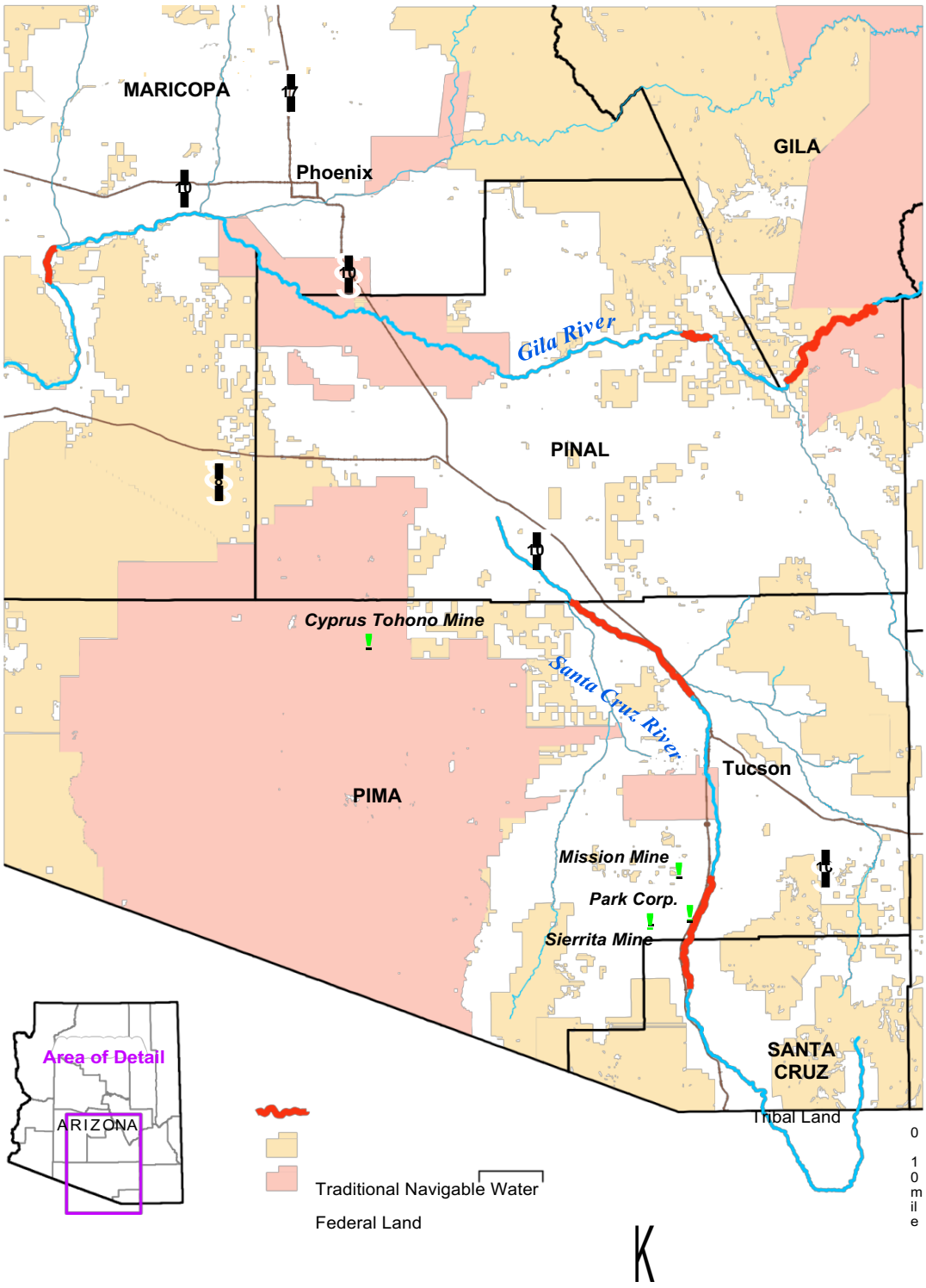

Figure 1--Location of Approved Jurisdictional Determinations (AJDs) mentioned in the text (Pima County map based on U. S. Army Corps of Engineers AJDs)

than speculative or insubstantial" basis for finding significant nexus. The recent determinations made by the Los Angeles District for projects in Pima County rely principally on maps and photographs submitted by the applicant to document a lack of relatively permanent waters or wetlands (Corps 2015a, 2015b, 2014, 2012). For the Sierrita mine analysis area, seventy-five drainage areas were determined to be isolated because they were cut off by the past mining activities that effectively impounded drainage on-site. For the remaining watercourses, the size of the project's watershed relative to the size of the Santa Cruz watershed, and the distance from the mines to the traditionally navigable reaches of the Santa Cruz River were important factors in the significant nexus decisions.

Some watersheds in both mining districts remain as WOTUS, but for different reasons. At the Sierrita Mine, the ephemeral streams discharging to the Santa Cruz River upstream of Continental Road are deemed WOTUS because they drain directly to a traditionally navigable reach of the Santa Cruz River (Figure 1). At the Mission Mine, no request was made to review the portion of the mine on tribal lands, so those watersheds remain under federal purview (Michael Langley, U. S. Army Corps, personal communication to the author, September 12, 2017). Other tribal watercourses have been found to be non-jurisdictional, for example, at the Cyprus Tohono Mine (AJD SPL-2012-00548, Figure 1).

A GAP IN WATER QUALITY GOVERNANCE

The shrinking scope of the Clean Water Act's jurisdiction leaves a gap in water quality regulation in Arizona for those watercourses deemed not to be WOTUS (Environmental Law Institute (ELI) 2013). As defined by ADEQ (2007), the permitting requirements for point source discharge, stream monitoring and assessment, non-point source remediation, and other state programs depend on the Act's jurisdiction. Most importantly, the state's authority to issue NPDES permits derives from the Act rather than any independent state authority. Recent Corps AJDs call into question the validity and enforceability of existing NPDES permits for wastewater treatment facilities, mines, and other entities on such water bodies. Consequently, Arizona is reviewing the status of its NPDES permits in relation to recent Corps determinations (Andy Koester, ADEQ, personal communication to the author, September 12, 2017). Statewide, there are seven ponds or lakes receiving discharges under AZPDES permits that are considered "problem areas for ADEQ" because they are not WOTUS (ADEQ 2017a), and over 400 other regulated waterbodies that are in "jurisdictional limbo" (ADEQ 2017b).

Arizona could set standards for waters of the state that are no longer WOTUS, based on Arizona Revised Statutes §49-221. New rule making would be needed to develop standards for these "waters of the state." ADEQ has identified lakes and 336 streams such as the tributaries to the Willcox Playa that could be potential "waters of the state" (ADEQ 2017a). Currently, the state's sole regulatory authority to protect water quality in waters of the state derives from its aquifer water quality regulations. Ephemeral streams play an important role in recharging the aquifer and purifying the infiltrating waters in Arizona; however, no rule making to protect those streams has been proposed (as of May 2018).

CONCLUSION

Recent, approved jurisdictional determinations indicate the Act's waning influence on polluting activities, leaving the state with some tough decisions about enforcement of existing NPDES permits the state administers. Because of the prevalence of ephemeral streams in the arid and semi-arid Western United States, the shrinking jurisdictional limits have broad implications for wildlife and their riparian and aquatic habitats. There will be fewer measures to avoid, minimize and mitigate project impacts to streams, wetlands, lakes and federally protected wildlife as the geographic scope of the Clean Water Act continues to shrink over the coming years.

AJDs resolve questions about which waters are subject to the Clean Water Act on a project basis. However, they are compounding regulatory questions in States like Arizona that currently rely on the Act to regulate pollutants entering its predominantly ephemeral streams. Arizona's assumption of Section 404 duties for non-navigable streams would not solve the growing disjunct between Section 404 jurisdiction and NPDES-related responsibilities, because Arizona would still be subject to same Supreme Court rulings as the Corps.

new rulemaking at the national level to resolve the limits of the Clean Water Act on ephemeral and intermittent waterbodies in in the United States and other issues is widely known, but hotly disputed. In July 2017, the U. S. proposed to rescind the definition of WOTUS which currently governs administration of the Clean Water Act (USEPA and Corps, 2017). In a later step, the US intends to consider using Justice Scalia's narrower opinion about water permanence from *Rapanos*. Regardless whose interpretation of jurisdiction gains traction, new rule making at the state level would be needed if discharges of pollutants to those dry streams and isolated lakes that will not be considered WOTUS are to be regulated at all in Arizona.

APPENDIX 1

ADEQ Arizona Department of Environmental Quality

Memorandum

Date:	November 16, 2016
To:	Hunter Moore, Natural Resource Policy Advisor
From:	Bret Parke, Deputy Director, ADEQ
Subject:	Request for Exception from the Rulemaking Moratorium Title 18, Chapter 11 – Water Quality Standards – Article 1. Water Quality Standards for Surface Waters

Arizona's Water Quality Standards must be updated to ensure that Arizona retains primacy and sole enforcement authority for Clean Water Act violations in Arizona. State standards must be updated to be consistent with and not more stringent than those established by the federal government, and to provide clear guidance to permittees and the general public regarding the extent of those authorities.

This memo requests that you please approve an exception to the rule making moratorium to develop with interested stakeholders a notice of proposed rulemaking for Arizona Administrative Code Title 18, Chapter 11 – Water Quality Standards – Article 1. Water Quality Standards for Surface Waters. This request complies with paragraph 2 of Executive Order 2016-03 to:

- To avoid violating a court order or federal law that would result in sanctions by a court orthe federal government against an agency for failure to conduct the rulemaking action.
- To comply with a state statutory requirement (A.R.S. 49-221).

The Arizona Department of Environmental Quality (ADEQ) sets water quality standards for navigable waters, implementing one of the major requirements of the Clean Water Act. The proposed rule-making would develop standards and language that conform with federal law and reduce confusion to permittees and the general public.

Section 303(c) of the Clean Water Act requires all states to review their water quality standards, at least once every three years, and revise where appropriate (known as the "triennial review"). EPA reviews, and must approve, any revised water quality standards, and has authority to impose water quality standards if it finds a state's to be insufficient. (33 U.S.C. § 1313(c)); 40 C.F.R. §131.22.

In August 2015, ADEQ completed an update which included only minor corrections and clarifications of previous revisions. At this time, ADEQ would like to begin the research for a broader review of the standards with the next triennial review in the fall of 2016, along with a robust stakeholder outreach effort that will conclude with the

completion of the review by August 2018. The triennial review will include:

- Updating standards to conform to EPA's 2015 updates;
- Realigning Arizona's categories of navigable waters, and taking into account U.S. Supreme Court decisions of the past ten years.
- Conforming to new EPA's 2015 variance procedure, allowing some permittees additional time to comply with water quality standards.
- Clarifying how Arizona categorizes tributaries to navigable waters ("the tributary rule").

The water quality standards impact various surface water programs, such as the Arizona Pollutant Discharge Elimination System (AZPDES) permitting program and the impaired waters listing. Beginning the triennial review now will allow ADEQ to prepare the necessary studies to withstand EPA's scrutiny and gather information and supporting documentation on stakeholders' views, especially as to realigning how Arizona categorizes waters of the U.S.

This request is consistent with Arizona Revised Statute §41-1038 (C) because the rules are necessary to avoid potential sanctions by the US Environmental Protection Agency.

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Building a path forward to secure water for Arizona's natural areas

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In response to the inadequate regulation and lack of policy tools to compel the consideration of water for Arizona's natural areas, the Sky Island Alliance and University of Arizona Water Resources Research Center are working toward a paradigm shift. Through an inventory of where and how water for natural areas is currently and should be prioritized in water management and planning decisions, we hope to better understand what it means to incorporate the environment in decisions about water. Voluntary, stakeholder-driven options are often the most viable responses available to provide water to the environment, especially within the Arizona context of limited water supplies and existing water rights and claims. To make these endeavors as cogent as possible, we are taking steps to systematically assess the public value of Arizona's natural areas and collectively set priorities. An inventory of these efforts includes a survey to understand how the public values natural areas paired with case studies that explore successful (and unsuccessful) avenues for priority setting in other arid parts of the world. While natural areas in Arizona are highly valued for recreation, intrinsic worth, and cultural significance, how do those values translate into water to sustain these areas? Through an iterative process, community values are included in the dialogue and applied to the prioritization process, while increasing understanding among diverse water interests.

Construyendo un camino hacia adelante para asegurar el agua para las áreas naturales de Arizona

En respuesta a la regulación inadecuada y la falta de herramientas de política para obligar a considerar el agua para las áreas naturales de Arizona, Sky Island Alliance y el Centro de Investigación de Recursos Hídricos de la Universidad de Arizona están trabajando para lograr un cambio de paradigma. A través de un inventario de dónde y cómo está el agua actualmente para las áreas naturales y como debe ser priorizada en la gestión del agua y las decisiones de planificación, esperamos comprender mejor lo que significa incorporar el medio ambiente en las decisiones sobre el agua. Las opciones voluntarias, impulsadas por las partes interesadas a menudo son las respuestas más viables disponibles para proporcionar agua al medio ambiente, especialmente dentro del contexto de Arizona de suministros de agua limitados y reclamos y derechos de agua existentes. Para que estos esfuerzos sean lo más convincentes posible, estamos tomando medidas para evaluar de manera sistemática el valor público de las áreas naturales de Arizona y establecer prioridades colectivamente. Un inventario de estos esfuerzos incluye una encuesta para comprender cómo el público valora las áreas naturales combinadas con estudios de casos que exploran vías exitosas (y sin éxito) para establecer prioridades en otras partes áridas del mundo. Si bien las áreas naturales en Arizona son muy apreciadas por la recreación, el valor intrínseco y la importancia cultural, ¿cómo se traducen esos valores en agua para sustentar estas áreas? A través de un proceso iterativo, los valores de la comunidad se incluyen en el diálogo y se aplican al proceso de priorización, al tiempo que aumentan la comprensión entre los diversos intereses relacionados con el agua.

NOTE: A manuscript was not submitted to accompany this presentation.

Water Sharing: Idealism or a Path Forward?

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River systems are among the most rapidly declining biodiverse systems in the world. In the face of growing demands on shrinking water resources to meet human and environmental needs, river restoration and conservation practitioners in arid regions are asking the same question: How can rivers stay in the race with cities, agriculture, and industry as water supplies are stretched thin? The Madrean Archipelago region is an ideal region to explore new and innovative tools for sharing water among different users. There are emerging examples of cities allocating water for the environment and opportunities to work within Arizona policies to include the environment in water management decisions. Since these ideas are newly emerging, there are many questions and spaces for creativity. This talk with cover the background context that sets the stage for water sharing agreements and present a few recent projects and examples.

Compartir el agua: ¿Idealismo o un camino hacia adelante?

Los sistemas fluviales se encuentran entre los sistemas de biodiversidad más rápidamente decrecientes del mundo. Ante la creciente demanda de recursos hídricos cada vez más pequeños para satisfacer las necesidades humanas y medioambientales, los restauradores de ríos y conservacionistas en las regiones áridas se hacen la misma pregunta: ¿cómo pueden los ríos mantenerse en la carrera con las ciudades, la agricultura y la industria? La región del archipiélago de Madrense es una región ideal para explorar herramientas nuevas e innovadoras para compartir agua entre diferentes usuarios. Hay ejemplos emergentes de ciudades que asignan agua para el medio ambiente y oportunidades para trabajar dentro de las políticas de Arizona para incluir el medio ambiente en las decisiones de gestión del agua. Dado que estas ideas están surgiendo recientemente, hay muchas preguntas y espacios para la creatividad. Esta charla cubre el contexto de fondo que establece el escenario para los acuerdos de intercambio
de agua y presenta algunos proyectos y ejemplos recientes.

NOTE: A manuscript was not submitted to accompany this presentation.

From Southern Arizona to South Australia: Exploring approaches for allocating water for natural areas

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Arizona is in one of the fastest warming and drying regions in the nation. Human demands for water are increasingly in conflict with protecting water for natural areas. Policies, management and dialogues about water do not adequately reflect the relationship between healthy human communities and water for natural areas. Our traditional approaches and basic assumptions about our water supply are being challenged by climate change impacts and ongoing drought. We must change the way we think about water and value it, or we will lose ecosystems and wildlife that depend on it. Adelaide, South Australia went through this reckoning during the Millennium drought of the 2000s. Under dire water scarcity conditions, communities reassessed their relationship to water and developed local and national legislation that

brought water for the environment strongly into policy and management. There are many ideas and potential lessons to be learned from South Australia that can help us reframe the link between healthy watersheds and healthy, thriving businesses and communities in southern Arizona. How can we consider and provide for the water needs of water-dependent ecosystems? How do we balance social, economic and environmental demands for water within the capacity of the water resources? How do we meet the water requirements of ecosystems to sustain the ecological values including processes and biodiversity? Recovering and allocating water for the environment must be part of our discussion and policy if we are to sustain our quality of life and community health in the face of great change.

Desde el sur de Arizona hasta el sur de Australia: enfoques exploratorios para asignar agua a áreas naturales

Arizona se encuentra en una de las regiones de calentamiento y sequias más rápidas de la nación. Las demandas humanas de agua están cada vez más en conflicto con la protección del agua para las áreas naturales. Las políticas, la gestión y los diálogos sobre el agua no reflejan adecuadamente la relación entre las comunidades humanas sanas y el agua para las áreas naturales. Nuestros enfoques tradicionales y suposiciones básicas sobre nuestro suministro de agua están siendo desafiados por los impactos del cambio climático y la sequía en curso. Debemos cambiar nuestra forma de pensar sobre el agua y valorarla, o perderemos los ecosistemas y la vida silvestre que dependen de ella. Adelaide, en el sur de Australia, pasó por este proceso durante la sequía del milenio de la década de 2000. Bajo condiciones extremas de escasez de agua, las comunidades reevaluaron su relación con el agua y desarrollaron legislación local y nacional que trajo agua para el medio ambiente con fuerza en las políticas y la gestión. Hay muchas ideas y lecciones potenciales que aprender de Australia del Sur que pueden ayudarnos a replantear el vínculo entre las cuencas sanas y las empresas y comunidades sanas y prósperas en el sur de Arizona. ¿Cómo podemos considerar y satisfacer las necesidades de agua de los ecosistemas dependientes del agua? ¿Cómo equilibramos las demandas sociales, económicas y ambientales del agua dentro de la capacidad de los recursos hídricos? ¿Cómo cumplimos con los requisitos hídricos de los ecosistemas para mantener los valores ecológicos, incluidos los procesos y la biodiversidad? La recuperación y la asignación de agua para el medio ambiente deben ser parte de nuestra discusión y política si queremos mantener nuestra calidad de vida y la salud de la comunidad frente a un gran cambio.

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Ensuring environmental flows in the Desert Watersheds of the U.S. and México: Barriers, solutions, and successful case studies

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Environmental flows represent life and refuge for aquatic and riparian species. They provide valuable ecosystem services including water supplies, food delivery, water purification, drought mitigation, nutrient delivery, recreational opportunities, biodiversity conservation, and religious or cultural meaning. Even with increased interest in providing water to meet the needs of riparian and aquatic ecosystems, we face major challenges in implementing on-the-ground solutions. Strategies to safeguard environmental flows are often limited by the social, political, and economic dimensions of a region and its communities. Barriers such as lack of scientific information, increase in water demands, and limited water resources can undermine efforts to secure water for natural areas. Water managers are hard pressed to determine the appropriate allocation for the environment and their success depends on sufficient quality information. This effort is identifying and evaluating successful planning/management strategies for ensuring environmental flows, mechanisms for engagement, key players, and barriers that hinder incorporation of flow prescriptions in the desert watersheds of the

U.S. and Mexico. While perspectives and regulations vary depending on the state and country, the need for quality information, education, and trust between water users are described by stakeholders in both the U.S. and México. This research utilized more than 400 articles available through the Desert Flows Database and the Desert Flows Methodology Guidebook (UA-WRRC, 2016; UA-WRRC, 2017.

Asegurar los flujos ambientales en las Cuencas del Desierto de los Estados Unidos y México: Barreras, soluciones, y estudios de casos exitosos

Los flujos ambientales representan vida y refugio para especies acuáticas y ribereñas. Proporcionan valiosos servicios ecosistémicos que incluyen suministro de agua, entrega de alimentos, purificación de agua, mitigación de la sequía, entrega de nutrientes, oportunidades recreativas, conservación de la biodiversidad y significado religioso o cultural. Incluso con un mayor interés en proporcionar agua para satisfacer las necesidades de los ecosistemas ribereños y acuáticos, enfrentamos grandes desafíos en la implementación de soluciones sobre el terreno. Las estrategias para salvaguardar los flujos ambientales a menudo están limitadas por las dimensiones sociales, políticas y económicas de una región y sus comunidades. Las barreras como la falta de información científica, el aumento en la demanda de agua y los recursos hídricos limitados pueden socavar los esfuerzos para asegurar el agua para las áreas naturales. Los administradores del agua tienen dificultades para determinar la asignación adecuada para el medio ambiente y su éxito depende de la información de calidad suficiente. Este esfuerzo consiste en identificar y evaluar estrategias exitosas de planificación / gestión para garantizar flujos ambientales, mecanismos de participación, actores clave y barreras que impiden la incorporación de prescripciones de flujo en las cuencas hidrográficas del desierto de EE. UU. y México. Si bien las perspectivas y los reglamentos varían según el estado y el país, los interesados en los Estados Unidos y México describen la necesidad de información, educación y confianza de calidad entre los usuarios del agua. Esta investigación utilizó más de 400 artículos disponibles a través de Desert Flows Database y Desert Flows Methodology Guidebook (UA-WRRC, 2016; UA-WRRC, 2017).

NOTE: A manuscript was not submitted to accompany this presentation.

The Arizona/Sonora Transboundary Aquifer Assessment Program: GIS and Mapping (Map)

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The binational United States-Mexico Transboundary Aquifer Assessment Program (TAAP) was officially launched on August 19, 2009. The Mexican and U.S. Principal Engineers of the International Boundary and Water Commission (IBWC) signed the “Joint Report of the Principal Engineers Regarding the Joint Cooperative Process United States-Mexico for the Transboundary Aquifer Assessment Program." This IBWC “Joint Report” has served as the framework for U.S.-Mexico coordination and dialogue to implement transboundary aquifer studies. In 2016, the Binational Study of the Transboundary San Pedro Aquifer was published. In this report, the United States and Mexico seek to contribute with scientific knowledge and binational data on climate, geology, soils, land cover, land use, and hydrology for the San Pedro aquifer. The report compiles and creates a database of scientific information from both countries, and identifies data gaps and information to be updated for subsequent phases. The Binational Study of the Transboundary Santa Cruz Aquifer is expected to be published by the end of 2018. Current mapping efforts include the development of 40 binational maps about climate, hydrology, geology, land use, soil distribution and vegetation, 23 binational water quality maps and four binational maps with information on depth to groundwater level for the year 2011. The GIS generated through the Transboundary Aquifer Assessment program represents one of the first integrated efforts that seek to present

harmonized information for both sides of the border. The purpose of this Map Gallery is to show some of the bilingual maps that were developed through this program.

El Programa de Evaluación de Acuíferos Transfronterizos de Arizona / Sonora: SIG y Mapeo (Mapa)

El Programa Binacional de Evaluación de Acuíferos Transfronterizos México-Estados Unidos (TAAP) se lanzó oficialmente el 19 de agosto de 2009. Los principales ingenieros mexicanos y estadounidenses de la Comisión Internacional de Límites y Aguas (IBWC/ CILA) firmaron el "Informe conjunto de los principales ingenieros sobre el Joint Proceso Cooperativo Estados Unidos-México para el Programa de Evaluación de Acuíferos Transfronterizos. "Este" Informe Conjunto "de CILA ha servido como el marco para la coordinación y el diálogo entre los Estados Unidos y México para implementar estudios de acuíferos transfronterizos. En 2016, se publicó el Estudio Binacional del Acuífero Transfronterizo de San Pedro. En este informe, los Estados Unidos y México buscan contribuir con conocimiento científico y datos binacionales sobre clima, geología, suelos, cubierta vegetal, uso de la tierra e hidrología para el acuífero de San Pedro. El informe compila y crea una base de datos de información científica de ambos países e identifica las lagunas de datos y la información que se actualizará para las fases posteriores. Se espera que el Estudio Binacional del Acuífero Transfronterizo de Santa Cruz se publique a fines de 2018. Los esfuerzos actuales de mapeo incluyen el desarrollo de 40 mapas binacionales sobre clima, hidrología, geología, uso del suelo, distribución del suelo y vegetación, 23 mapas binacionales de calidad del agua y cuatro mapas binacionales con información sobre la profundidad del nivel del agua subterránea para el año 2011. El SIG generado a través del programa de evaluación de acuíferos transfronterizos representa uno de los primeros esfuerzos integrados que buscan presentar información armonizada para ambos lados de la frontera. El propósito de esta galería de mapas es mostrar algunos de los mapas bilingües que se desarrollaron a través de este programa.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 13: Mt. Graham Red Squirrel: A Study in Extinction Prevention

Mount Graham and the Pinaleno Mountains, Coronado National Forest
(Photo courtesy of the USDA Forest Service, Coronado National Forest)

Abstracts and Papers
Dahlby
Derbridge
Koprowski
Merrick
Morandini
Wells

Post Frye Fire Conservation Actions for the Endangered Mt. Graham Red Squirrel

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In June and July 2017, the Frye Fire burned approximately 48,000 acres in the Pinaleño Mountains in southeastern Arizona, including ~78% of the main portion of the range of the endangered Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*). Key areas burned at high-severity, which completely removed significant portions of red squirrel habitat, but even in areas with low-severity fire red squirrels were negatively affected by ground fire that burned the middens (i.e., food caches used to store winter food supply). During the September 2017 annual survey, evidence of the Frye Fire was observed in 95% of the surveyed locations, with 80% showing at least some habitat loss and 44% completely burned. The 2017 population estimate was 35 individuals, down from 252 in 2016. Of immediate concern is ensuring the remaining red squirrels survive through the winter, considering much of their food supply was impacted by fire; the Coronado National Forest is carrying out a supplemental feeding program to assist in this endeavor. Other projects under development or in process are: deploying anti-aggregate pheromones to reduce likelihood of beetle kills of trees; collecting LiDAR data to determine remaining red squirrel habitat, areas suitable for habitat enhancement, and possible translocation sites within the species' range; reducing food and habitat competitors; completing a spring census of red squirrels to determine overwinter survival; determining possible translocation strategies and methods; continuing ex-situ breeding strategies at the Phoenix Zoo; and developing long-term forest management strategies across the fire-impacted landscape.

Acciones posteriores al incendio de Frye para la conservación de la especie en peligro de extinción Ardilla Roja de las Montañas Graham

En junio y julio de 2017, el incendio Frye quemó aproximadamente 48,000 acres en las montañas Pinaleño en el sureste de Arizona, incluyendo ~ 78% de la porción principal del rango de la Ardilla roja de las montañas Graham (Tamiasciurus hudsonicus grahamensis), en peligro de extinción. Las áreas clave quemadas a alta severidad, eliminaron completamente partes significativas del hábitat de ardilla roja, pero incluso en áreas con fuego de baja severidad las ardillas rojas se vieron negativamente afectadas por el fuego que quemaba los basureros (es decir, los alijos de comida utilizados para almacenar alimentos de invierno). Durante la encuesta anual de septiembre de 2017, se observó evidencia del fuego Frye en el 95% de los lugares estudiados, con un 80% que muestra al menos alguna pérdida de hábitat y un 44% completamente quemado. La población estimada para 2017 fue de 35 personas, frente a las 252 en 2016. De preocupación inmediata esta asegurar que las ardillas rojas restantes sobrevivan durante el invierno, ya que gran parte de su suministro de alimentos se vio afectado por los incendios; el Bosque Nacional de Coronado está llevando a cabo un programa de alimentación suplementaria para ayudar en este esfuerzo. Otros proyectos en desarrollo o en proceso son: el despliegue de feromonas antiagregantes para reducir la probabilidad de muerte por escarabajos de los árboles; recopilar datos de LiDAR para determinar el hábitat de la ardilla roja restante, las áreas adecuadas para la mejora del hábitat y los posibles sitios de translocación dentro del rango de la especie; reduciendo los competidores de comida y hábitat; completando un censo de primavera de ardillas rojas para determinar la supervivencia del invierno; determinar posibles estrategias y métodos de translocación; estrategias continuas de reproducción ex-situ en el zoológico de Phoenix; y el desarrollo de estrategias de manejo forestal a largo plazo en todo el paisaje afectado por el fuego, como la resiembra.

NOTE: A manuscript was not submitted to accompany this presentation.

Experimental removals reveal dietary niche partitioning facilitates coexistence between ecologically similar native and introduced species

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Niche overlap between native species and ecologically similar invaders can lead to competitive exclusion of threatened native species, but if two such species also co-occur naturally elsewhere, the anthropogenic interaction may mirror coevolved niche partitioning that reduces competition and promotes coexistence. A single, insular population of red squirrel (*Tamiasciurus fremonti*) the Mount Graham red squirrel (MGRS; *T. f. grahamensis*) in the Pinaleño Mountains, Arizona, USA, is critically endangered and resource competition with introduced Abert's squirrels (*Sciurus aberti*) may threaten its long-term persistence. The species are naturally syntopic in other mountain sites, and both consume diets comprised primarily of conifer seeds and fungi. We conducted experimental removals of introduced Abert's squirrels and used stable isotope analysis of diets before and after removals, and of diets in naturally syntopic populations to test the hypothesis that dietary niche partitioning can facilitate coexistence between native and introduced species. Mount Graham red squirrels and introduced Abert's squirrels partitioned the dietary niche similarly to naturally syntopic populations. Removals had no apparent effect. Diet of MGRS was more closely linked to availability of resources than to presence of Abert's squirrels. Flexibility in dietary niche of introduced Abert's squirrels may have allowed them to exploit a resource opportunity in syntopy with MGRS, which occur in lower density than other red squirrel populations. Competitive exclusion of the endangered MGRS appears unlikely to occur through competition for food with introduced Abert's squirrels. However, similarity in diets means negative effects of competition could occur in future. Red squirrels are winter specialists, but as in other peripheral populations facing climate change challenges, specializing in winter survival will ultimately cease to be an advantage. They may be replaced by other species.

Las extracciones experimentales revelan que la partición de nicho dietético facilita la coexistencia entre especies nativas e introducidas ecológicamente similares

La superposición de nichos entre las especies nativas y los invasores ecológicamente similares puede conducir a la exclusión competitiva de especies nativas amenazadas, pero si dos de esas especies también ocurren de forma natural en otro lugar, la interacción antropogénica puede reflejar particiones de nicho coevolucionadas que reducen la competencia y promueven la coexistencia. Una sola población insular de ardilla roja (Tamiasciurus fremonti), la ardilla roja de Mount Graham (MGRS, T. f. Grahamensis) en las montañas Pinaleño, Arizona, EE.UU., está críticamente en peligro y la competencia de recursos con las ardillas de Abert introducidas (Sciurus aberti) puede amenazar su persistencia a largo plazo. Las especies son naturalmente sintópicas en otros sitios de montaña, y ambas consumen dietas compuestas principalmente de semillas de coníferas y hongos. Realizamos extracciones experimentales de ardillas de Abert introducidas y utilizamos el análisis de isótopos estables de las dietas antes y después de las remociones, y de las dietas en poblaciones naturalmente sintomáticas para probar la hipótesis de que las divisiones de nichos dietéticos pueden facilitar la coexistencia entre especies nativas e introducidas. Las ardillas rojas de Mount Graham y las introducidas ardillas de Abert dividieron el nicho de la dieta de forma similar a las poblaciones naturalmente sintomáticas. Las eliminaciones no tuvieron efecto aparente. La dieta de MGRS estaba más relacionada con la disponibilidad de recursos que con la presencia de las ardillas de Abert. La flexibilidad en el nicho dietético de las introducidas ardillas de Abert puede haberles permitido explotar una oportunidad de recursos en sintopía con MGRS, que ocurre en una densidad menor que otras poblaciones de ardillas rojas. Es poco probable que se produzca la exclusión competitiva del MGRS en peligro a través de la competencia por la comida con las ardillas de Abert introducidas. Sin embargo, la similitud en las dietas significa que los efectos negativos de la competencia podrían ocurrir en el futuro. Las ardillas rojas son especialistas en invierno, pero como en otras poblaciones periféricas que enfrentan desafíos de cambio climático, la supervivencia en invierno dejará de ser una ventaja.

NOTE: A manuscript was not submitted to accompany this presentation.

A primer on the endangered Mt. Graham red squirrel: Current status and threats

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The Mt. Graham red squirrel (*Tamiasciurus fremonti grahamensis*) was federally listed as endangered in 1987 and this montane endemic has remained among the most critically endangered species in North America. Population numbers have fluctuated over 31 years of surveys but in recent years numbers had stabilized between 200 and 300 animals. However, the Frye Fire in summer 2017 affected nearly 20,000 ha and the population declined to 35 animals. Mt. Graham red squirrels traverse large home ranges that suggest issues related to habitat quality including response to fire, insect damage, roads, and introduced Abert's squirrels. Mortality is high with few animals living to reproduce more than once in their short lifetime. Litter size is reduced compared to non-endangered populations of red squirrels. The demographic challenges faced by Mt. Graham red squirrels are likely exacerbated by a paucity of genetic variation. Ultimately, the persistence of the USA's most endangered breeding mammal will depend on multi-agency, NGO, and academic collaboration on in situ and ex situ conservation efforts.

Una cartilla sobre la ardilla roja de Mt. Graham en peligro de extinción: estado actual y amenazas

La ardilla roja de Mt. Graham (Tamiasciurus fremonti grahamensis) fue incluida en la lista federal de especies en peligro de extinción en 1987 y se ha mantenido entre las especies en peligro crítico en América del Norte. Los números de población han fluctuado durante 31 años de encuestas, pero en los últimos años las cifras se han estabilizado entre 200 y 300 animales. Sin embargo, el incendio Frye en el verano de 2017 afectó a casi 20,000 hectáreas y la población disminuyó a 35 animales. Las ardillas rojas de Mt. Graham atraviesan grandes áreas de distribución, lo cual sugiere que existen problemas relacionados con la calidad del hábitat, incluida la respuesta al fuego, daños por insectos, caminos y las introducidas ardillas de Abert. La mortalidad es alta y pocos animales viven para reproducirse más de una vez en su corta vida. El tamaño de la camada es reducido en comparación con las poblaciones de ardillas rojas que no están en peligro. Los desafíos demográficos que enfrentan las ardillas rojas de Mt. Graham son probablemente exacerbados por una escasez de variación genética. En última instancia, la persistencia del mamífero en reproducción más amenazado de EE. UU. dependerá de la colaboración entre varias agencias, ONG y académicos en los esfuerzos de conservación in situ y ex situ.

NOTE: A manuscript was not submitted to accompany this presentation.

Burn severity is an important predictor of space use, settlement, and landscape connectivity for the endangered Mt. Graham red squirrel

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Altered fire regimes and drought are important drivers of disturbance events in forests throughout the western United States. Understanding how disturbance events such as fire influence space use, dispersal, and settlement of threatened and endangered species and whether populations are able to persist following disturbance is key. We modeled probability of landscape use by the endangered Mt. Graham red squirrel (*Tamiasciurus fremonti grahamensis*) in the Pinaleño Mountains, Arizona, USA as a function of topography, forest structure, and burn severity from three increasingly catastrophic fires in

1996 (2,600 ha), 2004 (12,029 ha), and 2017 (19,604 ha). Burn severity of past fires in 1996 and 2004 was among the most important variables to explain space use and settlement by dispersing animals; individuals rarely used locations where burn severity was moderate or high (only 2.8% of 10,805 locations). We applied circuit theory to assess landscape connectivity and identify potential dispersal corridors within a landscape fragmented by past fires. In 2017, the Frye Fire impacted the majority of remaining red squirrel habitat with higher burn severity; 15% moderate - high severity. We developed new probability of landscape use and connectivity models following the 2017 Frye Fire to predict areas that may support red squirrel persistence and assess how recent fire has further impacted connectivity. We used mountain-wide post-fire censuses for model validation. These efforts support and inform continued conservation.

La severidad de quemado es un importante predictor de uso del espacio, asentamiento y conectividad del paisaje para la ardilla roja de Mt. Graham en peligro de extinción

Los regímenes de incendios alterados y la sequía son importantes factores de perturbación en los bosques de todo el oeste de los Estados Unidos. Comprender cómo los eventos de perturbación, como el fuego, influyen en el uso del espacio, la dispersión y el asentamiento de especies amenazadas y en peligro de extinción, y si las poblaciones pueden persistir después de la perturbación es clave. Modelamos la probabilidad de uso del paisaje por el monte en peligro de extinción. Ardilla roja de Graham (Tamiasciurus fremonti grahamensis) en las montañas Pinaleño, Arizona, EE. UU. En función de la topografía, la estructura del bosque y la severidad de las quemaduras de tres incendios cada vez más catastróficos en 1996 (2.600 hectáreas), 2004 (12.029 hectáreas) y 2017 (19.604 hectáreas). La severidad de la quemadura de los incendios pasados en 1996 y 2004 fue una de las variables más importantes para explicar el uso y asentamiento del espacio al dispersar animales; los individuos raramente usaban lugares donde la severidad de las quemaduras era moderada o alta (solo 2.8% de las 10.805 localidades). Aplicamos la teoría de circuitos para evaluar la conectividad del paisaje e identificar posibles corredores de dispersión dentro de un paisaje fragmentado por incendios pasados. En 2017, el fuego Frye impactó a la mayoría del hábitat de ardilla roja restante con una mayor severidad de las quemaduras; 15% de severidad moderada a alta. Desarrollamos una nueva probabilidad de uso del paisaje y modelos de conectividad después de la Frye Fire 2017 para predecir las áreas que pueden apoyar la persistencia de la ardilla roja y evaluar cómo el fuego reciente ha afectado aún más la conectividad. Usamos los censos posteriores al incendio en toda la montaña para la validación del modelo. Estos esfuerzos apoyan e informan los continuos esfuerzos de conservación de uno de los mamíferos más amenazados de América del Norte.

NOTE: A manuscript was not submitted to accompany this presentation.

Impact of the Frye Fire on the endangered Mt. Graham red squirrel

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Wildfires cause major disturbances to wildlife communities. Their effects can have dramatic direct and indirect consequences on endangered species. The Frye Fire was ignited by lightning 7 June 2017 on Mt. Graham (Pinaleño Mountains, Arizona), was not contained until 30 July 2017 and scorched 19,704 ha (48,443 ac). The population of the federally endangered Mt. Graham Red Squirrel (MGRS) declined precipitously after the Frye Fire. Fire impacts animals directly, through death or injury, and/or indirectly, through changes to vegetation structures and composition, resource availability, predator pressures, and availability of nesting sites. Most of the previously radio collared MGRS survived the fire. Squirrels did not immediately abandon their middens (a larderhoard of conifer cones at the center of their territory), despite severe damage, but often later moved into other areas. We were also able to estimate some indirect fire impacts by comparing MGRS home range sizes before and after the fire. Post-fire home range sizes increased 30%, potentially impacting their survival and fitness. The fire caused drastic environment changes. Preliminary results of giving-up-density experiments revealed MGRS avoided burned areas, rather, selecting intact habitats, a behavior that can have implications for population connectivity. Selecting against

burned areas can constrain squirrel dispersal, creating isolated groups of individuals. Understanding how MGRS perceive different degrees of burned severity, would provide valuable insight for post-fire habitat restoration and help inform specific management actions to facilitate habitat connectivity for MGRS.

Impacto del fuego Frye en la ardilla roja de Mt. Graham en peligro de extinción

Los incendios forestales causan grandes disturbios a las comunidades de vida silvestre. Sus efectos pueden tener dramáticas consecuencias directas e indirectas en las especies en peligro de extinción. El fuego de Frye fue encendido por un rayo el 7 de junio de 2017 en el monte Graham (Montañas Pinaleño, Arizona), no fue contenida hasta el 30 de julio de 2017 y quemó 19.704 hectareas (48.443 acres). La población de la ardilla roja de Mt. Graham (MGRS por sus siglas en ingles) federalmente reconocida como en peligro de extinción disminuyó precipitadamente después de Frye Fire. El fuego afecta a los animales directamente, por muerte o lesión, y / o indirectamente, a través de cambios en las estructuras y composición de la vegetación, la disponibilidad de recursos, las presiones de los depredadores y la disponibilidad de sitios de anidación. La mayoría de los MGRS previamente otorgadas un collar radio sobrevivieron al fuego. Las ardillas no abandonaron inmediatamente sus basureros (una gran cantidad de conos de coníferas en el centro de su territorio), a pesar del daño severo, pero a menudo se trasladaron a otras áreas. También pudimos estimar algunos impactos indirectos del fuego al comparar los tamaños del alcance de hogar de MGRS antes y después del incendio. El tamaño del hogar después del incendio aumentó un 30%, lo que podría afectar su supervivencia y estado físico. El fuego causó cambios drásticos en el medio ambiente. Los resultados preliminares de los experimentos de abandono de la densidad revelaron que el MGRS evitaba las áreas quemadas, más bien, seleccionaba los hábitats intactos, un comportamiento que puede tener implicaciones para la conectividad de la población. En particular, seleccionar áreas quemadas puede limitar la dispersión de ardillas, creando grupos aislados de individuos. Comprender cómo MGRS percibe diferentes grados de severidad calcinada, proporcionaría información valiosa para la restauración del hábitat después del incendio y ayudaría a informar acciones de gestión específicas para facilitar la conectividad del hábitat para MGRS.

NOTE: A manuscript was not submitted to accompany this presentation.

Clues to Developing an ex situ Propagation for Release Program for Mt. Graham Red Squirrels (*Tamiasciurus fremonti grahamensis*), Through Conservation Physiology, Reproductive Behavioral Assessments and Adaptive Management Strategies

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Female Mount Graham red squirrels (*Tamiasciurus fremonti grahamensis*), are known to be receptive to breeding for a single day each season, and for perhaps only six hours during that season. If resources are abundant, they may have two breeding seasons in the wild, one in early spring, and again in late summer. This field observation of seasonal receptivity is believed to be true for each of the 25 *Tamiasciurus* sub-species. However, by tracking glucocorticoid estradiol levels in an ex situ managed population for two consecutive years, we discovered evidence of polyestrous cycles with an average interval between cycles of approximately 15-25 days. With this insight, we developed a schedule for conducting behavioral assessments and developed a breeding management strategy based upon insights gained through observations during these reproductive assessments. This work is part of an ongoing study to develop a consistent propagation release program for this endangered sub-species. We will continue to track metabolite hormones and refine our breeding management approach to determine the ideal timing for breeding introductions.

Pistas para desarrollar un programa de propagación ex situ para lanzamiento para la ardilla roja de Mt. Graham (Tamiasciurus fremonti grahamensis), a través de la Fisiología de la Conservación, evaluaciones del comportamiento reproductivo y estrategias de manejo adaptativo.

Se sabe que las ardillas rojas femeninas de Mount Graham (Tamiasciurus fremonti grahamensis) son receptivas a la reproducción durante un solo día cada temporada, y quizás durante solo seis horas durante esa temporada. Si los recursos son abundantes, es posible que tengan dos temporadas de reproducción en la naturaleza, una a principios de la primavera y otra a fines del verano. Se cree que esta observación de campo de la receptividad estacional es verdadera para cada una de las 25 subespecies de Tamiasciurus. Sin embargo, mediante el seguimiento de los niveles de glucocorticoides estradiol en una población administrada ex situ durante dos años consecutivos, descubrimos evidencia de ciclos poliestros con un intervalo promedio entre ciclos de aproximadamente 15-25 días. Con esta idea, desarrollamos un cronograma para realizar evaluaciones de comportamiento y desarrollamos una estrategia de manejo de cría basada en los conocimientos adquiridos a través de observaciones durante estas evaluaciones reproductivas. Este trabajo es parte de un estudio en curso para desarrollar un programa de liberación de propagación consistente para esta subespecie en peligro de extinción. Continuaremos rastreando las hormonas de los metabolitos y refinaremos nuestro enfoque de manejo de la cría para determinar el momento ideal para las introducciones de cría.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes Y Articulos*

Session 14: Mt. Graham Red Squirrel: A Study in Extinction Prevention

Mount Graham View, Coronado National Forest, Arizona.
(Photo courtesy of the USDA Forest Service, Coronado National Forest)

Abstracts and Papers
Gaylord
Lynch

Measures to mitigate bark beetle associated tree mortality after the Frye Fire

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Post-fire tree mortality from bark beetles is an increasing concern for forest managers in Arizona. Bark beetles are known to favor fire-injured trees and, in the case of Douglas-fir, an abundance of fire-injured trees have been documented as triggering beetle outbreaks. For example, the US Forest Service has documented a dramatic increase in beetle associated tree mortality within the burn perimeter of the Wallow Fire that burned over 215,000 ha in eastern Arizona in 2011. Similar beetle activity could occur in the Pinaleño Mountains as a result of the Frye Fire that burned during the summer of 2017. Of particular concern in this mountain range is protection of the remaining habitat and food sources (cones) for the endangered Mount Graham red squirrel. Limiting additional tree mortality from bark beetles is imperative for keeping the remaining habitat intact. Using information and input from multiple agencies, we developed a plan to strategically deploy pheromones that have been shown to deter attacks by Douglas-fir and mountain pine bark beetles on their host species, Douglas-fir and southwestern white pine, respectively. These two tree species are known to be important food sources for the red squirrel. Areas were prioritized based on habitat status and proximity to documented squirrel activity post-fire. The pheromones will be deployed starting in April of 2018 over 161 ha within the perimeter of the Frye Fire. Monitoring of beetle populations and activity will occur in fall of 2018. We anticipate this project will continue in 2019.

Medidas para mitigar la mortalidad de árboles asociada al escarabajo de corteza después del fuego Frye

La mortalidad post-incendio por resultado de los escarabajos de corteza es una preocupación creciente para los administradores forestales en Arizona. Se sabe que los escarabajos de corteza favorecen los árboles dañados por el fuego y, en el caso del abeto de Douglas, se ha documentado que una abundancia de árboles dañados por el fuego desencadena brotes de escarabajos. Por ejemplo, el Servicio Forestal de los EE. UU. Ha documentado un aumento dramático en la mortalidad de árboles asociada a escarabajos dentro del perímetro de quemado del fuego Wallow que quemó más de 215,000 hectáreas en el este de Arizona en 2011. Actividad de escarabajos similar podría ocurrir en las montañas Pinaleño como resultado de la Fuego Frye que quemó durante el verano de 2017. Hay un interés particular en esta cordillera por la protección del hábitat y las fuentes de alimento (conos) restantes para la ardilla roja Mount Graham en peligro de extinción. Es imperativo limitar la mortalidad adicional de árboles por los escarabajos de la corteza para mantener el hábitat restante intacto. Utilizando información y aportes de múltiples agencias, desarrollamos un plan para desplegar estratégicamente feromonas que han demostrado disuadir ataques de abeto de Douglas y escarabajos de corteza de pino de montaña en sus especies hospedadoras, el abeto Douglas y el pino blanco del suroeste, respectivamente. Se sabe que estas dos especies de árboles son importantes fuentes de alimento para la ardilla roja. Las áreas se priorizaron en función del estado del hábitat y la proximidad a la actividad documentada de la ardilla después del incendio. Las feromonas se desplegarán a partir de abril de 2018 en más de 161 ha dentro del perímetro del incendio Frye. El monitoreo de las poblaciones de escarabajos y la actividad ocurrirá en el otoño de 2018. Anticipamos que este proyecto continuará en 2019.

NOTE: A manuscript was not submitted to accompany this presentation.

A historical perspective of Mount Graham red squirrel habitat

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Mount Graham red squirrel (MGRS) habitat requirements include mature forest with sufficient cone-bearing trees (especially large spruce), closed canopy condition, logs, cool temperatures, and shade. Tree-ring reconstruction of Pinaleño high-elevation forest demographics and disturbance history shows small isolated patches of marginal habitat existed after high-severity fire in 1685. Engelmann spruce and corkbark fir gradually colonized the spruce-fir zone. The forest was in closed canopy condition by the early 1800s, and relatively mature throughout by the mid- to late 1800s. Fire was absent between 1685 and 2004. Spruce beetle outbreaks did not occur until 1779, but then occurred with some frequency. Outbreaks would have affected MGRS habitat by killing large spruce and opening the canopy but creating snags and logs. Outbreaks were relatively patchy until 1940, and individual outbreaks did not intensively damage the entire spruce-fir forest. Engelmann spruce extent increased rapidly once fire was excluded from the mixed-conifer, and insect regimes changed considerably once spruce matured throughout both the spruce-fir and mixed-conifer. Spruce beetle outbreak duration doubled, and the extent quadrupled compared to the pre-fire exclusion period. Outbreaks in the 1950s and late 1990s through early 2000s extensively affected all spruce-occupied areas. Effects of the 1950s outbreak on MGRS are not documented but were likely severe and possibly contributed to low MGRS population numbers at that time. The later outbreak devastated MGRS habitat. Our reconstruction indicates that little habitat existed in the late 1600s, gradually increased in area and quality through 1880, rapidly increased during the fire exclusion period, but declined rapidly in the 1950 and again in the late 1990s.

Una perspectiva histórica del hábitat de la ardilla roja del Monte Graham

Los requisitos de hábitat de la ardilla roja de Mount Graham (MGRS) incluyen bosques maduros con suficientes árboles con conos (especialmente piceas grandes), condiciones de dosel cerrado, troncos, temperaturas frescas y sombra. La reconstrucción del anillo arbóreo de la demografía forestal pinaleña de gran altitud y la historia de perturbaciones muestra pequeñas parcelas aisladas de hábitat marginal que existían después de un incendio de gran intensidad en 1685. El abeto Engelmann y el pino corkbark colonizaron gradualmente la zona de abetos. El bosque estaba en condiciones de dosel cerrado a principios de 1800, y relativamente maduro en todo el medio a fines de 1800. El fuego estuvo ausente entre 1685 y 2004. Los brotes del escarabajo de abeto no ocurrieron hasta 1779, pero luego ocurrieron con cierta frecuencia. Los brotes habrían afectado el hábitat del MGRS al matar grandes piceas y abrir el dosel, pero creando obstáculos y troncos. Los brotes fueron relativamente irregulares hasta 1940, y los brotes individuales no dañaron intensamente todo el bosque de abetos. La extensión de picea de Engelmann aumentó rápidamente una vez que se excluyó el fuego de la conífera mixta, y los regímenes de insectos cambiaron considerablemente una vez que la picea maduró tanto en el abeto rojo como en la conífera mixta. La duración del brote de escarabajo abeto se duplicó y su extensión se cuadruplicó en comparación con el período de exclusión previo al incendio. Los brotes en la década de 1950 y finales de la década de 1990 y principios de la de 2000 afectaron ampliamente a todas las áreas ocupadas por abetales. Los efectos del brote de 1950 en el MGRS no están documentados, pero probablemente fueron graves y posiblemente contribuyeron a un bajo número de poblaciones de MGRS en ese momento. El brote posterior devastó el hábitat de MGRS. Nuestra reconstrucción indica que el pequeño hábitat existía a fines del siglo XVII, aumentó gradualmente en área y calidad hasta 1880, aumentó rápidamente durante el período de exclusión del fuego, pero disminuyó rápidamente en el 1950 y nuevamente a fines del decenio de 1990.

NOTE: A manuscript was not submitted to accompany this presentation.

Session 16: Migrant Jaguars Go Both Ways, Sub-Session #1

Jaguar in the Peloncillo Mountains, Coronado National Forest, Arizona (Photo courtesy of the USDA Forest Service, Coronado National Forest)

Abstracts and Papers
Avila-Villegas
Cassaigne
Gutiérrez-González
Landau
Serraglio
Valenzuela

Northern Jaguars: Over A Decade of Field Observations along the Mexico-United States Borderlands

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We studied the jaguar (*Panthera onca*) in northwest Mexico and southwest United States from 2003 through 2017. From the remote Sierra Madre of Sonora, approximately 241 km south of the international border, to the sky islands of southeastern Arizona, there are similarities in topography, vegetation, and prey species in places occupied by jaguars, yet separated by cities, highways, borders and all sorts of human activity. Working in the field on both sides of the border provided us an insight into the habits of northern jaguars, broadening our perspective of jaguar conservation in a region historically occupied by this large cat. Habitat connectivity, from private properties and conservation areas in Mexico to national forests and other public lands in the United States, is vital for the long-term survival of the species. An impermeable barrier and unregulated law enforcement activities along the border are the biggest threat to the long- term recovery of jaguars in the region. Bi-national jaguar conservation efforts benefit other plants, animals and the places they inhabit, and allow people on a common goal.

Jaguares del Norte: Más de una década de observaciones de campo a lo largo de las fronteras de México y Estados Unidos

Estudiamos el jaguar (Panthera onca) en el noroeste de México y suroeste de los Estados Unidos desde 2003 hasta 2017. Desde la remota Sierra Madre de Sonora, aproximadamente 241 km al sur de la frontera internacional, hasta las islas del sudeste de Arizona, hay similitudes en la topografía, vegetación y especies de presas en lugares ocupados por jaguares, pero separados por ciudades, carreteras, fronteras y todo tipo de actividad humana. Trabajar en el campo a ambos lados de la frontera nos dio una idea de los hábitos de los jaguares del norte, ampliando nuestra perspectiva de la conservación del jaguar en una región históricamente ocupada por este felino grande. La conectividad del hábitat, desde propiedades privadas y áreas de conservación en México hasta bosques nacionales y otras tierras públicas en los Estados Unidos, es vital para la supervivencia a largo plazo de la especie. Una barrera impermeable y actividades policiacas no reguladas a lo largo de la frontera son las mayores amenazas para la recuperación a largo plazo de los jaguares en la región. Los esfuerzos binacionales de conservación del jaguar benefician a otras plantas, animales y lugares donde habitan, y permiten a las personas alcanzar un objetivo común.

NOTE: A manuscript was not submitted to accompany this presentation.

The Decline of a Jaguar (*Panthera onca*) Subpopulation in Sonora Mexico

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From January 2009 to June 2015, we placed trail cameras at 61 sites in a 441 km^2 area in northwestern Sonora, Mexico.We used the total number of jaguars captured/100 days of camera effort as the basis for a year-to-year evaluation of the status of the area's jaguar population. A T-test comparison between the first and last 365 days of the camera trapping effort shows

a significant difference between the two time period for jaguar presence as P= 0.006, t= 3.04. A marked decline in the number of jaguar detections/100 days was apparent. We documented the illegal killing of six jaguars and detected a 71% decline of the population by December of 2013. With a lack of enforcement of law, carbofuran, compound 1080 and traps, are being illegally use by many ranchers to kill predators. Focus of the study has changed since the middle of 2015 and we are now working directly with ranchers with the financial support of *Greater Good.org*. Through signed contracts they agree not to kill jaguars, or pumas, in return for financial assistance for ranch improvement infrastructure and synchronize calving plans to improve cattle management to reduce depredation. During this project, using GPS collars on jaguars and pumas, we were notified many times by cowboys that they would have killed the predators they observed, but were afraid that the animal was collared with a GPS collar. Such comments are indicative that a GPS collar can and does save jaguars and pumas, The collars can provide an investigative tool if needed in attempts to prosecute a person suspected of killing a jaguar or puma. It is recommended that as many Sonoran jaguars as possible be collared with GPS. This collaring effort should be combined with an education program that allows community school children to track and follow jaguars, even on their own family's ranch.

El declive de una subpoblación Jaguar (Panthera onca) en Sonora

Desde enero de 2009 a junio de 2015, colocamos cámaras de seguimiento en 61 sitios en un área de 441 km2 en el noroeste de Sonora, México. Usamos el número total de jaguares capturados / 100 días de esfuerzo de cámara como base para una evaluación anual del estado de la población de jaguares del área. Una comparación de prueba T entre el primero y el último de los 365 días del esfuerzo de captura de cámara muestra una diferencia significativa entre los dos períodos de tiempo para la presencia de jaguar como P = 0.006, t = 3.04. Una marcada disminución en el número de detecciones de jaguar / 100 días fue evidente. Documentamos el asesinato ilegal de seis jaguares y detectamos una disminución del 71% de la población para diciembre de 2013. Con la falta de aplicación de la ley, el carbofuran, el compuesto 1080 y las trampas están siendo utilizados ilegalmente por muchos rancheros para matar depredadores. El enfoque del estudio ha cambiado desde mediados de 2015 y ahora estamos trabajando directamente con ganaderos con el apoyo financiero de Greater Good.org. A través de contratos firmados, acuerdan no matar jaguares, o pumas, a cambio de asistencia financiera para la mejora de la infraestructura del rancho y sincronizar los planes de parto para mejorar el manejo del ganado a fin de reducir la depredación. Durante este proyecto, utilizando collares GPS en jaguares y pumas, los vaqueros nos avisaron en varias ocasiones que habrían matado a los depredadores que observaron, pero temieron que el animal tuviera un collar GPS. Tales comentarios son indicativos de que un collar GPS puede salvar a los jaguares y pumas, y puede proporcionar una herramienta de investigación si es necesario en un intento de enjuiciar a una persona sospechosa de matar a un jaguar o puma. Se recomienda que el mayor número posible de jaguares de Sonora tenga un collar con GPS. Este esfuerzo de collar debería combinarse con un programa educativo que permita a los niños de las escuelas comunitarias rastrear y seguir a los jaguares, incluso en el rancho de su propia familia.

Note: Full Paper Follows

The decline of a Jaguar (*Panthera onca)* subpopulation in Sonora Mexico.

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***Abstract**--During the period April 2009 - June 2015, we placed trail cameras at 61 sites in a 441 km^2 area in northwestern Sonora, Mexico. We used the total number of jaguars captured/100 days of camera effort as the basis for a year-to-year evaluation of the status of the area's jaguar population. A T-test comparison between the first and last 365 days of the camera trapping effort documented a significant difference between the two time periods for jaguar presence (P= 0.01, t= 2.56). We documented the illegal killing of six jaguars and detected a 71% decline of the population. With a lack of enforcement of law, poisons and traps are being illegally used by ranchers to kill predators. GPS collars can provide an investigative tool if needed in attempts to prosecute a person suspected of killing a jaguar or puma. We recommend that as many Sonoran jaguars as possible be collared with GPS combined with an education program that allows community school children to track and follow jaguars.*

INTRODUCTION

From April 2009 to June 2015, we placed trail cameras at 61 sites across 12 cattle ranches in a 441 km^2 area lying north of the junction of the Aros and Bavispe Rivers in northwestern Sonora, Mexico. We selected all 61 camera survey sites based on the presence of jaguar sign including tracks, scrapes, claw marks on scent trees, and locations from female and male jaguars captured and fitted with GPS satellite collars.

We accumulated 28,068 camera-trap days and identified individual jaguars using both right and left side pictures of unique rosette patterns. The total number of jaguars captured/100 days of camera effort was used as the basis for a year-to-year evaluation of the status of the area's jaguar population. All pictures were filed and analyzed using protocols described in Harris et al. 2010. This protocol is simple, free on the Internet and is compatible with Excel and the capture/recapture program Mark (Harris et al. 2010).

A total of 68,616 pictures of 29 mammalian species, including humans were captured. Twenty-six jaguars were identified by unique rosette patterns that included 13 males, 11 females, and two kittens. Five to 10 jaguars were present at anyone time within the study area from May 2009 through March 2012. After March 2012, we documented a steady decline in the number of jaguar detections/100days (Figure 1). Data from April 2009 to March 2010 were compared to data from April 2014 to March 2015, and resulted in a significant difference (P= 0.01, t= 2.56). By the end of March, 2014, we had already detected an approximate 71% decline of the jaguar population. By June 2015 only one jaguar was detected within the study area.

From January 2013 to May 2015, we documented the illegal killing of six jaguars within and surrounding the study area. The deaths of four of these animals were documented through interviews. The killing of one jaguar was validated with GPS collar data, and the examination of the burned remains of the carcass. This case, although turned over to the authorities, did not result in any penalty to the person responsible for the jaguar's death due to a lack of resources and experience of the authorities (PROFEPA and PGR). Additionally, we used a photo identification of the skin of a previously detected jaguar to verify a human-caused mortality.

Area ranchers told us that more jaguars were being killed in areas outside of the study area, but we could not verify these reports. Some of the jaguars we documented alive with camera traps would periodically be absent from the study area, only to return some months later. Some of these missing individuals may have relocated their home range and may still be alive. However, both GPS collared jaguars on our study site were killed, one probably by poison, and one by gunshot. Carbofuran (see An Ever-Changing Ecological Battlefield, The Wildlife Professional, May/June 2017) is a pesticide that is currently legal to

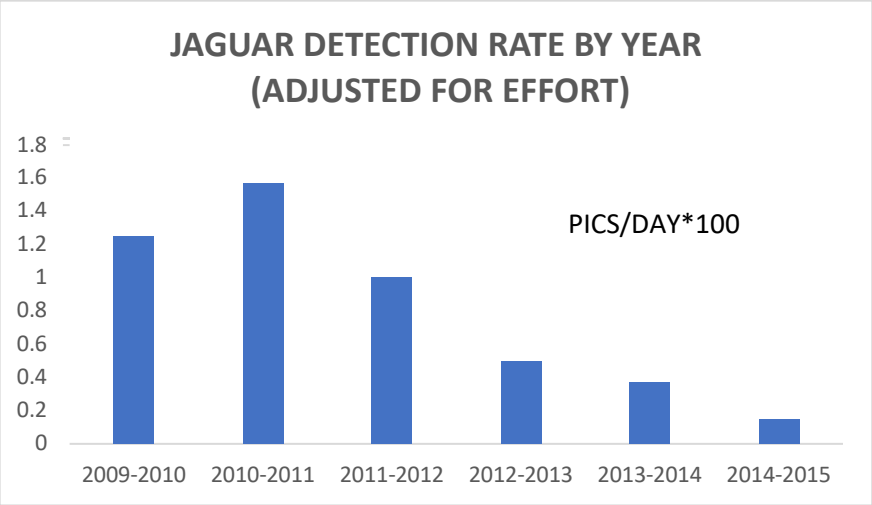

Figure 1. Declining detection rate of jaguars during the monitored periods from 2009 to 2015. These data include individuals photographed more than once, and adjusted by the number of pictures/100 days.

sell and use in Mexico. Compound 1080 is banned and illegal to use in Mexico, yet it is still manufactured for restricted use in the United States. Ranchers in Mexico are illegally using 1080 and/or Carbofuran to poison predators (Cassaigne and Galaz pers. observations). Placement of traps to kill animals is also illegal in Mexico, yet the lack of enforcement of law allows many ranchers to buy traps manufactured in the United States (and sold openly in Mexico), and place these traps on their ranches. We have captured pumas on camera with only 3 paws (Figure 2). Photographic evidence, sent to us anonymously, is proof of the current use of traps in the vicinity (Figure 3).

Figure 2. Picture of a puma from the study area missing a right front paw likely lost by steel-jawed trap). Note the atrophied right shoulder tissue (photo: Primero Conservation-Procer SEMARNAT-CONANP 2015).

Figure 3. Picture of dead jaguar sent anonymously. These highly effective trap sites are similar to those currently in use legally in Texas and New Mexico. Animals die likely from dehydration, exhaustion, and trauma due to infrequent trap site inspections (photo: anonymous).

The focus of the study has changed since the middle of 2015 and with the financial support of the not-for-profit Greater Good we are now working directly with ranchers that sign contracts not to kill jaguars or pumas in return for financial and field assistance for development of alternative water sources to keep livestock out of riparian areas favored by prey and predators during the dry seasons and to initiate a synchronized calving program, for which we also provide veterinarian assistance. Cameras are still being maintained in the core study area.

While documenting the diets of puma and jaguar during this project using GPS collars (Cassaigne et al. 2016), we were notified many times that "I would have killed a jaguar I observed, but I was afraid it may have had a GPS collar on it." Although satellite GPS collars are considered by many as being detrimental to an animal's daily activities, such comments from cowboys have showed us that GPS collars can and do save jaguars. When there is an informed community of area ranchers GPS collars can provide an investigative tool needed in any attempt to prosecute a person suspected of killing a jaguar or puma. It is recommended that as many Sonoran jaguars as possible be collared, and that the reasons for this be made public in the surrounding communities where jaguars are still extant.

CONCLUSIONS

This collaring effort should be combined with an educational program that allows community school children to track and follow jaguars, possibly on their own family's ranch. This will bring more attention to a declining jaguar population and the for-all-to-view reasons of mortalities. Along with this effort, there needs to be a salaried full-time person (privately funded) that will closely monitor collared animals, both on the internet and in the field, who can then immediately notify federal officials of a rapid response team of any mortalities. This person can also help verifying reported jaguar depredation of livestock for payment by existing governmental insurance programs. Finally, Mexico's laws need to be modified to increase the severity of punishment for crimes against wildlife and funding for wildlife law enforcement increased to facilitate proper training and resources that will result in improved investigations.

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Long-term jaguar monitoring in Sonora reveals healthy reproductive population

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The Northern Jaguar Project has worked since 2003 in a remote area near Sahuaripa, Sonora, Mexico. In this area, the 222-km² Northern Jaguar Reserve was established to protect a part of the northernmost reproductive jaguar population, which has been consistently monitored with camera traps since late 1999. To date, we have documented 60 individuals. We detect new individuals each year, and we have documented the presence of four cubs. Long-term monitoring has also allowed us to detect trends in densities, survival rates, and individual permanency. We observed a sex ratio population close to 1:1, indicating a healthy reproductive population. Maximum permanency for a male has been 3.6 years and 7.3 years for a female. We recently documented the return, after almost three years of absence, of the second-longest recorded female presence with 5.6 years in the area, indicating that larger areas need to be protected for jaguars. Jaguars in the region face threats mainly from illegal hunting and the use of poison. Besides the establishment of a protected jaguar reserve, we have maintained signed annual agreements with local ranchers to protect wildlife since 2007. This protection strategy has proven effective for jaguar survival, and it is an alternative to land purchase for jaguar conservation.

El monitoreo a largo plazo del jaguar en Sonora revela una población reproductora saludable

El Proyecto Northern Jaguar ha funcionado desde 2003 en un área remota cerca de Sahuaripa, Sonora, México. En esta área, la Reserva Northern Jaguar de 222 km² se estableció para proteger a una parte de la población de jaguares reproductivos más norteña, que ha sido monitoreada consistentemente con cámaras trampa desde fines de 1999. Hasta la fecha, hemos documentado 60 individuos. Detectamos nuevos jaguares cada año, y hemos documentado la presencia de cuatro cachorros. El monitoreo a largo plazo también nos ha permitido detectar tendencias en densidades, tasas de supervivencia y permanencia individual. Observamos una proporción de sexos cercana a 1: 1, lo que indica una población reproductiva saludable. La permanencia máxima para un macho ha sido de 3.6 años y 7.3 años para una hembra. Recientemente documentamos el regreso, después de casi tres años de ausencia, de la segunda presencia femenina más larga registrada con 5.6 años en el área, lo que indica que las áreas más grandes deben protegerse para los jaguares. Los jaguares en la región enfrentan amenazas principalmente de la caza ilegal y el uso de veneno. Además del establecimiento de una reserva de jaguar protegida, hemos mantenido acuerdos anuales firmados con rancheros locales para proteger la vida silvestre desde 2007. Esta estrategia de protección ha demostrado ser efectiva para la supervivencia del jaguar, y es una alternativa a la compra de tierras para la conservación del jaguar.

NOTE: A manuscript was not submitted to accompany this presentation.

Jaguar connectivity in the Borderlands: an evaluation of habitat connectivity in the Madrean Sky Islands

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In the Sky Islands, US-Mexico border security infrastructure and other barriers substantially impede cross-border connectivity for many species. Jaguars (*Panthera onca*) are no exception. The Sky Islands contain substantial habitat for jaguars, but for

currently unoccupied habitat in the United States to become occupied, jaguars must disperse from Mexico through a complex and changing landscape. To explore how jaguars might move through this landscape, we developed habitat connectivity models using Circuitscape. Source patches were delineated using a statistically derived map of jaguar habitat, and movement resistance was parameterized using the same habitat map in conjunction with data representing functional movement barriers and human disturbance. We mapped connectivity at a fine spatial scale to understand the degree to which suitable habitat patches in the Sky Islands are connected, identify where habitat corridors may exist, and explore how human land use in the form of transportation and border infrastructure affects habitat connectivity in the region.

Conectividad del Jaguar en las Tierras Fronterizas: una evaluación de la conectividad del hábitat en las Islas Serranas

En las Islas Serranas, la infraestructura de seguridad fronteriza entre Estados Unidos y México y otras barreras impiden sustancialmente la conectividad transfronteriza para muchas especies. Los jaguares (Panthera onca) no son una excepción. Las Islas Serranas contienen hábitat sustancial para los jaguares, pero para que el hábitat actualmente desocupado por esta especie en los Estados Unidos se ocupe, los jaguares deben dispersarse desde México a través de un paisaje complejo y cambiante. Para explorar cómo los jaguares podrían moverse a través de este paisaje, desarrollamos modelos de conectividad de hábitats utilizando Circuitscape. Los parches de origen se delinearon utilizando un mapa del hábitat del jaguar derivado estadísticamente, y la resistencia al movimiento se parametrizó utilizando el mismo mapa del hábitat junto con los datos que representan las barreras de movimiento funcional y la perturbación humana. Mapeamos la conectividad a una escala espacial fina para comprender el grado de conexión de hábitats adecuados en las Islas Serranas, identificamos dónde pueden existir corredores de hábitats y exploramos cómo el uso del suelo humano en forma de transporte e infraestructura fronteriza afecta la conectividad del hábitat en la región.

NOTE: A manuscript was not submitted to accompany this presentation.

Overview of the status of Jaguars in the U.S.

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Jaguars in the United States are few and far between, but millions of acres of suitable habitat remain available and the species benefits from special legal status and protections, which raises the prospect for recovery through the expansion of the Sonoran population into the U.S. However, threats abound from habitat fragmentation due to natural resource extraction, development and poaching. The proposed U.S.-Mexico border wall is the most egregious threat, but there are others. While lurching toward walling off the border on one hand, on the other, the U.S. government has established critical habitat for jaguars and is working on a recovery plan for the species, a draft of which has been released and received public comment. A brief overview of the situation in the U.S. will help set the stage for the panel discussion to follow.

Descripción general del estado de los jaguares en los EE. UU.

Los jaguares en los Estados Unidos son pocos y distantes, pero quedan millones de hectáreas de hábitat adecuado disponibles y la especie se beneficia de un estado legal especial y protecciones, lo que aumenta las posibilidades de recuperación mediante la expansión de la población de Sonora a los Estados Unidos. Sin embargo abundan las amenazas, desde la fragmentación del hábitat hasta la extracción de recursos naturales, el desarrollo y la caza furtiva. El muro fronterizo propuesto entre EE. UU. y México es la amenaza más atroz, pero hay otros. Mientras se tambalea para tapar la frontera por un lado, por otro lado, el gobierno de Estados Unidos ha establecido un hábitat crítico para los jaguares y está trabajando en un plan de recuperación

para la especie, cuyo borrador ha sido publicado y ha recibido comentarios del público. Una breve descripción general de la situación en los EE. UU. ayudará a establecer el escenario para la discusión del panel.

NOTE: A manuscript was not submitted to accompany this presentation.

Monitoring of wild cats using the photo-trapping technique in the Jaguar del Norte Reserve, Sahuaripa, Sonora

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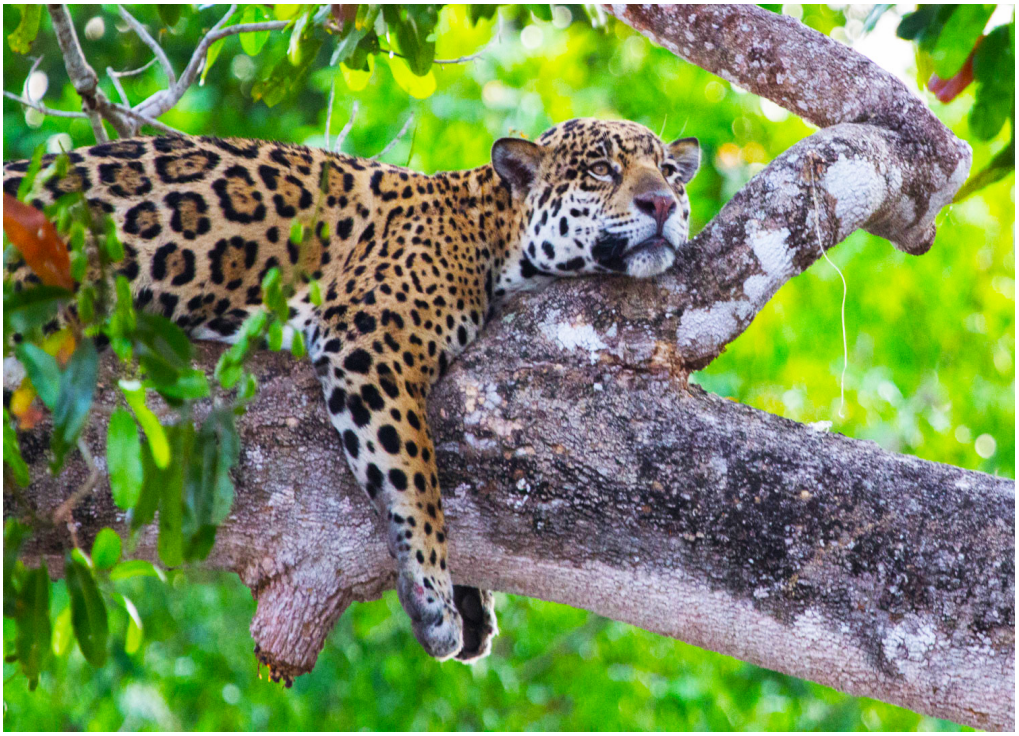
The Jaguar Reserve of the North (RJN) was created in 2003 with the purpose of protecting the northernmost population of jaguars (*Panthera onca*), and other equally important species that inhabit the territory of that region. With the purpose of generating information on the population of wild cats: jaguar, puma (*Puma concolor*), ocelot (*Leopardus pardalis*), and wild cat (*Lynx rufus*) were monitored with 92 trap cameras inside the RJN. In total, a sampling effort of 24,841 camera days was obtained for the seven periods in which the study was divided (January-December 2014). Thirteen species of mammals were recorded, among which, in addition to the felines, the coyote (*Canis latrans*) and the gray fox (*Urocyon cinereoargenteus*) stand out. The jaguar was photo-captured in 26 reserve sites. As for the indices of abundance (reg./100 days-cameras) the felines that got the highest values were, the lynx with 6.67 and the puma with 1.42. In contrast, the jaguar with 1.02 and the ocelot with 0.46 were the lowest. Regarding the density for the jaguar, the maximum value estimated was 1.5 (± 0.20) ind / 100 km^2. The photographic trapping was an efficient tool to estimate the abundance and density of wild cats. In order to conserve the jaguar in the RJN, the integral management of its populations and habitat must be considered. The results of the monitoring in the RJN continue demonstrating the importance of this region in the conservation of the jaguar and other key species.

Monitoreo de felinos silvestres mediante la técnica de foto-trampeo en la Reserva Jaguar del Norte, Sahuaripa, Sonora

La Reserva Jaguar del Norte (RJN) se creó en 2003 con la finalidad de proteger la población más norteña de jaguares (Panthera onca), y a otras especies igualmente importantes que habitan en el territorio de esa región. Con el propósito de generar información de la población de felinos silvestres: jaguar, puma (Puma concolor), ocelote (Leopardus pardalis), y gato montes (Lynx rufus) se realizaron monitoreos con 92 cámaras-trampa dentro de la RJN. En total se obtuvo un esfuerzo de muestreo de 24,841 días-cámaras para los siete periodos en los que se dividió el estudio (enero-diciembre del 2014). Se registraron 13 especies de mamíferos, entre las que destacan además de los felinos, el coyote (Canis latrans) y la zorra gris (Urocyon cinereoargenteus). El jaguar fue foto-capturado en 26 sitios de la reserva. En cuanto a los índices de abundancia (reg./100 días-cámaras) los felinos que consiguieron los valores más altos fueron, el lince con 6.67 y el puma con 1.42. En contraste, el jaguar con 1.02 y el ocelote con 0.46 fueron los más bajos. En lo que respecta a la densidad para el jaguar el valor máximo estimado fue 1.5 (±0.20) ind/100 km^2. El trampeo–fotográfico fue una herramienta eficiente para estimar la abundancia y densidad de los felinos silvestres. Para conservar al jaguar en la RJN se debe contemplar el manejo integral de sus poblaciones y del hábitat. Los resultados del monitoreo en la RJN continúan demostrando la importancia de esta región en la conservación del jaguar y otras especies claves.

NOTE: A manuscript was not submitted to accompany this presentation.

Session 17: Migrant Jaguars Go Both Ways, Sub-Session #2



Jaguar in the Peloncillo Mountains, Coronado National Forest, Arizona
(Photo courtesy of the U.S. Fish and Wildlife Service)

Abstracts and Papers
Alcála-Galván
Cassaigne
Gutiérrez-González

Ecological and productive conditions of livestock ranches with jaguar depredation conflicts in southern Sonora, Mexico

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This research was conducted by Naturalia - Comité para la Conservación de Especies Silvestres A. C. and the University of Sonora to generate conservation strategies for the jaguar in the Sierra Alamos - Cuchujaqui River Wildlife Protection Area. The objectives were to determine the ecological characteristics of rangelands and to evaluate the productivity of livestock systems. Analyses were carried out on ejido lands as well as on private ranches during the years 2014 to 2016. In general, livestock is developed under the cow-calf system with the production of calves for commercialization at weaning. Some producers combine this activity with the use of agricultural crops (grains and forage). In addition, at different scales, forest exploitation of tree species for construction material and coal production is carried out. All the activities together have an impact both on the ecological condition and on the current livestock productive capacity. As results we observed outstanding evidences of heavy overgrazing (30 to 800% of cattle overstocking) for prolonged periods of time. Consequently, there is a decrease in diversity and vegetation coverage, allowing continuous processes of hydric erosion. In terms of livestock productivity, the lack of livestock identification and production records is common, absence of grazing rotation systems and breeding seasons not defined. The production of calves is chronologically irregular, and calves are widely dispersed in the pasture. Cattle do not have their best nutritional status and are therefore weak and with limited defense capacity. This raises the risk of potential attacks by predators.

Condiciones ecológicas y productivas de ranchos ganaderos con conflictos de depredación jaguar en el sur de Sonora, México.

Esta investigación fue realizada por Naturalia - Comité para la Conservación de Especies Silvestres A.C. y la Universidad de Sonora para generar estrategias de conservación para el jaguar en la Sierra Álamos - Área de Protección de Vida Silvestre del Río Cuchujaqui. Los objetivos fueron determinar las características ecológicas de los pastizales y evaluar la productividad de los sistemas pecuarios. Los análisis se llevaron a cabo en tierras ejidales y en ranchos privados durante los años 2014 a 2016. En general, el ganado se desarrolla bajo el sistema vaca-ternera con la producción de terneros para comercialización al destete. Algunos productores combinan esta actividad con el uso de cultivos agrícolas (granos y forraje). Además, a diferentes escalas, se lleva a cabo la explotación forestal de las especies arbóreas para el material de construcción y la producción de carbón. Todas las actividades juntas tienen un impacto tanto en la condición ecológica como en la capacidad productiva actual del ganado. Como resultados, observamos evidencias sobresalientes de exceso de pastoreo (30 a 800% del ganado excedente) durante períodos prolongados. En consecuencia, hay una disminución de la diversidad y la cobertura de la vegetación, lo que permite procesos continuos de erosión hídrica. En términos de productividad ganadera, la falta de registros de identificación y producción de ganado es común, la ausencia de sistemas de rotación de pastoreo y las temporadas de cría no están definidas. La producción de terneros es cronológicamente irregular y están ampliamente dispersos en el pasto. El ganado no tiene su mejor estado nutricional y, por lo tanto, es débil y tiene una capacidad de defensa limitada. Esto aumenta el riesgo de posibles ataques de depredadores.

NOTE: A manuscript was not submitted to accompany this presentation.

The role of native prey restoration in reducing livestock depredation by puma (*Puma concolor*) and jaguar (*Panthera onca*) in Sonora, Mexico

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Livestock depredation by pumas and jaguars often results in their illegal killing in retaliation by ranchers. Through augmentation of peccaries (*Pecari tajacu*) and white-tailed deer (*Odocoileus virginianus*) on a 7,000 ha ranch, we tested the hypothesis of prey switching by both predators, when native prey species became more available. During an 8-month initial control period, we identified the diets of both pumas (*Puma concolor*) and jaguars (*Panthera onca*) in the study area. We estimated the relative abundances of white-tailed deer, peccary and cattle (*Bos tarus*) with camera traps. We collected scat for molecular identification of both prey and the depositing predator species, identified prey consumed at kill sites using GPS kill site clusters and estimated predator diet selectivity. During a subsequent second 8-month period, we translocated peccaries and increased deer density through artificial feeding during fawning season. Using molecular analyses of scat and GPS kill site investigations we detected a 73% and 65% decrease in livestock as prey, respectively. Since completing our study, we have added 5 more ranches to a program that includes restoration of peccaries, protection of native prey and improvement of cattle management through synchronized breeding with the support of Greater Good.org. Actions like killing predators to protect prey species have proven to be unseccesful in the long term and detrimental to the environment. The conservation of prey and predators in ranching operations should be achieved by actions that consider all species interaction and good livestock management practices.

El papel de la restauración de presas nativas en la reducción de la depredación del ganado por el puma (Puma concolor) y el jaguar (Panthera onca) en Sonora, México

La depredación de ganado por pumas y jaguares a menudo resulta en su muerte ilegal como represalia por parte de los rancheros. Mediante el aumento de los pecaríes (Pecari tajacu) y el venado de cola blanca (Odocoileus virginianus) en un rancho de 7,000 ha, probamos la hipótesis del cambio de presa por ambos depredadores, cuando las especies de presas nativas se volvieron más disponibles. Durante un período de control inicial de 8 meses, identificamos las dietas de ambos pumas (Puma concolor) y jaguares (Panthera onca) en el área de estudio. Estimamos la abundancia relativa de venado de cola blanca, pecarí y ganado (Bos tarus) con cámaras trampa. Recolectamos el excremento para la identificación molecular tanto de la presa como de las especies de depredadores depositantes, se identificaron las presas consumidas en los sitios de exterminio utilizando agrupaciones de sitios de destrucción GPS y la selectividad estimada de la dieta de los depredadores. Durante un segundo período subsecuente de 8 meses, trasladamos pecaríes y aumentamos la densidad de venado a través de la alimentación artificial durante la temporada de adormidera. Usando análisis moleculares de investigaciones de sitios de muerte de scat y GPS, detectamos una disminución del 73% y del 65% en el ganado como presa, respectivamente. Desde que completamos nuestro estudio, hemos agregado 5 ranchos más a un programa que incluye la restauración de pecaríes, la protección de las presas autóctonas y la mejora del manejo del ganado a través del mejoramiento sincronizado con el apoyo de Greater Good.org. Las acciones como matar depredadores para proteger a las especies presa han demostrado ser inexactas a largo plazo y perjudiciales para el medio ambiente. La conservación de presas y depredadores en operaciones de cría en granjas se debe lograr mediante acciones que consideren la interacción de todas las especies y las buenas prácticas de manejo del ganado.

NOTE: A manuscript was not submitted to accompany this presentation.

Viviendo con felinos: Community and conservation living with felines

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The Viviendo con Felinos (Living with Felines) project extends protection for four felines – jaguar, ocelot, mountain lion, and bobcat – on ranches surrounding the 222-km² Northern Jaguar Reserve. Viviendo con Felinos encourages an appreciation for the presence of living wildlife, minimizes human-wildlife conflicts, reduces jaguar mortality, restores essential habitat, and provides scientific data beyond the limits of the reserve. Ranchers sign annual contracts not to hunt, trap, bait, or disturb wildlife, and they receive economic incentives for feline photo documentation. Today, 14 ranches participate in the project, which encompasses a total of 308 km². Viviendo con Felinos is now in its tenth year and is sharing ranchers' perceptions of and motivations for participation, as well as how threats to felines and their habitat have been reduced. More than 25 individual jaguars have been documented, with 2,900 feline photo awards distributed. As they learn more about wildlife on their properties, ranchers recognize the value of increasing prey populations to reduce the likelihood of depredation, and they seek expanded and continuing assistance with restoration activities designed to benefit both wildlife and livestock. Overall, this project has proven to be a good strategy for jaguar survival. Developed by the Northern Jaguar Project, Viviendo con Felinos is a model of collaboration for communities throughout Mexico and the U.S. where human-wildlife conflicts exist.

Viviendo con felinos: Comunidad y conservación viviendo con felinos

El proyecto Viviendo con Felinos (Vivir con felinos) extiende la protección de cuatro tipos de felinos: jaguar, ocelote, león de montaña y lince rojo en los ranchos que rodean la Reserva del Jaguar del norte de 222 km². Viviendo con Felinos fomenta la apreciación de la presencia de vida silvestre viviente, minimiza los conflictos entre humanos y vida silvestre, reduce la mortalidad de jaguares, restaura el hábitat esencial y proporciona datos científicos más allá de los límites de la reserva. Los rancheros firman contratos anuales para no cazar, atrapar, cebar o alterar la vida silvestre, y reciben incentivos económicos para la documentación fotográfica felina. Hoy, 14 ranchos participan en el proyecto, que abarca un total de 308 km². Viviendo con Felinos está ahora en su décimo año y comparte información acerca de las percepciones y motivaciones de participación entre los rancheros, al igual que información en cómo se han reducido las amenazas a los felinos y su hábitat. Se han documentado más de 25 jaguares individuales, y se han distribuido 2,900 premios fotográficos de felinos. A medida que aprenden más sobre la vida silvestre en sus propiedades, los ganaderos reconocen el valor de aumentar las poblaciones de presas para reducir la probabilidad de depredación, y buscan asistencia ampliada y continua con actividades de restauración diseñadas para beneficiar tanto a la vida silvestre como al ganado. En general, este proyecto ha demostrado ser una buena estrategia para la supervivencia del jaguar. Desarrollado por Northern Jaguar Project, Viviendo con Felinos es un modelo de colaboración para comunidades en todo México y los EE. UU., donde existen conflictos entre humanos y vida silvestre.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 19: Ecological and Environmental Change, Sub-Session #1

Sky Island grasslands and mountain ecosystems.
(Photo courtesy of the Sky Island Alliance)

Abstracts and Papers
Chavez
Flesch
Higuera
Perkins
Sanderlin
Thomas

Drought and Climate Change: Impacts to Pima County and the Southwest

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Arizona has been in continuous drought since the mid 1990's. The 2014 U.S National Climate Assessment projects heat, drought and water scarcity will increase in the Southwest with continued climate change. Even without the effects of anthropogenic increases in greenhouse gasses, the Southwest has experienced extended periods of drought in the past. Drought has persisted locally in Pima County for approximately 22 years, observed by reoccurring below normal precipitation. While precipitation has decreased, local temperatures have increased. The years 2017, 2016, 2015 and 2014 were the warmest three four-year period on record. Rising temperature has significant implications for drought impacts. Decreased Colorado River Basin streamflow, snowpack and runoff efficiency combined with diminished local monsoon activity and an increasing probability of multi-decadal drought periods will affect water supply, ecosystem services, human health and economic sectors. Pima County is preparing for drought and climate change by implementing several programs and policies. The Drought Response Plan establishes four drought stages and corresponding response actions. The Community Wildfire Protection Plan establishes Wildland Urban Interface boundary. Ecological monitoring of Pima County's conservation lands evaluates environmental health by tracking changes in species, habitat and landscape patterns. This paper will describe drought and climate changes impacts to Pima County and the Southwest and the local programs and policies to addressthese impacts.

Sequía y cambio climático: impactos en el condado de Pima y el suroeste

Arizona ha estado en sequía continua desde mediados de la década de 1990. La Evaluación Climática Nacional 2014 de EE. UU., proyecta que el calor, la sequía y la escasez de agua aumentarán en el suroeste con el cambio climático continuo. Incluso sin los efectos del aumento antropogénico en los gases de efecto invernadero, el suroeste ha experimentado largos períodos de sequía en el pasado. La sequía persistió localmente en el Condado de Pima durante aproximadamente 22 años, observada por un recurrente bajo nivel de precipitación. Si bien la precipitación ha disminuido, las temperaturas locales han aumentado. Los años 2017, 2016, 2015 y 2014 fueron los tres períodos más cálidos de cuatro años en el registro. El aumento de la temperatura tiene implicaciones significativas para los impactos de la sequía. La disminución del flujo de la cuenca del río Colorado, la acumulación de nieve y la eficiencia de escorrentía combinada con la disminución de la actividad monzónica local y la creciente probabilidad de períodos de sequía multidecenal afectarán el suministro de agua, los servicios ecosistémicos, la salud humana y los sectores económicos. El Condado de Pima se está preparando para la sequía y el cambio climático mediante la implementación de varios programas y políticas. El Plan de respuesta a la sequía establece cuatro etapas de sequía y acciones de respuesta correspondientes. El Plan Comunitario de Protección contra Incendios Forestales establece el límite de la Interfaz Urbana Silvestre. El monitoreo ecológico de las tierras de conservación del Condado de Pima evalúa la salud ambiental mediante el seguimiento de los cambios en las especies, el hábitat y los patrones del paisaje. Este documento describirá los impactos de las sequías y los cambios climáticos en el Condado de Pima y el sudoeste y los programas y políticas locales para abordar estos impactos.

NOTE: A manuscript was not submitted to accompany this presentation.

Patterns and drivers of long-term changes in breeding bird communities in the Madrean Sky Islands and adjacent Sierra Madre in Mexico

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Periodic assessments of wildlife communities are important for understanding environmental change, especially in regions of high conservation value. Although the Madrean Sky Islands (MSI) are world renowned for their biodiversity, information on faunal and environmental change is limited, especially in Mexico. I compared observations from recent fieldwork (2009-2012) in Mexico with an extensive historical dataset (1880s-1950s), and used modeling and multivariate techniques to assess changes in species occurrence, richness, community composition, and associations with variation in climate, land-use, and other factors. Fieldwork spanned 26 MSI and 6 areas of the adjacent Sierra Madre, with historical comparisons focused on 11 ranges with extensive baselines. Breeding species richness in the MSI peaked in larger, higher-elevation ranges in the south and east, with regional beta diversity attributable more to turnover than nestedness. Species richness increased since the 1950s due to gains in riparian-, pine-, and forest-dependent species, and those with Neotropical and Madrean affinities. Distributions of Neotropical and Madrean species generally expanded northward and were associated with increasing temperature and summer-fall precipitation, suggesting poleward shifts linked to climate forcing now occurring globally. Despite regional gains of pine-dependent species, losses and turnover where higher in smaller more arid ranges where habitat loss consistent with anticipated climate-change impacts likely drove extinctions. High regional losses and turnover of cavity-dependent forest species were greatest in logged ranges due to past habitat degradation. Despite some auspicious trends, threats remain high. Restoration of large trees and snags combined with targeted species translocations may enhance conservation prospects.

Patrones y factores impulsores de los cambios a largo plazo en las comunidades de aves reproductoras en las Islas Serranas y la Sierra Madre adyacente en México

Las evaluaciones periódicas de las comunidades de vida silvestre son importantes para entender el cambio ambiental, especialmente en regiones de alto valor de conservación. Aunque las Islas Serranas Madrenses (MSI, por sus siglas en inglés) son mundialmente reconocidas por su biodiversidad, la información sobre el cambio en la fauna y el medio ambiente es limitada, especialmente en México. Comparé las observaciones del reciente trabajo de campo (2009-2012) en México con un extenso conjunto de datos históricos (1880s-1950s), y usé modelos y técnicas multivariantes para evaluar cambios en la ocurrencia de especies, riqueza, composición de la comunidad y asociaciones con la variación en clima, tierra -use, y otros factores. El trabajo de campo abarcó 26 MSI y 6 áreas de la Sierra Madre adyacente, con comparaciones históricas centradas en 11 rangos con líneas de base extensas. La riqueza de especies reproductoras en el MSI alcanzó su punto máximo en los rangos más grandes y de mayor elevación en el sur y el este, y la diversidad beta regional se atribuye más a la rotación que a la anidación. La riqueza de especies aumentó desde la década de 1950 debido a las ganancias en las especies ribereñas, pinadas y dependientes del bosque, y aquellas con afinidades neotropicales y maduras. Las distribuciones de las especies Neotropicales y Madrenses generalmente se expandieron hacia el norte y se asociaron con el aumento de la temperatura y la precipitación en el verano boreal, lo que sugiere cambios en los polos vinculados al forzamiento climático que se están dando en todo el mundo. A pesar de las ganancias regionales de las especies dependientes del pino, las pérdidas y el volumen de negocios fueron mayores en los rangos más pequeños y áridos donde la pérdida de hábitat consistente con los impactos anticipados del cambio climático probablemente condujo a la extinción. Las altas pérdidas regionales y el volumen de negocios de las especies forestales dependientes de cavidades fueron mayores en los intervalos de explotación debido a la degradación del hábitat en el pasado. A pesar de algunas tendencias auspiciosas, las amenazas siguen siendo altas. La restauración de árboles grandes y los inconvenientes combinados con translocaciones de especies específicas puede mejorar las perspectivas de conservación.

NOTE: A manuscript was not submitted to accompany this presentation.

Paleoenvironmental record from "El Kípor" region in the northwestern Sierra Madre Occidental, Sonora, Mexico

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A multidisciplinary study with a geological/ecological approach was made in a Late Quaternary small basin in the El Kípor region. This basin is located in the northwestern Sierra Madre Occidental (28° 24' 14"N, 108° 36' 00"W), to the southeast of the Sky Islands, in the state of Sonora, Mexico. The aim of this study is to determine the geological and biological paleoenvironments associated with this formation. Pollen, sediment grain size and organic content analyses in a 3.3 m sediment profile from the basin provided a paleoenvironmental record from 40,000 to 12,000 cal yr^{-1} BP. During this period, the study site, which is now surrounded by a pine-oak forest, was located in the mixed-conifer forest under more mesic conditions than today. Pollen and sediment data tracked high frequency climatic changes in the middle and late Wisconsin Period. Vegetation changes indicating drier and wetter periods were reflected in the pollen data by varying percentages of herb (mainly Poaceae) and tree pollen (mainly *Pinus*) and coarser/finer sediments respectively. During the wetter periods of the Late Wisconsin the plant communities were dominated by a mixed conifer forest with *Pinus, Abies, Picea* and *Pseudotsuga* at 1600 m altitude, whereas during drier periods, grasslands or more open woodlands were dominant.

Registro paleoambiental de la región "El Kípor" en el noroeste de la Sierra Madre Occidental, Sonora, México

Se realizó un estudio multidisciplinario con un enfoque geológico / ecológico en una pequeña cuenca del Cuaternario Tardío en la región de El Kípor. Esta cuenca se encuentra en el noroeste de la Sierra Madre Occidental (28 ° 24 '14 "N, 108 ° 36' 00" W), al sureste de las Islas Serranas, en el estado de Sonora, México. El objetivo de este estudio es determinar los paleoambientes geológicos y biológicos asociados con esta formación. El polen, el tamaño del grano de sedimento y los análisis de contenido orgánico en un perfil de sedimentos de 3.3 m de la cuenca proporcionaron un registro paleoambiental de 40,000 a 12,000 cal año^{-1} BP. Durante este período, el sitio de estudio, que ahora está rodeado por un bosque de pino-encino, se encuentra en el bosque de coníferas mixtas en condiciones más mésicas que en la actualidad. Los datos de polen y sedimentos registraron los cambios climáticos de alta frecuencia en el período medio y tardío de Wisconsin. Los cambios de vegetación que indican períodos más secos y húmedos se reflejaron en los datos de polen mediante porcentajes variables de hierba (principalmente Poaceae) y polen de árbol (principalmente Pinus) y sedimentos más gruesos / más finos, respectivamente. Durante los períodos más húmedos de finales de Wisconsin, las comunidades vegetales estuvieron dominadas por un bosque mixto de coníferas con Pinus, Abies, Picea y Pseudotsuga a 1600 m de altitud, mientras que durante los períodos más secos predominaron los pastizales o los bosques abiertos. análisis de contenido orgánico en un perfil de sedimentos de 3.3 metros de la cuenca proporcionaron un registro paleoambiental de 40,000 a 12,000 cal año BP. Durante este período, el sitio de estudio, que ahora está rodeado por un bosque de pino-encino, se encuentra en el bosque de coníferas mixtas en condiciones más mésicas que en la actualidad. Los datos de polen y sedimentos registraron los cambios climáticos de alta frecuencia en el período medio y tardío de Wisconsin. Los cambios de vegetación que indican períodos más secos y húmedos se reflejaron en los datos de polen mediante porcentajes variables de hierba (principalmente Poaceae) y polen de árbol (principalmente Pinus) y sedimentos más gruesos / más finos, respectivamente. Durante los períodos más húmedos de finales de Wisconsin, las comunidades vegetales estuvieron dominadas por un bosque mixto de coníferas con Pinus, Abies, Picea y Pseudotsuga a 1600 m de altitud, mientras que durante los períodos más secos predominaron los pastizales o los bosques abiertos.

NOTE: A manuscript was not submitted to accompany this presentation.

Potential extirpations and declines of medium and large mammals in the Tucson Mountains

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An inventory of mammals using camera traps (wildlife cameras) in the Tucson Mountain District of Saguaro National Park during 2011-2012 failed to detect several small carnivore species that were detected during a similar survey in 2002-2003, despite a larger effort and the fact that we found little difference between two surveys in the same period in the Rincon Mountain District of the park. Concerned that the Tucson Mountains may be losing mammal species, Saguaro National Park has continued surveys and worked in collaboration with many local organizations to compile wildlife camera data from the greater Tucson Mountain area during the past six years. We will present the results of these efforts and discuss the potential for extirpation and declines of species in the Tucson Mountains as it becomes increasingly isolated due to urban development and linear infrastructure such as canals and highways.

Posibles extirpaciones y disminuciones de mamíferos medianos y grandes en las montañas de Tucson

Un inventario de mamíferos usando cámaras trampa (cámaras de vida silvestre) en el Distrito de Tucson del Parque Nacional Saguaro durante 2011-2012 no detectó varias especies pequeñas de carnívoros que se detectaron durante una encuesta similar en 2002-2003, a pesar de un esfuerzo mayor y el hecho que encontramos poca diferencia entre dos encuestas en el mismo período en el Distrito de las Montañas Rincon. Preocupado de que las montañas de Tucson puedan estar perdiendo especies de mamíferos, el Parque Nacional Saguaro ha continuado las encuestas y trabajado en colaboración con una gran cantidad de organizaciones locales para recopilar datos de cámaras de vida salvaje de la zona montañosa de Tucson durante los últimos seis años. Presentaremos los resultados de estos esfuerzos y discutiremos el potencial de extirpación y disminución de especies en las montañas de Tucson, ya que se vuelve cada vez más aislado debido al desarrollo urbano y la infraestructura lineal, como canales y carreteras.

NOTE: A manuscript was not submitted to accompany this presentation.

Evaluating change in avian communities from wildfire in the Arizona Sky Islands

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The avifauna within the Sky Islands of southeastern Arizona includes species found nowhere else in the U.S. Thus, birdwatchers from across the globe visit the region, providing a vibrant state and local ecotourism industry. We initiated a study on birds across montane forest and woodland types in the Santa Rita, Santa Catalina, Huachuca, Chiricahua, and Pinaleño Mountains (Coronado National Forest) from 1991 to 1995. Since then, the region has been under increased stress from ongoing drought and wildfire, possibly associated with climate change. We know little about fire effects on populations and habitats of Neotropical migratory birds in this region. Our objectives were to determine if bird distribution patterns and species diversity changed over time and if changes were attributable to fire and climate change. Secondly, we wanted to evaluate relationships of fire severity and time since fire with these avian communities. During spring and summer 2014, we

resampled birds and vegetation at 28 of the original transects (n = 328 count stations). We used multi-species, multi-season occupancy models in a Bayesian hierarchical framework to estimate species richness and community dynamics, while accounting for imperfect detection. We used time since fire and fire severity to assess temporal and spatial variation in fire effects. Results indicate positive and negative responses to fire by individual species, and changes in community dynamics. By re-sampling vegetation and birds following wildfire, our study can provide guidance with post-fire restoration, and assist with conserving avian community structure.

Evaluación del cambio en las comunidades avícolas a causa de los incendios forestales en las Islas Serranas de Arizona

La avifauna dentro de las Islas Serranas del sudeste de Arizona incluye especies que no se encuentran en ningún otro lugar en los Estados Unidos. Por lo tanto, los observadores de aves de todo el mundo visitan la región, proporcionando un vibrante estado y la industria del ecoturismo local. Iniciamos un estudio sobre aves a través de bosques montanos y tipos de bosques en las montañas Santa Rita, Santa Catalina, Huachuca, Chiricahua y Pinaleño (Bosque Nacional Coronado) de 1991 a 1995. Desde entonces, la región ha estado bajo mayor estrés por la sequía en curso e incendios forestales, posiblemente asociados con el cambio climático. Sabemos poco sobre los efectos del fuego en las poblaciones y hábitats de aves migratorias neotropicales en esta región. Nuestros objetivos fueron determinar si los patrones de distribución de aves y la diversidad de especies cambiaron con el tiempo y si los cambios fueron atribuibles a incendios y al cambio climático. En segundo lugar, queríamos evaluar las relaciones de gravedad del incendio y el tiempo desde el incendio con estas comunidades avícolas. Durante la primavera y el verano de 2014, volvimos a muestrear aves y vegetación en 28 de los transectos originales (n = 328 estaciones de conteo). Utilizamos modelos de ocupación multiespecífica y de varias temporadas en un marco jerárquico bayesiano para estimar la riqueza de especies y la dinámica de la comunidad, a la vez que tomamos en cuenta la detección imperfecta. Utilizamos el tiempo desde la severidad del incendio y del fuego para evaluar la variación temporal y espacial en los efectos del fuego. Los resultados indican respuestas positivas y negativas al fuego por especies individuales y cambios en la dinámica de la comunidad. Al volver a muestrear la vegetación y las aves después de un incendio forestal, nuestro estudio puede proporcionar una guía para la restauración posterior al incendio y ayudar a conservar la estructura de la comunidad aviar.

NOTE: A manuscript was not submitted to accompany this presentation.

A look to Sky Island plant community vulnerability to changing climate

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Land stewards have interest in how plant communities and their component species will respond to future climate conditions. Within plant communities, declining climatic suitability for characteristic plants may increase vulnerability of the community. With increased vulnerability, the structure and function of the community may degrade and provisioning of ecosystem services decline. We characterized vulnerability of major plant communities of the Madrean region as represented by the Apache-Highlands ecoregion in Arizona under two future climate scenarios representing lower- and higher-end projections of precipitation and temperature averaged for 2041 to 2060. We modeled the suitable climate of characteristic plants of communities within the Apache-Highlands. Change in suitable climate for each species between current and future climate scenarios was categorized as increasing, stable, less, or declining suitability. We characterized plant community vulnerability (high, medium, or low) by combining the suitability models of the communities' component characteristic species. We found 22.5% and 20.0% of this ecoregion was predicted to have low vulnerability under the lower- and higher-end scenarios, respectively, and 8.9% and 14.1% predicted with high vulnerability. Landscape-level forecasts, such as this, can inform management decision-making in response to the complex challenges shifting climatic conditions pose.

Una mirada a la vulnerabilidad de la comunidad de plantas en las Islas Serranas al clima cambiante

Los administradores de la tierra tienen interés en cómo las comunidades de plantas y sus especies componentes responderán a las condiciones climáticas futuras. Dentro de las comunidades de plantas, la disminución de la idoneidad climática para las plantas características puede aumentar la vulnerabilidad de la comunidad. Con una mayor vulnerabilidad, la estructura y la función de la comunidad pueden degradarse y el aprovisionamiento de los servicios del ecosistema puede disminuir. Caracterizamos la vulnerabilidad de las principales comunidades vegetales de la región Madrense representada por la ecorregión Apache-Highlands en el sur de Arizona en dos escenarios climáticos futuros que representan las proyecciones de precipitaciones y temperaturas más bajas y más altas promediadas para 2041 al 2060. Modelamos el clima adecuado de plantas características de las comunidades dentro de las tierras altas de Apache. El cambio en el clima adecuado para cada especie entre los escenarios climáticos actuales y futuros se categorizó como idoneidad creciente, estable, menor o decreciente. Caracterizamos la vulnerabilidad de la comunidad vegetal (alta, media o baja) al combinar los modelos de idoneidad de las especies características de las comunidades. Encontramos que el 22.5% y el 20.0% de esta ecorregión tienen baja vulnerabilidad en los escenarios de menor y mayor nivel, respectivamente, y 8.9% y 14.1% son de alta vulnerabilidad. Los pronósticos a nivel del paisaje, como este, pueden informar la toma de decisiones de la administración en respuesta a los complejos desafíos que plantean las cambiantes condiciones climáticas.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 20: Ecological and Environmental Change, Session #2

Peloncillo Mountains and Animas Mountains (in the distance, Coronado National Forest, New Mexico (Photo courtesy of the USDA Forest Service, Rocky Muntain Research Station. Photo by Gerald J. Gottfried)

Abstracts and Papers
Iniguez
Lynch
Lynch
Minor

Changes in forest structure relative to burn severity across Madrean vegetation communities

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The forest and woodlands of the sky island region of Southeastern Arizona have recently been impacted by a series of wildfires that have changed their structure, however other than satellite-based burn severity maps there is little quantitative information on those specific impacts. We used data from vegetation plots, sampled across forest cover types using the same methodology before and after wildfires in five sky islands, to assess changes in forest structure. We sampled pre-fire forest structure in 1994-1995 as part of an avian community study, while post-fire measurements were collected between 2009 and 2015. Wildfire impacts varied among cover types and forest structure metrics. High severity wildfires typically reduced basal area and tree density to very low levels in all cover types, while low severity fires had little impact in most cover types. Moderate severity fires, however, significantly reduced basal area and tree densities which are now within the regional desired conditions. Our results suggest that in many cases recent wildfires have been beneficial in terms of moving forest structures towards desired conditions; however, in many cases frequent fires are still needed to maintain open forest structure and reduce the increase of dead and down wood.

Cambios en la estructura del bosque en relación con la severidad de las quemaduras en las comunidades de vegetación de la región Madrense

Los bosques de la región insular del sudeste de Arizona se han visto recientemente afectados por una serie de incendios que han cambiado su estructura; sin embargo, aparte de los mapas de gravedad de incendio basados en satélites, hay poca información cuantitativa sobre esos impactos específicos. Utilizamos datos de parcelas de vegetación, muestreadas a través de tipos de cubierta forestal utilizando la misma metodología antes y después de incendios forestales en cinco Islas Serranas, para evaluar los cambios en la estructura del bosque. Muestreamos la estructura forestal anterior al incendio en 1994-1995 como parte de un estudio de la comunidad aviar, mientras que las mediciones posteriores al incendio se recogieron entre 2009 y 2015. Los impactos de los incendios forestales variaron entre los tipos de cobertura y las métricas de la estructura forestal. Los incendios forestales de alta severidad típicamente reducen el área basal y la densidad de árboles a niveles muy bajos en todos los tipos de cobertura, mientras que los incendios de poca severidad tienen poco impacto en la mayoría de los tipos de cobertura. Los incendios de severidad moderada, sin embargo, redujeron significativamente la superficie basal y las densidades arbóreas que ahora se encuentran dentro de las condiciones regionales deseadas. Nuestros resultados sugieren que en muchos casos los recientes incendios forestales han sido beneficiosos en términos de mover las estructuras forestales hacia las condiciones deseadas; sin embargo, en muchos casos todavía se necesitan incendios frecuentes para mantener la estructura del bosque abierto y reducir el aumento de la madera muerta y caída.

NOTE: A manuscript was not submitted to accompany this presentation.

Spruce aphid (*Elatobium abietinum*) population response to temperature regimes on Engelmann spruce in the Pinaleño Mountains

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Elatobium abietinum (Walker) is an exotic insect causing extensive and severe damage to Engelmann spruce in Southwestern montane forests. Spruce aphid feeds on dormant spruce, and in maritime forests, outbreaks develop in the spring after warm winters. Prior to establishing in the Southwestern U.S., outbreaks and damage were limited to maritime areas where temperatures seldom fall below freezing. In the Southwest outbreaks develop in autumn and early winter, sometimes persisting through spring. I monitored spruce aphid population densities over several years in the Pinaleños to establish population responses to montane temperature regimes. A cold-hardy egg stage allows populations to survive temperatures well below freezing, so populations can persist over cold winters. Extended autumns in which Engelmann spruce is dormant and temperatures are warm allow aphid populations to increase and be maintained at damaging levels over extended periods. A long period with damaging population levels causes trees to decline and, in the worst years, to die (24-42% mortality after a severe event). This exotic will continue to destabilize spruce-fir forests in the Southwest, especially with increasingly frequent warm winters.

Respuesta de la población de pulgón de abeto (Elatobium abietinum) a los regímenes de temperatura en el abeto Engelmann en las montañas de Pinaleño

Elatobium abietinum (Walker) es un insecto exótico que causa daños extensos y severos a la picea de Engelmann en los bosques montanos del sudoeste. El áfido de abeto se alimenta de abeto inactivo, y en los bosques marítimos, los brotes se desarrollan en la primavera después de inviernos cálidos. Antes de establecerse en el sudoeste de los EE. UU., los brotes y daños se limitaban a áreas marítimas donde las temperaturas rara vez caían por debajo del punto de congelación. En el suroeste de los Estados Unidos, los brotes se desarrollan en otoño e inicios de invierno, a veces persistiendo durante la primavera. Supervisé las densidades de población de áfidos de picea durante varios años en los Pinaleños para establecer las respuestas de la población a los regímenes de temperatura montañosa. Una etapa de huevo resistente al frío permite que las poblaciones sobrevivan las temperaturas muy por debajo del punto de congelación, por lo que las poblaciones pueden persistir durante los inviernos fríos. Los otoños extendidos en los que el abeto Engelmann está inactivo y las temperaturas son cálidas permiten que las poblaciones de áfidos aumenten y se mantengan a niveles perjudiciales durante períodos prolongados. Un largo período con niveles perjudiciales de población hace que los árboles disminuyan y, en los peores años, que mueran (mortalidad del 24-42% después de un evento grave). Este exótico continuará desestabilizando los bosques de piceas en el suroeste, especialmente con inviernos cálidos cada vez más frecuentes.

NOTE: A manuscript was not submitted to accompany this presentation.

Disturbance regime changes during the period of fire exclusion in high-elevation forests of the Pinaleño Mountains, Arizona: Characterization and management implications

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Historically, fire was rare in cool, moist Southwestern spruce-fir forests and thus spruce-fir was not directly impacted by fire exclusion during the post-settlement era. However, fire exclusion did affect lower-elevation adjacent mixed-conifer forests, altering disturbance regimes in spruce-fir and mixed-conifer forests. We dendrochronologically reconstructed tree population demographics and fire and insect disturbance histories along a gradient of forest types to determine effects of fire exclusion on tree population demographics and disturbance regimes. As expected, structure and species composition changed substantially in the mixed-conifer forests but not in the spruce-fir forest during the period of fire exclusion, with median tree densities in the mixed-conifer increasing 8- to 18-fold. Significant changes to species composition in mixed-conifer forests favored competition-mediated species over fire-adapted species. After fire was excluded, Engelmann spruce and corkbark fir colonized the mixed-conifer forest, doubling their extent. Subsequent spruce beetle outbreak size increased with spruce extent, and outbreak duration doubled. Occupation of relatively low-elevation habitats by Engelmann spruce originating from higher-elevation seed sources has likely contributed to the high severity of spruce aphid outbreaks. Eighty percent of the studied landscape was converted from a frequent, low-severity fire regime to an infrequent mixed- to high-severity fire regime. High quantities of vertically and horizontally connected fuels in the mixed-conifer forest likely contributed to loss of the majority of the spruce-fir forest in 2004 and 2017 fires that spread from the adjacent mixed-conifer forest. Our findings have important implications for forest restoration efforts and will assist managers in prioritizing treatments.

Cambios en el régimen de perturbaciones durante el período de exclusión de incendios en bosques de alta elevación de las montañas Pinaleño, Arizona: implicaciones de caracterización y manejo

Históricamente, el fuego era raro en los bosques frescos y húmedos del abeto del sudoeste de los Estados Unidos y, por lo tanto, el abeto no se vio directamente afectado por la exclusión del fuego durante la era posterior al asentamiento Europeo. Sin embargo, la exclusión de incendios sí afectó bosques de coníferas mixtas adyacentes de menor elevación, alterando los regímenes de perturbación en los bosques de abetos y de coníferas mixtas. Hemos reconstruido dendrocronológicamente los datos demográficos de la población de árboles y los incendios y las historias de perturbaciones de insectos a lo largo de un gradiente de tipos de bosques para determinar los efectos de la exclusión de incendios en la población de árboles demográficos y los regímenes de perturbación. Como era de esperar, la estructura y la composición de las especies cambiaron sustancialmente en los bosques de coníferas mixtas pero no en el bosque de abetos durante el período de exclusión del fuego, con densidades medias de árboles en las coníferas mixtas que aumentaron de 8 a 18 veces. Los cambios significativos en la composición de las especies en los bosques mixtos de coníferas favorecieron a las especies mediadas por la competencia sobre las especies adaptadas al fuego. Después de que se excluyera el fuego, abeto Engelmann y abeto blanco colonizaron el bosque de coníferas mixtas, doblando su extensión. El tamaño posterior del brote de escarabajo de abeto aumentó con la extensión de abeto, y la duración del brote se duplicó. La ocupación de hábitats de altura relativamente baja por piceas de Engelmann provenientes de fuentes de semillas de mayor elevación probablemente haya contribuido a la alta severidad de los brotes de áfidos de abeto. El ochenta por ciento del paisaje estudiado se convirtió de un régimen de fuego frecuente, de baja severidad, a un régimen de fuego infrecuente de severidad mixta a alta. Grandes cantidades de combustibles conectados vertical y horizontalmente en el bosque de coníferas mixtas probablemente contribuyeron a la pérdida de la mayoría del bosque de abetos en los incendios de 2004 y 2017 que se extendieron desde el bosque adyacente de coníferas mixtas. Nuestros hallazgos tienen implicaciones importantes para los esfuerzos de restauración forestal y ayudarán a los gerentes a priorizar los tratamientos.

NOTE: A manuscript was not submitted to accompany this presentation.

Vegetation Community Change following Mixed-Severity Reburning

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The Madrean Sky Islands contain fire-adapted vegetation communities composed of plants displaying a range of traits that help them survive or recover following fire. These traits include fire resistance (thick bark, lofted canopies, durable seeds) and fire resilience (below-ground reserves, and rapid post-fire sprouting or germination from seed). The capacity of various species to survive and recover in response to sequences of mixed-severity fire is a function of the unique set of fire resistant and fire resilient adaptations. We evaluated the response of Madrean Sky Island plant communities, grouped into fire-relevant plant functional types and differentiated by structural form, to sequences of mixed-severity fire separated by 17 years in Pine-Oak and Mixed-Conifer vegetation types in the Chiricahua Mountains of southeastern Arizona. Using the 1994 Rattlesnake Fire, which was reburned by the 2011 Horseshoe 2 Fire, we studied the plant communities emerging following the two fires across the full range of fire severity combinations. In Pine-Oak forests, repeated moderate and high severity fire shifts the community into shrubland dominated by resprouting species. In Mixed Conifer forests, recent high severity fire promotes the growth of seed-germinating shrub species and aspen-locust patches, as well as conversion to meadows. Unburned Pine-Oak forests differ significantly from areas experiencing sequences of low, moderate, and high severity fire, and contain species typically found in mesic and high-elevation areas. Unburned Mixed Conifer forests do not differ as greatly from similar forests experiencing sequences of low severity fire, but have structural and compositional differences from more severely burned areas.

Cambio en la comunidad de la vegetación después de la reabastecimiento de gravedad mixta

Las Islas Serranas Madrenses contienen comunidades de vegetación adaptadas al fuego, compuestas de plantas que exhiben una variedad de características que las ayudan a sobrevivir o recuperarse después de un incendio. Estos rasgos incluyen resistencia al fuego (corteza gruesa, toldos elevados, semillas duraderas) y resiliencia al fuego (reservas subterráneas, y brotación o rápida germinación de la semilla después del fuego). La capacidad de varias especies para sobrevivir y recuperarse en respuesta a secuencias de fuego de gravedad mixta es una función del conjunto único de adaptaciones resistentes al fuego. Evaluamos la respuesta de las comunidades vegetales de las Islas Serranas Madrenses, agrupadas en tipos funcionales de plantas relevantes para incendios y diferenciadas por forma estructural, a secuencias de incendios de gravedad mixta separados por 17 años en tipos de vegetación de pino-roble y conífera mixta en las montañas Chiricahua del sudeste de Arizona. Utilizando el 1994 Rattlesnake Fire, que fue re-incendiado por el 2011 Horseshoe 2 Fire, estudiamos las comunidades de plantas que surgieron después de los dos incendios en toda la gama de combinaciones de severidad de incendios. En los bosques de pino-encino, el fuego repetido de intensidad moderada y alta convierte a la comunidad en un matorral dominado por especies de rebrotaje. En los bosques mixtos de coníferas, los recientes incendios de alta severidad promueven el crecimiento de especies de arbustos germinadores de semillas y parches de álamo temblón, así como la conversión a prados. Los bosques de pino-encino no quemados difieren significativamente de las áreas que experimentan secuencias de fuego de severidad baja, moderada y alta, y contienen especies que se encuentran típicamente en áreas mésicas y de gran elevación. Los bosques mixtos de coníferas no quemadas no difieren tanto de los bosques similares que experimentan secuencias de fuego de baja severidad, pero tienen diferencias estructurales y de composición con respecto a las áreas quemadas más severamente.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 21: Ecological and Environmental Change, Session #3

Peloncillo Mountains Precribed Fire, Coronado National Forest, New Mexico
(Photo courtesty of the USDA Forest Service, Coronado National Forest)

Abstracts and Papers
Bryan
Robinson

Scenario Planning Around Resource Challenges (SPARC): A Management-Centered Approach to Scenario Planning for Climate Adaptation

Alexander Bryan[1], Carolyn Enquist[2]

U.S. Geological Survey, Amherst, MA[1]; and U.S. Geological Survey, Tucson, AZ[2]

Scenario planning is a strategy or framework that aids making decisions under uncertainty. Inspired by widespread use in the areas of military and business, recent work has applied the strategy to anticipate the effects of climate change on natural resource management. Most scenario planning efforts identify scenarios based on uncertain response in two key drivers of change (e.g., climate, ecology, land use) and then consider the resultant effects on the system and possible changes to management protocols. We present an alternative implementation of scenario planning — Scenario Planning Around Resource Challenges (SPARC) — that produces scenarios that are driven directly by management concerns rather than by the leading scientific uncertainties. The three-step process entails (1) compiling information from the manager (resources, goals, priorities), (2) building scenarios from the leading possible outcomes suggested by the scientific literature and manager perspectives, and (3) running each scenario (i.e., outcome) one-by-one to consider adjustments to management protocols. In short, the unknowns become the scenarios that reflect management priorities. Rather than focusing on the dominant scientific uncertainties, managers spend their time considering only the uncertainties that directly affect the decisions they make. Here, we examine this approach using a case study from a landscape conservation design process led by the Desert Landscape Conservation Cooperative in the Madrean Ecoregion of southeastern Arizona, U.S.A.

Planificación de escenarios en torno a los desafíos de recursos (SPARC): un enfoque centrado en la gestión para la planificación de escenarios para la adaptación climática

La planificación de escenarios es una estrategia o marco que ayuda a tomar decisiones en condiciones de incertidumbre. Inspirado por el uso generalizado en las áreas militar y empresarial, el trabajo reciente ha aplicado la estrategia para anticipar los efectos del cambio climático en la gestión de los recursos naturales. La mayoría de los esfuerzos de planificación de escenarios identifican escenarios basados en respuestas inciertas en dos factores clave de cambio (por ejemplo, clima, ecología, uso de la tierra) y luego consideran los efectos resultantes en el sistema y los posibles cambios en los protocolos de gestión. Presentamos una implementación alternativa de planificación de escenarios - Planificación de escenarios en torno a desafíos de recursos (SPARC) - que produce escenarios que son impulsados directamente por preocupaciones de gestión en lugar de por las principales incertidumbres científicas. El proceso de tres pasos implica (1) recopilar información del gerente (recursos, metas, prioridades), (2) construir escenarios a partir de los principales resultados posibles sugeridos por la literatura científica y las perspectivas del gerente, y (3) ejecutar cada escenario (es decir, , resultado) uno por uno para considerar los ajustes a los protocolos de gestión. En resumen, las incógnitas se convierten en escenarios que reflejan las prioridades de gestión. En lugar de centrarse en las incertidumbres científicas dominantes, los gerentes dedican su tiempo a considerar solo las incertidumbres que afectan directamente las decisiones que toman. Aquí, examinamos este enfoque utilizando un estudio de caso de un proceso de diseño de conservación del paisaje dirigido por la Cooperativa de Conservación del Paisaje del Desierto en la ecorregión Madrean del sureste de Arizona, EE. UU.

Note: Full Paper Follows

Scenario Planning Around Resource Challenges (SPARC): A Management-Centered Approach to Scenario Planning for Climate Adaptation

Alexander Bryan[1], Carolyn Enquist[2]

U.S. Geological Survey, Amherst, MA[1]; and U.S. Geological Survey, Tucson, AZ[2]

Abstract--*Scenario planning is a strategy or framework that aids making decisions under uncertainty. Inspired by widespread use in the areas of military and business, recent work has applied the strategy to anticipate the effects of climate change on natural resource management. Most scenario planning efforts identify scenarios based on uncertain response in two key drivers of change (e.g., climate, ecology, land use) and then consider the resultant effects on the system and possible changes to management protocols. We present an alternative implementation of scenario planning — Scenario Planning Around Resource Challenges (SPARC) — that produces scenarios that are driven directly by management concerns rather than by the leading scientific uncertainties. The three-step process entails (1) compiling information from the manager (resources, goals, priorities), (2) building scenarios from the leading possible outcomes suggested by the scientific literature and manager perspectives, and (3) running each scenario (i.e., outcome) one-by-one to consider adjustments to management protocols. In short, the unknowns become the scenarios that reflect management priorities. Rather than focusing on the dominant scientific uncertainties, managers spend their time considering only the uncertainties that directly affect the decisions they make. Here, we examine this approach using a case study from a landscape conservation design process led by the Desert Landscape Conservation Cooperative in the Madrean Ecoregion of southeastern Arizona, U.S.A.*

INTRODUCTION

Scenario planning is the act of planning ahead in the face of future uncertainty by considering multiple plausible alternative futures, or scenarios (Coates 2000; Peterson et al. 2003). Long used by the military and the business community (e.g., Royal Dutch Shell) to anticipate enemy or competitor responses to actions (Kahn and Wiener 1967; Shoemaker and van der Heijden 1992), the approach is now widely used for climate adaptation planning across a variety of sectors (e.g., city utilities, community development, insurance industry, military training, business supply chains, etc.). In natural resource management, efforts typically have focused on utilizing the dominant *scientific* uncertainties, especially related to climate change but also focused on ecology or human dimensions (e.g., land use or management), to construct the scenarios (Fisichelli et al. 2016; Hartmann 2012; Rowland et al. 2014; Star et al. 2016a; Symstad et al. 2017; Weeks et al. 2011). For instance, scenarios might contrast futures with mild versus strong warming, or wetter versus drier conditions (Fisichelli et al. 2016; Star et al. 2016a). Not surprisingly, management professionals have reported feeling dissatisfied by this approach for reasons that include having trouble connecting the changes in temperature and precipitation with actual decisions about management actions, having a sense that not all uncertainties are captured, or having difficulty envisioning the scenarios due to their overwhelming complexity (Rickards et al. 2014).

Here, we demonstrate an alternative approach to scenario planning — Scenario Planning Around Resource Challenges (SPARC) — that builds on a shared understanding of management priorities and uncertainties, as opposed to starting from scientific uncertainties. Moreover, current social science research findings strongly suggest effective integration of science into management requires direct collaborations between scientists and managers (Snover et al. 2013, Meadow et al. 2015, Star et al. 2016b; Enquist et al. 2017). Accordingly, SPARC is driven by actual management decisions, fostering a deliberate collaboration between scientists and managers to co-develop management-centered scenarios.

METHODS: A MANAGEMENT-CENTERED SCENARIO PLANNING APPROACH

Beginning in 2016, the Southwest Climate Adaptation Science Center (SW CASC) partnered with Sky Island Alliance (SIA) and Southwest Decision Resources, Inc. (SWDR) to pilot a management-centered scenario planning effort as part of a landscape-focused conservation process led by Desert Landscape Conservation Cooperative (DLCC). Focused on the Madrean Ecoregion of southeastern Arizona, southwestern New Mexico, and northern Mexico (Figure 1, thick solid boundary), the

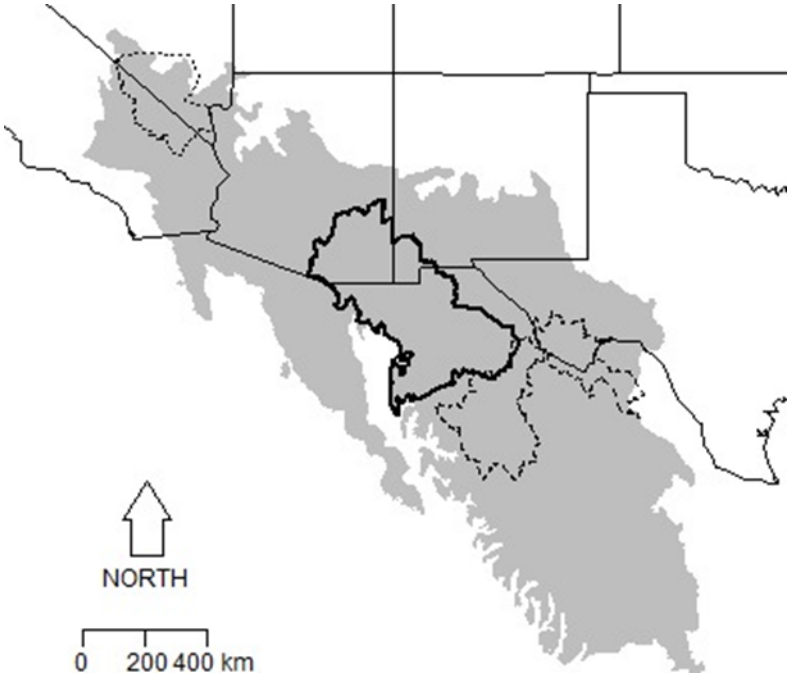

Figure 1—Boundaries of the Desert LCC (gray shading) and the three pilot sub-regions: Dos Rios-Big Bend (dashed)Madrean Watersheds (thick solid), and Eastern Mojave (dotted).

effort engaged resource managers across state and national boundaries from the start, including a kick-off workshop, followed by a series of small group meetings. The process started with the goal of establishing an understanding of shared management objectives.

As a pilot effort, SPARC evolved as the project progressed, with regular team meetings that resulted in refinements in our methodology. Here, we document the SPARC approach and share lessons learned. The team consisted of representatives from the partner organizations, regional state and federal land managers, and practitioners from conservation organizations. SPARC consists of three phases: (1) delineation of management resources, (2) identification of threats & development of scenarios, and (3) management considerations & actions.

Phase 1: Delineation of Management Resources

Phase 1 entails gathering background information from the management community on the resources they manage. Useful information includes managers' jurisdictions, resources, current actions and the overlying objectives behind those actions. The more details the team can collect, the more relevant the scenarios are and, thus, useful to managers. A good starting point is to peruse current management plans or protocols that drive managers' operations, if they exist.

Phase 2: Identification of Threats & Development of Scenarios

Phase 2 entails identifying the threats facing the resources within managers' jurisdictions and collecting information about what is known and unknown about those threats and, most importantly as these become the scenarios, *possible outcomes*. Both the management and academic communities contribute to this phase; natural resource managers are often scientists by training, familiar with the scientific literature and even conducting their own research. Managers also offer the benefit of having deep perspectives through their on-the-ground experiences, which are often more specific and nuanced than represented in the scientific literature. Logistically, it may make sense to combine Phases 1 and 2 into a single workshop for managers to minimize the number of workshops they attend. However, we recommend, and thus assume for the rest of the article, that a separate workshop devoted to Phase 2 consisting of both researchers and managers is conducted. For the

sake of experts' time, we recommend multiple workshops (or breakout groups at a single workshop) with sub-groups focused on a particular resource or threat (e.g., grasslands, fire, invasive species) as opposed to systematically discussing/reviewing each resource and/or threat with all experts present. Time permitting, the team may also choose to interview experts (researchers and managers) individually rather than hold workshops. Because experts may disagree on perspectives, extra time should be allotted to allow for consensus to be reached, if possible. If not possible, areas of difference serve as a good basis for additional scenarios. When selecting researchers, prioritize experts with specialized knowledge of the resources and threats within managers' jurisdictions.

Experts (researchers and managers) begin by offering their concerns (i.e., identifying the threats) facing the resources identified in Phase 1. These concerns need not be limited to climate change but should include them, even if at a lower priority. Considerations about how climate change may exacerbate or enable higher priority concerns are encouraged, recognizing that many stressors are inextricably linked. Experts then rank their concerns through the preferred voting system, for example by asking experts to vote for their top three or four concerns and tallying the votes. Electing the top 3-4 concerns may help make the scenario planning process more manageable such that considerable time is not spent on minor or unlikely threats.

Next, experts then offer their perspectives on *what we know*, *what we don't know*, and *what could happen* regarding these threats to their resources, both according to the scientific literature and managers' on-the-ground observations. Generally, *what we know* includes information in which there is consistent support, both through published studies (observational and modeling) and on-the-ground manager observation. *What we don't know* represents cases where disagreement exists among scientists or between scientists and managers, or not enough, or any, information exists to reach consensus. *What could happen* builds off *what we don't know* by listing the various trends (i.e. scenarios) indicated by disparate studies or observations. For each resource or threat (e.g., fire, as shown in the example in Table 1), information should include trends, current statuses, and other relevant information (e.g., what we know would happen if a certain state is reached; see the example of a fuel-limited environment under *what we know* in Table 1). Trends and other information should include not only direct observations regarding the resource or threat (e.g., fires are getting larger) but also drivers or influences on the resource or threat (e.g., ecological: "fuels are getting drier"; socioeconomic: "public fear of fire inhibits prescribed burning"; etc.). Each statement should be supported by evidence in three categories: scientific measurements, modeling, and on-the-ground observation.

As you can see, scenarios in the SPARC approach derive from unknowns where options exist (proposed by either the science or management communities). In the case where options do *not* exist (i.e. in the absence of any science or manager observation support), scenarios cannot be formed. These include "unknown unknowns" (i.e., unknowns unacknowledged by either community, Rumsfeld 2002) or simply unknowns where neither science nor management observation yields any indication of future trends. The key to forming scenarios is: When faced with an unknown, attempt to locate possibilities for the future from science and/or management observation. In other words, scenarios are simply possibilities for the future. In this sense, SPARC is consistent with past approaches of scenario planning in that it is a tool for incorporating uncertainty in decision making.

Phase 3: Management Considerations & Actions

Once the scenarios are finalized (i.e., drafted and refined by both the researcher and management communities), a final workshop occurs where the final scenarios are presented to managers and managers consider actions they would take under each individual scenario. Managers first consider current management activities and decide whether the status-quo response can be maintained or if it needs to be revised or removed to meet their management objectives. Next, managers consider new, alternative management actions to improve the successful outcomes of management priorities (e.g., goals). Once a final list of actions is acquired for each scenario, participants (1) compile common actions across multiple scenarios and other "no-regrets" actions (e.g., monitoring, education), (2) consider the potential repercussions of each action on other sectors (e.g., farmers, ranchers, ecotourism, tribes, public utilities and infrastructure, etc.), and (3) detail the requirements needed to implement the actions (e.g., funding, personnel). Managers also identify indicators that they will monitor to track the development of scenarios and establish a timeline to revisit the scenarios to see which, if any or perhaps multiple, scenario(s) are unfolding. Managers should account for resource needs that are required for continuous long-term monitoring and consider how to maintain commitment given fluctuating budgets, personnel turnover, and reprioritization. Scientists also

provide additional resources for managers to track the scenarios, such as maps of vegetation, land use, or other existing indicators, to help managers identify areas of highest risk from a given scenario.

RESULTS: A PILOT PROJECT WITH THE DESERT LCC

Our test case for SPARC is part of a conservation project with the Desert LCC (Figure 1, grey shading). The project aim is to connect land managers across jurisdictions to collaboratively develop an ecosystem-scale management plan that accounts for the potential effects of climate change on their ecosystems. The Desert LCC has selected three sub-regions to pilot this effort: Dos Rios-Big Bend (Figure 1, dashed boundary), Madrean Watersheds (thick solid), and Eastern Mojave (dotted). The three sub-regions are at different phases in their project with Madrean Watersheds furthest ahead and thus the focus of this study.

As outlined in the Methods, the first step (Phase 1) of SPARC is to meet with the management community to establish key resources and other pertinent information about the management context (e.g., jurisdictions, objectives, priorities, constraints, etc.). The SIA and SWDR teams held preliminary workshops to collect this information in the Madrean Watersheds region (Madrean, for short). Managers identified over seven major ecosystem types that they manage: grasslands, springs, streams, Madrean pine-oak woodland, high-elevation montane ecosystems, critical wildlife movement corridors, upland Sonoran Desert, and others. Additionally, as part of the same series of workshops, the SIA and SWDR teams completed the first part of Phase 2: identifying and ranking the primary threats facing each resource. For example, managers voted that grasslands are most threatened by, in descending order of importance: 1) Fragmentation from land development, transmission lines, and roads; 2) poorer soil quality due to increased erosion from heavier rainfalls, desertification from warmer and drier weather and increased or continued groundwater pumping, and unsustainable grazing; and 3) invasive species, especially fire-adapted species.

Following these workshops, the SW CASC team repeated the first part of Phase 2 with the academic community, consulting with landscape ecologists, hydrologists, and other scientists at the University of Arizona to identify the leading threats and knowns and unknowns related to these threats (example related to fire management in Table 1). For example, the team spoke with an expert on wildfires in the Sonoran desert region about how climate change might alter the fire regime. Current observations suggest the region is in a fire-limited regime and that area burned, fire season length, and fire intensity have all increased over the past decades (Dennison et al. 2014). As current observations, we classify these as *what we know* (Table 1). Future projections, on the other hand, are conflicted. Some projections show continuous fire-limited regime going into the future, marked by continued increases in area burned, fire season length, and fire intensity (Kitzberger et al. 2017). Another study, however, indicates that the fire regime may enter a fuel-limited state assuming fire managers conduct prescribed burns at least every 20 years to maintain low fuel densities (Fulé et al. 2013). Therefore, *what we don't know* (Table 1) is whether the Madrean will persist in its current fire-limited regime for the time being or whether the region will enter a fuel-limited regime. These two possible futures fall under *what could happen* (Table 1) and thus become the "scenarios" to be considered in Phase 3. In addition, the team compiled other relevant information, such as: In a fuel-limited environment, we know area burned, fire season length, and fire intensity declines (Fulé et al. 2013). This becomes important when considering the scenario of the Madrean entering a fuel-limited regime.

At publication of this research, the pilot project is still in progress, currently completing Phase 2. However, we outline our future steps here to illustrate the completion of the SPARC process. Next, managers will review the three columns (Table 1) and comment on the consistency of the information therein, or lack thereof, with their perceptions from their on-the-ground observations to fulfill the remainder of Phase 2.

Once completed, managers will review each scenario one by one and consider potential effects on their current management practices and potential new management goals and actions (Phase 3). For instance, considering the scenario of a continued fire-limited regime, a manager might consider the possibility of a year-round fire season — a novel environment that they may have not managed before. In such a case, managers may need to adjust their current hiring structure (e.g., budgets, timeline) to accommodate hiring more full-time employees (FTEs) that work year-round as opposed to the current system of hiring seasonal firefighters. Additionally, reservoirs may need to be replenished year-round rather than only once in the spring just ahead of the fire season. In this sample set of scenarios around fire management, natural resource managers will also need to consider management that sustains diverse forests post-fire under a changing climate (Millar et al. 2007).

Table 1—Supporting science and scenarios for the Madrean Archipeligo related to managing for fire.

What We Know	What We Don't Know	What Could Happen
Trends *Threat Itself* ➢ Fires are getting larger o Increased annual area burned observed over past 3 decades (Dennison et al, 2014) o Projections suggest continued Increase in the Southwest (Kitzberger et al. 2017) o Fire managers at Saguaro National Park observe this. ➢ The fire season is getting longer o Increased length in fire season in recent years (Dennison et al. 2014) *Drivers* ➢ Fuels are getting drier (Ecological) ➢ Fewer acres burned by prescribed Burning due to public fears about fire, reduced budgets, reduced personnel (socioeconomic) **Current Status** ➢ The fire regime is fire-limited	➢ Will the fire regime remain fire-Limited or become fuel-limited? o Fire area projected to Increase up to a point until the fire regime becomes fuel-limited and/or fire regime change (Fulé et al. 2013)	**Scenario 1:** Fire regime remains fire-limited in near to long term ➢ *Consequences:* Fire area, intensity, and length of fire season continue increasing **Scenario 2:** Fire regime continues in a fire-limited state in the near-tem but eventually becomes fuel-limited ➢ *Consequences:* Fire area, intensity, and length of fire season increase up to a point and then begin to decrease

For instance, managers might attempt to *resist* change by creating fire breaks to protect native species. Managers can also make forests more *resilient* by seed banking and widespread planting to build biological and age diversity. Finally, managers can aid forests' *response*, or transition, to changing and future environmental conditions by introducing warm-adapted species from neighboring ecosystems. Managers may also identify and acquire (if needed) land projected to remain suitable for native species under a warmer climate (e.g., higher elevations) and conserve them as "climate change refugia" (Morelli et al. 2016). As best as the state of the science will allow, managers should consider impacts over multiple time horizons (i.e., what could happen in the next 5, 10, 20, 50, or 100 years?). Even if managers are planning actions that are valid for the next 5-10 years or until the next revision when they are re-evaluated, those actions should also consider a longer term horizon.

After compiling a list of actions, managers identify common actions across scenarios. For example, in both scenarios, whether fire-limited or fuel-limited, wildfires will occur in a warmer, drier climate, allowing fires to flare up more readily and spread more rapidly. Therefore, one common action across scenarios might be to stock up on additional resources (e.g., water, budget, personnel). In addition to common actions, managers gather other "no regrets" actions that they can act upon immediately, such as setting up a monitoring network to track the fire regime, thus being able to track which scenario unfolds. As a prerequisite, managers should try to identify quantifiable indicators to adequately track the fire regime. Additionally, managers can analyze spatial data provided by the academic community to determine areas most at risk, and then develop a "watch list" to monitor those areas in most risk. A final "no regrets" action is to develop education programs about fire safety to prevent accidents such at campgrounds.

To conclude Phase 3, managers will consider the repercussions of each action against other sectors. For example, switching to replenishing reservoirs year-round will increase the amount of groundwater pumping, taking away water resources from farmers for irrigation and the public for drinking, toilets, showers, lawn watering, etc. However, by considering this challenge, managers may creatively identify alternative approaches that do not have negative consequences for other sectors. For instance, instead of groundwater pumping, perhaps the reservoir can be replenished through changes in upstream water rights laws that enable higher proportions of rain water to runoff to the region, or by rechanneling streams toward a reservoir provided no consequences to downstream ecosystems.

Also in this final segment of Phase 3, managers will consider the requirements needed for certain actions to take place successfully. For instance, hiring additional FTE firefighters to accommodate a year-round fire season will require additional financial resources for salaries, which managers can begin to request at any point regardless of scenario so that the funds are available when needed — especially important given the pace of bureaucracy. Likewise, year-round replenishing of the reservoirs will require both financial resources for the additional water and additional employees.

CONCLUSIONS

Here, we propose an alternative implementation of scenario planning in the field of climate change adaptation planning, we call Scenario Planning Around Resource Challenges (SPARC), so called for its focus on uncertainties directly affecting managed resources. Ironically, this approach relies very little on climate uncertainties (e.g., mild vs strong warming, drier vs wetter conditions) and instead focuses on the uncertainties of climate-induced ecological impacts and the implications for natural resource management. SPARC also allows consideration of non-climate drivers of change, often viewed with higher concern (e.g., socioeconomic threats). Heeding the advice from the social science literature, this approach begins with understanding the management context and involves scientists and managers working in tandem throughout the process, thus requires initial legwork prior to developing the scenarios.

While this pilot application is still in progress, managers have responded positively to the new approach thus far, likely because the scenarios better connect with the resources they manage, get at the most management-relevant uncertainties, reflect managers' perceptions on the ground, increasing credibility in the scenarios, and are more straightforward for managers to grasp. Though applied to climate change adaptation in this example, SPARC has relevance in any planning application in which uncertainty exists. As a side benefit, scenario planning, whatever the approach, prompts a conversation among managers about future conditions and how to anticipate them, thus shifting the management culture from reactive to proactive. Overall, scenario planning remains a powerful strategy for eliminating the paralysis that comes from planning under uncertainty.

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Collaborating on Climate Adaptation at the Urban-Open Space Interface

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In 2017, when the U.S signaled its intent to withdraw from the Paris Agreement, the Pima County Board of Supervisors adopted two climate resolutions to independently align the County's efforts with the UN's climate goals. As part of the County's climate commitment, both adaptation and mitigation targets are being formalized in a new Sustainable Action Plan for County Operations (SAPCO) which will be delivered in 2018. Related to carbon mitigation, the County is cutting its CO2 emissions by 40% by the year 2025 and improving its fleet efficiency. On the adaptation side, recognizing that the Pima-Tucson Basin will be hotter and drier and experience more frequent extreme heat events and flooding, the County is exploring a range of strategies to protect human and natural communities. The County's open space lands protected under the Sonoran Desert Conservation Plan may buffer climate variability through the protection of micro-climate refugium. Resilient landscapes are better equipped to recover from disturbance and defend against flood, drought, heat and other risks to human communities. In the urban environment where rising temperatures will challenge human health and productivity, the County is planning Green Infrastructure installations that will harvest stormwater and mimic some open space characteristics to provide adaptation benefits. And connecting both open and urban spaces in the Pima-Tucson Basin are a mosaic of ephemeral rivers and arroyos that the County's Regional Flood Control District has been actively restoring for two decades. In considering the interface of open space and urban space, planners, hydrologists, biologists and sustainability practitioners at Pima County are exploring how these biophysical features may in fact provide mutually reinforcing climateresilience benefits.

Colaborando en la adaptación climática en la interfaz urbano-espacio abierto

En el 2017, cuando EE. UU. señaló su intención de retirarse del Acuerdo de París, la Junta de Supervisores del Condado de Pima adoptó dos resoluciones climáticas para alinear independientemente los esfuerzos del Condado con los objetivos climáticos de la ONU. Como parte del compromiso climático del Condado, tanto los objetivos de adaptación como los de mitigación se están formalizando en un nuevo Plan de Acción Sostenible para Operaciones del Condado (SAPCO por sus siglas en inglés) que se entregará en el 2018. En relación con la mitigación de carbono, el Condado está reduciendo sus emisiones de CO2 en un 40% para el año 2025 y mejorará la eficiencia de su flota. Por el lado de la adaptación, reconociendo que la cuenca Pima-Tucson será más caliente y más seca y experimentará eventos de calor extremo e inundaciones más frecuentes, el Condado está explorando una variedad de estrategias para proteger a las comunidades humanas y naturales. Las tierras de espacios abiertos del Condado protegidos por el Plan de Conservación del Desierto Sonorense pueden amortiguar la variabilidad climática a través de la protección del refugio microclimático. Los paisajes resilientes están mejor equipados para recuperarse de las perturbaciones y defenderse de inundaciones, sequías, calor y otros riesgos para las comunidades humanas. En el entorno urbano donde el aumento de las temperaturas pondrá a prueba la salud humana y la productividad, el Condado está planificando instalaciones de Infraestructura Verde que recogerán aguas pluviales e imitarán algunas características de espacios abiertos para proporcionar beneficios de adaptación. Y la conexión de espacios abiertos y urbanos en la Cuenca Pima-Tucson es un mosaico de ríos efímeros y arroyos que el Distrito Regional de Control de Inundaciones del Condado ha estado restaurando activamente durante dos décadas. Al considerar la interfaz del espacio abierto y el espacio urbano, los planificadores, hidrólogos, biólogos y profesionales de la sostenibilidad en el Condado de Pima están explorando cómo estas características biofísicas pueden, de hecho, proporcionar beneficios de climaterioiliencia que se refuerzan mutuamente.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 22: Velvet Mesquite: Riparian Keystone or Grassland Pest?

Mesquite Bosque, Coronado National Forest
(Photo courtesy of the U.S. National Parl Service)

Abstracts and Papers
Barron-Gafford
Bodner
Gornish
Nieto
Turner

Impacts of hydraulic redistribution on overstory-understory interactions in semiarid upland and riparian savannas

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Hydraulic redistribution (HR) is an important ecohydrological process in dryland environments by which plants preferentially move water from wet to dry soil layers. How does this water movement by the overstory influence physiological activity in the understory? Are there periods of facilitation when the tree is lifting water and periods of competition when the water is being moved deeper in the profile? We combined trunk, lateral root, and taproot sap flow data, and linked these measures with ecosystem monitoring data. During prolonged periods of drought, mesquites drew upon this deeper, stored water to meet biological demands. We created plots under mesquite that experienced HR and plots where HR was physically prohibited to quantify the impacts of HR on understory performance. We measured carbon and water exchange at the leaf-level on mesquite and understory grass and for entire understory ecosystem using a large, portable chamber. We found that HR provided a drought-buffering capacity for the overstory mesquite and a significant decrease in mesquite photosynthesis in trees where the capacity for HR was reduced. While we had hypothesized that water lifted by the mesquite in periods of drought would facilitate understory grass function, we found no evidence for this in the upland environment, but we did see evidence of “water sharing” in the riparian setting. Ultimately, we found that HR in upland savannas, where there is little to no access to deep water, yields a competitive interaction between overstory mesquites and understory grasses, but there is more facilitation in the riparian zone.

Impactos de la redistribución hidráulica en las interacciones entre dosel y sotobosque en tierras altas semiáridas y pastizales ribereños

La redistribución hidráulica (RH) es un proceso ecohidrológico importante en los ambientes de las tierras áridas por el cual las plantas mueven el agua de las capas húmedas a las secas. ¿Cómo influye este movimiento del agua en el dosel a la actividad fisiológica del sotobosque? ¿Hay períodos de facilitación cuando el árbol está levantando agua y períodos de competencia cuando el agua se mueve más profundamente en el perfil? Combinamos los datos de flujo de savia troncal, raíz lateral y raíz pivotante, y relacionamos estas medidas con los datos de monitoreo del ecosistema. Durante períodos prolongados de sequía, los mezquites recurrieron a esta agua más profunda y almacenada para satisfacer las demandas biológicas. Creamos parcelas bajo mezquite que experimentaron RH y parcelas donde RH estaba físicamente prohibido para cuantificar los impactos de RH en el desempeño del sotobosque. Medimos el intercambio de carbono y agua a nivel de hoja en mesquites y hierba de sotobosque en todo el ecosistema del sotobosque usando una cámara grande y portátil. Descubrimos que la RH proporcionó una capacidad de resistencia a la sequía para el mezquite y una disminución significativa de la fotosíntesis en los árboles donde se redujo la capacidad de la RH. Si bien habíamos planteado la hipótesis de que el agua levantada por el mezquite en períodos de sequía facilitaría la función del césped del sotobosque, no encontramos evidencia de esto en el entorno de las tierras altas, pero vimos evidencia de "agua compartida" en el entorno ribereño. Finalmente, encontramos que la RH en los pastizales de las tierras altas, donde hay poco o ningún acceso a aguas profundas, produce una interacción competitiva entre los mesquites y los pastos del sotobosque, pero hay más facilitación en la zona ribereña.

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Mesquites across the landscape: how form and function differ between upland, wash, and river settings

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Velvet mesquite (*Prosopis velutina*) is among the most ubiquitous plants in Southwestern US and northwestern Mexico, occupying habitats from semi-desert grasslands to Sonoran Desert washes and river floodplains. They tolerate a wide range of environmental conditions and achieve dramatically different forms depending on those conditions—from low-growing shrubs in coppice dunes to tall trees in dense woodlands of river floodplains. As riparian trees, they are prized for shade, flood protection, wildlife habitat, and carbon capture. As grassland shrubs, they are despised as thorny invaders. This variability brings challenges and opportunities to management and research. For managers, the species' ecological flexibility can benefit restoration, e.g. increasing successful establishment in plantings. On the other hand, a single management unit may have goals to both improve bosque habitats along streams, and remove woody plants expanding into grasslands—increasing and reducing abundance of the same species on different acres. As a research challenge, conclusions drawn from one setting may not apply to plants in a different setting. If settings are not clearly distinguished, experimental results may appear to conflict from one study to another, and modeling efforts may use inappropriate parameters and produce unrealistic results. To promote clarity for managers and researchers, this paper: (1) illustrates three distinctive settings for mesquites in the region and describes plant and community attributes in these settings; (2) addresses gradations and variations on these settings; (3) describes notable differences between conditions in this focal area and nearby r0egions; and (4) discusses ongoing questions and ways to answer them.

Mesquites en todo el paisaje: cómo la forma y la función difieren entre las tierras altas, arroyos y ríos

El mezquite terciopelo (Prosopis velutina) es una de las plantas más ubicuas en el sudoeste de los EE. UU. y el noroeste de México, ocupando hábitats desde pastizales semidesérticos hasta arroyos del desierto de Sonora y llanuras aluviales. Toleran una amplia gama de condiciones ambientales y logran formas dramáticamente diferentes dependiendo de esas condiciones, desde arbustos de bajo crecimiento en dunas de monte bajo hasta árboles altos en bosques densos de llanuras aluviales de ríos. Como árboles ribereños, son apreciados por la sombra, la protección contra las inundaciones, el hábitat de la vida silvestre y la captura de carbono. Como arbustos de pastizales, son despreciados como invasores espinosos. Esta variabilidad trae desafíos y oportunidades para la administración y la investigación. Para los administradores, la flexibilidad ecológica de la especie puede beneficiar la restauración, i.e. aumentar el establecimiento exitoso en las plantaciones. Por otro lado, una sola unidad de manejo puede tener objetivos tanto para mejorar los hábitats de bosque a lo largo de los arroyos como para eliminar las plantas leñosas que se expanden hacia los pastizales, aumentando y reduciendo la abundancia de la misma especie en diferentes acres. Como un desafío de investigación, las conclusiones extraídas de un entorno pueden no aplicarse a las plantas en un entorno diferente. Si los contextos no se distinguen claramente, los resultados experimentales pueden parecer conflictivos de un estudio a otro, y los esfuerzos de modelado pueden usar parámetros inapropiados y producir resultados poco realistas. Para promover la claridad para los gerentes e investigadores, este documento: (1) ilustra tres configuraciones distintivas para los mezquites en la región y describe los atributos de plantas y comunidades en estos entornos; (2) trata gradaciones y variaciones en estos contextos; (3) describe diferencias notables entre las condiciones en esta área focal y las regiones cercanas; y (4) discute preguntas en curso y formas de responderlas.

NOTE: A manuscript was not submitted to accompany this presentation.

Relationships between grass and mesquite cover based on long-term data: Implications for restoration opportunities

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Vegetation abundance data has been regularly collected since the 1950's at the Santa Rita Experimental Range in Green Valley, AZ. The data has been collected from transects that exist across gradients of soil types, grazing presence, fire presence and mesquite dominance. These data have been leveraged to identify relationships between mesquite abundance and the abundance of desired and invasive plants and to understand how these relationships change depending on site-specific characteristics. Although mesquite prohibits the abundance of many plant species, many native and high quality forage species are encouraged by the presence of mesquite. This is likely due to the 'islands of fertility' that are cultivated under mesquite canopies. These areas provide opportunity for restoration initiation across arid land systems in southern AZ.

Las relaciones entre la cobertura de hierba y mezquite se basan en datos a largo plazo: Implicaciones para las oportunidades de restauración

Los datos de abundancia de vegetación han sido recolectados regularmente desde la década de 1950 en la Cordillera Experimental Santa Rita en Green Valley, AZ. Los datos han sido recolectados de transectos que existen a través de gradientes de tipos de suelo, presencia de pastoreo, presencia de fuego y dominancia de mezquite. Estos datos se han aprovechado para identificar las relaciones entre la abundancia de mezquite y la abundancia de plantas deseadas e invasivas y para entender cómo estas relaciones cambian dependiendo de las características específicas del sitio. Aunque el mezquite prohíbe la abundancia de muchas especies de plantas, muchas especies de forraje nativas y de alta calidad son alentadas por la presencia de mezquite. Esto probablemente se deba a las "islas de fertilidad" que se cultivan bajo los doseles de mezquite. Estas áreas brindan la oportunidad de iniciar la restauración en los sistemas de tierras áridas en el sur de Arizona.

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An assessment of the watershed-scale impacts of brush management on ecosystem services in southeastern Arizona. Is it worth it?

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Land managers have traditionally used brush management (BM) to limit shrub encroachment, restore lost forage production, and improve groundwater recharge. However, numerous other ecosystem services (ES) are potentially impacted by BM, and an accounting for them would provide a more complete assessment of the viability of BM as a conservation practice. Accordingly, we are examining the impacts of BM on a portfolio of ES (herbaceous diversity, forage production, net ecosystem exchange, carbon sequestration, erosion) at the watershed scale in a southeastern Arizona desert grassland encroached by velvet mesquite (*Prosopis velutina*). We collected pre-treatment data of these ES from September 2015 to May 2016 in each of four watersheds prior to applying an herbicide cocktail of clopyralid, aminopyralid, and triclopyr. The herbicide was then applied on two watersheds in June 2016, while retaining the other two watersheds as controls. Following treatment, we established four permanent transects to evaluate mesquite foliage recovery and continued to track ES responses. Our results

indicate that BM in this desert grassland may shift the community composition in favor non-native perennials and annuals over native perennials, perhaps triggered by periods of precipitation shortfall, with unintended adverse consequences for herbaceous biodiversity and ANPP. The herbicide application initially caused a 90% reduction in mesquite foliar cover but recovered to an average of 50% by the following year. Mesquite plant mortality was less than 1%. Thus, a single application of our herbicide cocktail was short-lived and not particularly effective in reducing mesquite canopy cover.

Una evaluación de los impactos a escala de cuencas hidrográficas del manejo de arbustos en los servicios ecosistémicos en el sureste de Arizona. ¿Vale la pena?

Los administradores de tierras han utilizado tradicionalmente el manejo de arbusto (BM por sus siglas en inglés) para limitar la invasión de arbustos, restaurar la producción de forraje perdido y mejorar la recarga de aguas subterráneas. Sin embargo, muchos otros servicios ecosistémicos (SE) son potencialmente impactados por BM, y una contabilidad para ellos proporcionaría una evaluación más completa de la viabilidad de BM como una práctica de conservación. En consecuencia, estamos examinando los impactos de BM en una cartera de SE (diversidad herbácea, producción de forraje, intercambio neto de ecosistemas, secuestro de carbono, erosión) en la cuenca hidrográfica en una pradera del sudeste del desierto de Arizona invadida por mezquite aterciopelado (Prosopis velutina). Recolectamos datos previos al tratamiento de estos SE de septiembre de 2015 a mayo de 2016 en cada una de las cuatro cuencas hidrográficas antes de aplicar un cóctel herbicida de clopyralid, aminopyralid y triclopyr. El herbicida se aplicó en dos cuencas hidrográficas en junio de 2016, manteniendo las otras dos cuencas como controles. Luego del tratamiento, establecimos cuatro transectos permanentes para evaluar la recuperación del follaje de mezquite y seguimos rastreando las respuestas de SE. Nuestros resultados indican que BM en este pastizal del desierto puede cambiar la composición de la comunidad en favor de plantas perennes no nativas y plantas anuales perennes nativas, tal vez desencadenadas por períodos de precipitación insuficiente, con consecuencias adversas no intencionales para la biodiversidad herbácea y ANPP. La aplicación del herbicida causó inicialmente una reducción del 90% en la cobertura foliar de mezquite pero se recuperó a un promedio del 50% para el año siguiente. La mortalidad de la planta de mezquite fue menor al 1%. Por lo tanto, una sola aplicación de nuestro cóctel de herbicidas fue efímera y no particularmente efectiva en la reducción de la cobertura del dosel del mezquite.

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Results of mesquite thinning to improve riparian forests

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Velvet mesquite (*Prosopis velutina*) in riparian settings is known for developing bosques, low-density stands of mature trees with an open understory that supports other native plants and wildlife. Many historic mesquite bosques in the Madrean Archipelago have been cleared to allow farming on river floodplains. In some cases, cultivation of those farm fields was later abandoned, leading to a rapid recolonization by mesquite. The result has been dense stands of small mesquites, all competing for limited soil moisture and groundwater supply. We looked at the possibility of advancing one of those stands toward the structure of a mature community by an experimental thinning program. A treatment plot was thinned from 26.8 to 5.4 plants/100 m^2. During the first two years, stem diameters increased faster in the thinned area than an adjacent control plot. After 19 years, the thinned plot still showed a more open stand structure than the control plot. However, resprouting of cut trees led to mixed results in basal area and area at breast height, so success of the effort would likely have been greater with some follow-up treatment. Based on these results and several studies of honey mesquite (*Prosopis glandulosa*) in Texas, it appears that thinning dense sapling stands can produce significantly higher growth rates in the remaining trees and inhibit establishment of new seedlings, leading to open stands of large trees.

Resultados del raleo de mezquite para mejorar los bosques ribereños

Velvet mezquite (Prosopis velutina) en entornos ribereños es conocida por desarrollar bosques, rodales de baja densidad de árboles maduros con un sotobosque abierto que soporta otras plantas nativas y la vida silvestre. Muchos bosques históricos de mezquite en el Archipiélago Madrense han sido despejados para permitir la agricultura en las llanuras de inundación de los ríos. En algunos casos, el cultivo de los campos de cultivo fue abandonado más tarde, lo que llevó a una rápida recolonización por mezquite. El resultado han sido los densos rodales de mezquites pequeños, todos los cuales compiten por la humedad del suelo limitada y el suministro de agua subterránea. Examinamos la posibilidad de avanzar en uno de esos rodales hacia la estructura de una comunidad madura mediante un programa experimental de adelgazamiento. Una parcela de tratamiento se adelgazó de 26.8 a 5.4 plantas / 100 m^2. Durante los dos primeros años, los diámetros del tallo aumentaron más rápido en el área adelgazada que una parcela de control adyacente. Después de 19 años, la trama adelgazada todavía mostraba una estructura de pedestal más abierta que la parcela de control. Sin embargo, el rebrote de árboles cortados produjo resultados mixtos en el área basal y el área a la altura del pecho, por lo que el éxito del esfuerzo probablemente habría sido mayor con algún tratamiento de seguimiento. Con base en estos resultados y en varios estudios de mezquite miel (Prosopis glandulosa) en Texas, parece que adelgazar densos plantones puede producir tasas de crecimiento significativamente más altas en los árboles restantes e inhibir el establecimiento de nuevas plántulas, lo que lleva a rodales abiertos de árboles grandes.

Note: Full Paper Follows

Velvet mesquite thinning to improve riparian forests

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***Abstract**--Velvet mesquite (*Prosopis velutina*) in riparian settings is known for developing bosques, stands of mature trees with an open understory that supports other native plants and wildlife. Many historic mesquite bosques in the Madrean Archipelago have been cleared to allow farming on river floodplains. In some cases, cultivation of those farm fields was later abandoned, leading to a rapid recolonization by mesquite. The result has been dense stands of small mesquites, all competing for limited soil moisture and groundwater supply. We looked at the possibility of advancing one of those stands toward the structure of a mature community by an experimental thinning program. A treatment plot was thinned from 2,683 to 542 trees ha^{-1} (1086 to 219 trees ac^{-1}). During the first two years, stem diameters increased 67% faster in the thinned area than an adjacent control plot. After 19 years, the thinned plot still showed a more open stand structure and had a taller canopy than the control plot. However, resprouting of some cut trees affected results in basal area and area at breast height, so success of the effort would likely have been greater with some follow-up treatment. Based on these results, it appears that thinning dense sapling stands can produce significantly higher growth rates in the remaining trees, accelerating the transition to open stands of large trees that might provide better habitat for other species.*

INTRODUCTION

Velvet mesquite (*Prosopis velutina*) evolved within the Sonoran Desert and Madrean Archipelago regions of North America. It grows in a variety of geomorphic settings and can be part of very different biotic communities, largely dependent on access to water. In riparian contexts with relatively shallow groundwater, they can grow quite large and form closed-canopy forests known as bosques (Minkley and Clark 1981). Similar communities with the same common name are also formed by honey mesquite (*P. glandulosa* var. *glandulosa*) and western honey mesquite (*P. glandulosa* var. *torreyana*). Mesquite bosques were formerly abundant along low-elevation (below 1,200 m) rivers in the southwestern U.S. and northwestern Mexico, but they have been reduced to small remnant stands due to land clearing for agriculture and declining water tables. Virtually none remain in pristine condition, suggesting a need for both protection and restoration efforts (Brown 1982; Shreve and Wiggins 1964; Stromberg 1993; Szaro 1989).

Large velvet mesquite bosques were historically common along the San Pedro River in Sonora and Arizona, and small bosques remain common there as patch communities (Minkley and Clark 1981, Stromberg 1993). These bosques along the San Pedro River in Arizona were historically common only in entrenched reaches or along reaches where the flow was intermittent. After entrenchment spread during floods of 1890-1926, much of the river had suitable groundwater conditions to develop bosques. These were subsequently reduced by human activities, and small bosques remain common there as patch communities (Hereford and Betancourt 2009; Stromberg 1993; Stromberg et al. 2009).

Mature bosques were historically described as having dense canopies with a low density of large, single-trunked trees (Table 1). They tend to be strongly dominated by mesquite, with less than 25% of other tree species, and typically have a low-density understory of shrubs, vines, and seasonal herbaceous plants (Stromberg 1993).

Bosques are known to support diverse wildlife communities. Breeding bird species richness in riparian mesquite forests is equal to that found in cottonwood forests, and these riparian forest types support different suites of species (Brand et al. 2008). Bosques are particularly important for birds such as Abert's towhee (*Melozone aberti*) and Lucy's warblers (*Vermivora luciae*), and historically were important for Yellow-billed cuckoo (*Coccyzus americanus*) and Cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*)(Arnold 1940; Gavin 1973; Johnson et al. 1997; Johnson et al. 2000; Marshall 1960; Phillips et al. 1964). They were also the primary habitat for Merriam's mesquite mouse (*Peromyscus merriami*) (Arnold 1940; Hoffmeister 1986).

This study began with the observation that multiple sites along the San Pedro River had inactive farm fields, previously cleared of mesquite, that were displaying substantial recruitment of young mesquite. That recruitment appeared to be mediated by cattle which ate mesquite pods under nearby trees and deposited seed in their dung on the farm fields. The result was growth of mesquite seedling or sapling stands that appear dense enough to have intraspecific water competition.

Table 1—Structure of mature mesquite bosques. Values are reported as ranges or as means ± 1 SE.

Area	Density Trees Trees/ha (trees/ac)	Basal Area m^2/ha (ft^2/ac)	Canopy Height m (ft)	N	Reference
Arizona	736 ± 158 (298 ± 64)	39.8 ± 5.6 (173.4 ± 24.4)		4	Szaro 1989
Location:					
San Pedro River, Hassayampa River, Tanque Verde Creek		28.2 ± 1.6 (22.8 ± 7.0)	10.3 ± 0.5 (33.8 + 1.6)	10	Stromberg et al. 1993
Gila River	256 ± 86 (104 ± 35)		2-12 (6.6-39.4)	4	Minckley and Clark 1981
Sonoran Desert			15-18 (49.2-59.1)		Shreve and Wiggins 1964
Salt River	85 (35)				Douglas 1938
Lower Salt and Verde Rivers	200 trees >3m (81 trees >10 ft)			4	Higgins and Ohmart 1981
Salt River	260-530 (105-214)				Turner 1983
Hassayampa River	375-500 >1 cm dbh (148-197 >0.4 in dbh)				J. Stromberg unpubl. data

Our goal was to determine whether thinning of a dense stand of young velvet mesquite can speed the development of mature mesquite bosque community characteristics.

Silvicultural research on other tree species has clearly demonstrated that individual trees in dense stands will grow faster when released from intraspecific competition for resources (e.g., Roberts and Harrington 2008; Ronco et al. 1985; Stoneman et al. 1997). Several studies on upland stands of honey mesquite in Texas found that thinning dense sapling stands produced significantly higher growth rates in the remaining trees and inhibited establishment of new seedlings, leading to open stands of large trees (Cornejo-Oviedo et al. 1991; Felker et al. 1990; Patch and Felker 1997). A regression line of stand density against biomass/ha indicated that about 100 trees ha^{-1} (40 trees ac^{-1}), or 10 m (33 ft) spacing between trees, would produce the greatest volume of timber in honey mesquite stands. That regression had a slope that differed from the commonly reported -3/2 which might lead to full site occupancy without canopy closure, apparently due to the extensive root system of honey mesquite (Felker et al. 1990). We are not aware of previous comparable studies for velvet mesquite or other mesquite species in riparian settings.

METHODS

This study was conducted at Bingham Cienega Natural Preserve, a 115-ha (284 ac) site on the San Pedro River owned by the Pima County Flood Control District (32.458056°N, 110.483033°W). An analysis of 1879 General Land Office surveys of the area described a cienega (wetland) with adjacent sacaton grasslands, deciduous riparian forests, and mesquite bosques, along with some cultivated fields (Fonseca 1998). Much of the area around the cienega was cleared for agriculture soon after that. The agricultural fields on the Preserve were last cultivated in 1987, and grazing was eliminated in 1990.

Study plots were established on the Preserve in 1998, with a 0.34 ha (0.83 ac) treatment plot and an adjacent 0.18 ha (0.43 ac) control. Study plots were initially designed as adjacent rectangles, but the reference plot was clipped along one margin to avoid a layer of gypsum soils that clearly affected tree height and density. Initial density in the control plot was 2,683 trees ha^{-1} (1,086 trees ac^{-1}).

Mesquite stems on the treatment plot were thinned in April, 1998, so that adjacent individuals were 5-6 m (16.4-19.7 ft) apart, with a density of 542 trees ha^{-1} (219 trees ac^{-1}). This value was determined by literature densities for mature mesquite forests (Table 1). Trees were cut by hand, the cut stumps were treated with herbicide (Garlon™; Dupont de Nemours, Inc.), and the remaining trees were counted. We tagged 58 mesquite saplings in the thinned plot and 50 in the control plot and measured their stem diameter and maximum height in June 1998 and May 2000.

We revisited the plots on December 12, 2017. After relocating and marking boundaries, all mesquite trees were counted on each plot. A tree with more than one stem emerging from the trunk (main stem) or from the root crown was counted as a single individual. We also counted all understory shrubs by species on each plot. Tags from the initial study had been removed, so we were unable to identify previously tagged individuals. For 20 randomly chosen mesquite trees on each plot, we measured basal diameter at ground level, diameter at breast height (1.37 m high, 4.5 ft high) of all stems, and counted stems. Measurements were compared using two-sample t-tests assuming unequal variances.

To compare current tree heights, we obtained Lidar data for the area from Pima County, with data acquired from flights on February 20-26, 2015. Absolute vertical accuracy for the data was verified at 10.3 cm (4.1 in) for the raw LAS files. For the study area, the data had an average point density of 1.3 points m^{-2} (0.1 points ft^{-2}). It was collected in late winter, and thus at the time least likely to produce return data from leaf surfaces. There was no field verification of individual tree height and no attempt to correlate with basal diameter for a weighted canopy average, so the values used here provide a useful comparison between plots but cannot be assumed as a value comparable to other sites. Canopy top height was determined from the highest 10% of Lidar returns for each plot (reference plot n= 239, treated plot n=430). The mean ground surface elevation for each plot was subtracted from every canopy value, giving a canopy height above ground. Height values for the two plots were compared with a two-sample t-test assuming unequal variances. We used a significance value of p=0.05 with a two-tail probability.

RESULTS

Two years after thinning, there was a significantly greater increase in diameter among mesquites in the thinned plot, which increased an average of 2.5 cm (means of 4.6 and 7.1 cm in 1998 and 2000, respectively) compared to 1.5 cm in the control plot (4.5 and 6.0 cm)($p<0.005$, 105 df). This corresponds to a 67% increase in tree growth due to thinning in only two years. There was no significant difference in the change in tree height from 1998 to 2000. Trees in the thinned plot increased from 2.31 to 2.94 m (7.58 to 9.65 ft) compared to 2.19 to 2.95 m (7.19 to 9.68 ft) in the control ($p=0.17$, df=104). Most trees in the thinned and control plots had only a single stem. In 2000, 56 of the 58 trees in the thinned plot (97%) had a single stem or trunk, compared to 45 out of 50 trees in the control plot (90%); the remaining trees in both plots had two stems.

Measurements in 2017 showed that mesquite tree density increased on the thinned plot, from 542 to 1,363 trees ha^{-1} (219 to 552 trees ac^{-1}), between 1998 and 2017, through a combination of cut trees that resprouted and recruitment of new individuals. In contrast, the unthinned control plot showed a decrease, from 2,683 to 1,975 trees ha^{-1}. Trees on the

thinned plot grew significantly taller than on the control plot, with mean top heights of 5.49 m (18.02 ft) in the thinned plot and 5.34 m (17.54 ft) in the unthinned plot (two-tailed p=0.005, df=420).

Mean basal area of trees was slightly greater on the thinned than the control plot (0.06 vs. 0.04 m^2, 0.67 vs. 0.38 ft^2), but the difference was not statistically significant (p=0.38). When considering only those trees with one or two stems at ground level (13 of the 20 measured on thinned plot, 19 of 20 on the control plot), basal area was almost identical between thinned and control plots (0.03 vs. 0.04 m^2, 0.33 vs. 0.38 ft^2).

Resprouted stems were conspicuous and significantly more abundant on the thinned plot. The sampled trees on the thinned plot had a mean of 5.2 live stems at breast height (range 1-13), twice the density on the control plot (mean 2.7 live stems at breast height, range 1-5; p=0.009) indicating a shift to a more shrub-like growth form. Understory shrubs found on the plots in 2017 showed differences in population density between plots. Graythorn (*Zizyphus obtusifolia*) had 122 plants ha^{-1} (49 plants ac^{-1}) on the thinned plot and 341 plants ha^{-1} (138 plants ac^{-1}) on the control plot, and hackberry (*Celtis* sp.) had 24 plants ha^{-1} (10 plants ac^{-1}) on the thinned plot and 205 plants ha^{-1} (83 plants ac^{-1}) on the control plot. Desert broom (*Baccharis sarothroides*) had 21 plants ha^{-1} (8 plants ac^{-1}) on the thinned plot and none on the control plot. Wolfberry (*Lycium* sp.) had one plant on each plot. A vine component was also present but leafless, and the herbaceous component was dormant during the field visit in 2017.

DISCUSSION

These results demonstrate that thinning a dense stand of young velvet mesquite can result in faster growth rates. It is possible that the effect would have been stronger if the area had been retreated at least once to eliminate root sprouts from cut trees. Despite the return of some cut trees and recruitment of new trees, the treated plot maintained a lower tree density than the control plot 19 years after treatment.

The decrease in tree density on the control plot supports the concept of self-thinning in mesquites, whereby higher density stands will cause enough competition to encourage natural mortality (Felker et al 1990). Despite that, density in the thinned stand remained 2-10 times higher than in mature mesquite reference sites.

The shrubs found on the plots are among those characteristic of mature mesquite bosques (Stromberg 1993). While there were differences in population density of shrub species between plots, mosty of the shrubs counted were very small individuals, not reproductive plants. Thus, these differences are not conclusive but a recommended subject for further study.

While mesquite trees in any context provide habitat value for wildlife, the value of mature mesquite bosques is largely due to the composition and structure of the plant community. High foliage density in multiple height strata supports diversity and abundance among birds, while the understory shrub component supports frugivorous birds (Stromberg 1993). This study suggests that thinning can accelerate development of wildlife habitat in young mesquite stands.

These results may be useful to inform management decisions at Bingham Cienega and at other sites with similar conditions along the San Pedro River and elsewhere, including the San Pedro Riparian National Conservation Area (managed by BLM), Three Links Farm (TNC), and 7B Ranch (Resolution Copper).

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Session 23: Grasslands

Prescribed fire, Sky Islands, Arizona, Grasslands
(Photo courtesy of the USDA Forest Service Coronado National Forest)

Abstracts and Papers
De La Rosa
Hruska
Ponce-Guevera
Priesson

Sonoran cows that browse choose the forest, not the trees

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On the western slope of the Sierra Madre Occidental of southeastern Sonora, Mexico, a conservation easement protects large stands of primary and secondary tropical deciduous forest (TDF). Within this area, people sustain themselves through farming and low-density cattle ranching. Though cattle may negatively impact tree diversity in areas where they roam, few researchers have quantified cattle foraging preferences for woody plant species, or tested hypotheses explaining potential impacts. I investigated cattle foraging and ranging behavior in order to address the following questions: (1) are cows selecting (or avoiding) particular species of woody plant in the TDF? And, (2) is woody plant diversity in their preferred foraging habitat different from diversity across all forested areas accessible to cows? To quantify the woody plant component of cow diets, I designed and deployed animal-mounted time-lapse video and data logging equipment to record cow feeding and movement. Using GPS data on cow foraging paths, I returned to documented feeding points and censused woody plants within a 5m by 5m area surrounding the eaten plant. I also collected plant census data at 100m intervals across all habitat. I then compared diversity in cow diet, preferred foraging areas, and all available habitat. My results suggest that cows are not picky eaters— in terms of available species, they generally eat what is abundant, given the choices in front of them. Selective behavior, however, is more apparent at the habitat level, cows preferring to forage in areas that are more diverse compared to diversity across all available habitat. A better understanding of cattle foraging and ranging behavior can help inform sustainable economic development practices and conservation, in Mexican TDF and in other multiple use forests.

Las vacas de Sonora que exploran eligen el bosque, no los árboles

En la vertiente occidental de la Sierra Madre Occidental, en el sureste de Sonora, México, una servidumbre de conservación protege grandes rodales de bosque caducifolio tropical primario y secundario (TDF). Dentro de esta área, las personas se sostienen mediante la agricultura y la ganadería de baja densidad. Aunque el ganado puede tener un impacto negativo en la diversidad arbórea en las áreas donde deambulan, pocos investigadores han cuantificado las preferencias de forraje del ganado por especies de plantas leñosas, o han probado hipótesis que explican los posibles impactos. Investigué el comportamiento de alimentación y rango del ganado para abordar las siguientes preguntas: (1) ¿están las vacas seleccionando (o evitando) especies particulares de plantas leñosas en el TDF? Y, (2) ¿es la diversidad de plantas leñosas en su hábitat de alimentación preferido diferente de la diversidad en todas las áreas boscosas accesibles a las vacas? Para cuantificar el componente de la planta leñosa de las dietas de las vacas, diseñé e implementé equipos de registro de datos y video de lapso de tiempo montados en animales para registrar la alimentación y el movimiento de las vacas. Al utilizar los datos de GPS en las rutas de alimentación de las vacas, volví a los puntos de alimentación documentados y centré las plantas leñosas en un área de 5m por 5m que rodeaba la planta comido. También recopilé datos del censo de plantas a intervalos de 100 m en todo el hábitat. Luego comparé la diversidad en la dieta de las vacas, las áreas de alimentación preferidas y todo el hábitat disponible. Mis resultados sugieren que las vacas no son quisquillosas: en términos de especies disponibles, generalmente comen lo abundante, dadas las opciones que tienen delante. El comportamiento selectivo, sin embargo, es más evidente a nivel de hábitat, las vacas prefieren alimentarse en áreas que son más diversas en comparación con la diversidad en todos los hábitats disponibles. Una mejor comprensión de la alimentación del ganado y el comportamiento de variación pueden ayudar a informar las prácticas de desarrollo económico sostenible y la conservación, en el TDF mexicano y en otros bosques de uso múltiple.

NOTE: A manuscript was not submitted to accompany this presentation.

Understanding Different Land Use Patterns in the Valleys of the Madrean Borderlands

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Conversion of rangeland to housing and irrigated crops continues to be a concern in the Southwest. This study was devoted to understanding dramatic differences in land use/land cover in the US-Mexico borderlands at the Chihuahua-Sonora-Arizona-New Mexico nexus. While southwestern New Mexico and northeastern Sonora have remained overwhelmingly devoted to ranching, northwestern Chihuahua has undergone steady conversion of range to irrigated crops, and southeastern Arizona has seen exurban development and a recent change in farm dynamics. To understand the drivers of these different trajectories, I conducted extensive interviews in 2017 with residents of Janos, Chihuahua; Hidalgo County, New Mexico; and Cochise County, Arizona. The research revealed several regulatory differences between states that are important contributing factors, but the key drivers are social and microeconomic. Land conversion in Janos has been driven by the conjuncture of three quite separate factors: Mexico's historic land reform that fractured large ranches; an influx of ethnolinguistically distinct farmers – Mennonites – with a strong cultural value for farming; and a system of groundwater regulation that does little to regulate groundwater. Divergent patterns of land use and ownership between Cochise County, Arizona and Hidalgo County, New Mexico relate partly to significant historical differences of mining and settlement and partly to contrasting groundwater regulations. Understanding the social trends and policy differences between states will be crucial for strategizing conservation or restoration efforts.

Comprendiendo los diferentes patrones de uso de tierra en los valles de las tierras fronterizas en el Archipiélago Madrense

La conversión de pastizales a viviendas y cultivos de riego continúa siendo una preocupación en el suroeste de los Estados Unidos. Este estudio se dedicó a comprender las diferencias dramáticas en el uso de la tierra / cobertura de la tierra en las tierras fronterizas de México y los Estados Unidos en el nexo Chihuahua-Sonora-Arizona-Nuevo México. Mientras que el suroeste de Nuevo México y el noreste de Sonora han permanecido abrumadoramente dedicados a la ganadería, el noroeste de Chihuahua ha experimentado una conversión constante a cultivos de riego, y en el sudeste de Arizona se ha producido un desarrollo exurbano y un cambio reciente en la dinámica de las granjas. Para comprender los impulsores de estas diferentes trayectorias, realicé extensas entrevistas en 2017 con residentes de Janos, Chihuahua; Condado de Hidalgo, Nuevo México; y el condado de Cochise, Arizona. La investigación reveló varias diferencias regulatorias entre los estados que son factores contribuyentes de importancia, pero los factores clave son sociales y microeconómicos. La conversión de la tierra en Janos ha sido impulsada por la coyuntura de tres factores bastante distintos: la reforma agraria histórica de México que fracturó ranchos grandes; una afluencia de agricultores etnolingüísticamente distintos - menonitas - con un fuerte valor cultural para la agricultura; y un sistema de regulación de aguas subterráneas que hace poco para regular el agua subterránea. Los patrones divergentes de uso de la tierra y propiedad entre el Condado de Cochise, Arizona y el Condado de Hidalgo, Nuevo México se relacionan en parte con importantes diferencias históricas de minería y asentamiento y en parte con las regulaciones contrastantes de aguas subterráneas. Comprender las tendencias sociales y las diferencias de política entre los estados será crucial para la estrategia de los esfuerzos de conservación o restauración.

NOTE: A manuscript was not submitted to accompany this presentation.

Long term persistence of prairie dog colonies in Mexico

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Over the last century, prairie dog (*Cynomys* spp) distribution was drastically reduced by habitat fragmentation, poisoning campaigns, diseases, and climate change. Populations reduction increased the probability of local extinctions and compromised their long-term persistence. By 1980, Mexico maintained one of the largest complexes of colonies in North America, dispersed in a matrix of private and communal properties where livestock and agriculture has been the main economic activities, but also the greatest threat to prairie dog habitat due to unsustainable practices and the lack of technical capacity of local producers. To protect the last prairie dog populations in Mexico, a Biosphere Reserve was created in 2009; since then, close collaborations with local producers has been established to design and implement sustainable management and restoration programs within the Biosphere Reserve, protecting the last prairie dog populations and grassland ecosystems in Mexico.

Persistencia a largo plazo de colonias de perros de las praderas en México

Durante el siglo pasado, la distribución del perro de las praderas (Cynomys spp) se redujo drásticamente por la fragmentación del hábitat, las campañas de envenenamiento, las enfermedades y el cambio climático. La reducción de las poblaciones aumentó la probabilidad de extinciones locales y comprometió su persistencia a largo plazo. Para 1980, México mantenía uno de los mayores complejos de colonias de América del Norte, disperso en una matriz de propiedades privadas y comunales donde el ganado y la agricultura eran las principales actividades económicas, pero también la mayor amenaza para el hábitat de perros de las praderas debido a prácticas insostenibles y la falta de capacidad técnica de los productores locales. Para proteger a las últimas poblaciones de perros de las praderas en México, se creó una Reserva de la Biosfera en 2009; desde entonces, se han establecido estrechas colaboraciones con productores locales para diseñar e implementar programas de gestión y restauración sostenibles dentro de la Reserva de Biosfera, protegiendo las últimas poblaciones de perros de las praderas y ecosistemas de pastizales en México.

NOTE: A manuscript was not submitted to accompany this presentation.

A New Vision for Pima County's Range Program

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Nationwide the sale of family ranches for development has led to habitat fragmentation and increased water use. In response to these issues and the desire to preserve ranch heritage, Pima County has acquired 13 ranches, including associated state and federal livestock grazing leases. Most of the ranches have active livestock operations that are managed in partnerships between the County and private ranchers. Many of the current ranchers on County-owned and leased ranches are nearing retirement age, and many of them do not have successors within the family. Pima County desires to continue livestock operations on its ranches, because existing infrastructure, water and rangeland maintenance fall into disrepair with no onsite management. Beginning ranchers (ranching for less than 10 years) could serve as potential private-sector ranch managers for Pima County once current ranchers retire. Most of the demand for

grazing land comes from these beginning ranchers. However, beginning ranchers lack access to affordable lease land and often need mentors to provide the necessary range of experience. Pima County is proposing a new program to support beginning ranchers and provide a process to transfer its grazing leases from retiring ranchers to new, capable operators. The program will 1) train beginning ranchers in methods that promote responsible use of natural resources and economic viability, and 2) provide access to affordable leased land as current ranchers retire. This program can be adapted to other regions where local agencies could implement programs to provide access to affordable land, education and mentorship from established ranchers.

Una nueva visión para el programa de campos ganaderos del condado de Pima

A nivel nacional, la venta de ranchos familiares para el desarrollo ha llevado a la fragmentación del hábitat y al aumento del uso del agua. En respuesta a estos problemas y al deseo de preservar el patrimonio de los ranchos, el Condado de Pima ha adquirido 13 ranchos, que incluyen arriendos de pastoreo de ganado estatales y federales asociados. La mayoría de los ranchos tienen operaciones activas de ganado que se administran en asociaciones entre el Condado y los ganaderos privados. Muchos de los rancheros actuales en ranchos arrendados y propiedad del Condado están llegando a la edad de jubilación, y muchos de ellos no tienen sucesores dentro de la familia. El Condado de Pima desea continuar las operaciones ganaderas en sus ranchos, debido a que la infraestructura existente, el agua y el mantenimiento de los pastizales caen en mal estado sin administración en el sitio. Los rancheros principiantes (ranchos de menos de 10 años) podrían servir como posibles administradores de ranchos del sector privado para el Condado de Pima una vez que los rancheros se retiren. La mayoría de la demanda de tierras de pastoreo proviene de estos rancheros principiantes. Sin embargo, los rancheros principiantes carecen de acceso a tierras de arrendamiento asequibles y, a menudo, necesitan mentores para proporcionar el rango necesario de experiencia. El Condado de Pima está proponiendo un nuevo programa para apoyar a los rancheros principiantes y proporcionar un proceso para transferir sus arriendos de pastoreo de ganaderos retirados a nuevos operadores capaces. El programa 1) capacitará a ganaderos principiantes en métodos que promuevan el uso responsable de los recursos naturales y la viabilidad económica, y 2) proporcionen acceso a tierras arrendadas asequibles a medida que los ganaderos actuales se retiren. Este programa se puede adaptar a otras regiones donde las agencias locales podrían implementar programas para proporcionar acceso a tierras asequibles, educación y tutoría de rancheros establecidos.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 24: Mining, Environmental Compliance, Reclamation, and Restoration

Ray Mine open pit copper excavation, Kearney, Arizona
(Photo courtesy of the U.S. Geological Survey)

Abstracts and Papers
Callegary
Gray
Jennings
Reinthal

Development of a conceptual hydrologic model of the Patagonia Mountains, Arizona using geology, geochemistry, groundwater data, and rainfall-runoff and sediment-transport modeling

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The goal of this study is to develop a conceptual hydrologic model of a fractured-rock aquifer in the Patagonia Mountains of southeast Arizona using available geologic, geophysical, chemical, and hydrologic data. The study is motivated by a need to understand current hydrologic and hydrochemical baseline conditions due to an increased interest in mineral exploration and extraction. Rainfall-runoff modeling with sediment transport is being used to understand both hydrology and movement of metal-laden sediments. Model calculation of evapotranspiration and recharge provides estimates of water-budget components at relatively high resolution. Modeled baseflow will be compared with perennial reaches to evaluate if groundwater flow through surficial alluvial material and soils is sufficient to explain baseflow or whether groundwater discharge from faults is required to sustain baseflow. Sediment-transport modeling is being used to evaluate potential impacts of erosion of hillslopes and metal-rich tailings. Isotopes, major ions, and trace metals are being used to understand spatial water quality variability and for flow path delineation. Because wells in the mountains are few, data on known elevations of springs and flowing adits are being used to supplement groundwater level information. Published geologic maps and cross-sections indicate likely directions of groundwater flow via major northwest-southeast trending faults. Breccia pipes, shear zones, and hydrothermally altered rocks likely have low permeability due to precipitation of minerals and secondary weathering to clay. Location and extent of tunnels, adits, and unlined drillholes are poorly known and add a high degree of uncertainty to the understanding of the groundwater flow field.

Desarrollo de un modelo hidrológico conceptual de las montañas de la Patagonia, Arizona utilizando geología, geoquímica, datos de aguas subterráneas y modelación e lluvia-escorrentía y transporte de sedimentos

El objetivo de este estudio es desarrollar un modelo hidrológico conceptual de un acuífero de roca fracturada en las montañas Patagonia, en el sureste de Arizona, utilizando los datos geológicos, geofísicos, químicos e hidrológicos disponibles. El estudio está motivado por la necesidad de comprender las condiciones actuales hidrológicas e hidroquímicas de referencia debido a un mayor interés en la exploración y extracción de minerales. Se está utilizando el modelo de precipitación-escorrentía con transporte de sedimentos para comprender tanto la hidrología como el movimiento de los sedimentos cargados de metal. El cálculo del modelo de evapotranspiración y recarga proporciona estimaciones de los componentes del presupuesto de agua a una resolución relativamente alta. El flujo de base modelado se comparará con alcances perennes para evaluar si el flujo de agua subterránea a través del material aluvial superficial y los suelos es suficiente para explicar el flujo de base o si se requiere la descarga de aguas subterráneas de fallas para mantener el flujo de base. La modelación del transporte de sedimentos se está utilizando para evaluar los impactos potenciales de la erosión de las pendientes y los relaves ricos en metales. Los isótopos, los iones principales y los metales traza se utilizan para comprender la variabilidad espacial de la calidad del agua y para la delineación de la trayectoria del flujo. Debido a que los pozos en las montañas son pocos, los datos sobre elevaciones conocidas de manantiales y corrientes flotantes se utilizan para complementar la información del nivel del agua subterránea. Los mapas geológicos publicados y las secciones transversales indican las direcciones probables del flujo del agua subterránea a través de las principales fallas de tendencia del noroeste al sureste. Las tuberías de brechas, las zonas de cizalla y las rocas alteradas hidrotermalmente tienen una baja permeabilidad debido a la precipitación de minerales y la erosión secundaria a la arcilla. La ubicación y la extensión de los túneles, los accesos y los sondajes sin revestimiento son poco conocidos y añaden un alto grado de incertidumbre a la comprensión del campo de flujo del agua subterránea.

NOTE: A manuscript was not submitted to accompany this presentation.

Mineral-Environmental Baseline Geologic and Geochemical Studies—Keys to Understanding the Equilibrium between Naturally Existing Metal Toxin Levels, Their Dispersion Pathways, and Factors Influencing Down-gradient Risk Potential, and Vulnerabilities

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The Patagonia Mountains are underlain by a complex geologic sequence displaying widespread magmatic and hydrothermal activity and overlapping episodes of mineral deposition. The area has yielded significant resources of Zn, Pb, Cu, Ag, Mn and lesser amounts of Au, Mo, V, and W from base-and precious metal systems. Streams draining the area show acid-generating, metal leaching, metal precipitation, and attenuation processes occurring in both undisturbed natural settings and disturbed, industrial excavation sites. Both the unmined porphyry copper deposits, Red Mountain and Sunnyside, have an environmental footprint of natural acid generation, metal and sulfate dispersion in surface waters derived from dissolution of pyrite-arsenopyrite and secondary reactions under near-surface, oxidizing conditions brought about by their unroofing, erosion, and fractured rock permeability. Waters in these systems have the lowest pH values, moderate specific conductance, and moderately high trace-element content. Mine impacted areas, including World's Fair, Blue Nose, and Lead Queen mines display low pH values, the highest specific conductances, and highest major-and trace-element concentrations in springs and stream reaches and are hosted in felsic volcanic and intrusive rocks. Aluminum, As, Cd, Cu, Fe, Mn, Ni, Pb and Zn are found in high concentrations in water samples and stream sediments down-gradient of both occurrences. Other mines and mineralized areas hosted in limestones and associated rocks show diminished dispersion of heavy metals due to rapid self-mitigation and neutralization. A detail examination of the baseline conditions as well as sediment and hydrologic pathways of the major phases of mineralization present in the mountain range may serve as key to understanding future risks from climate variance and human activity.

Estudios Mineral-Ambientales para medir líneas bases Geológicas y Geoquímicas - Claves para Comprender el Equilibrio entre los Niveles de Toxinas Metálicas Existentes Naturalmente, Sus Rutas de Dispersión y Factores que Influyen en el Potencial de Riesgo de Gradiente Descendente y Vulnerabilidades

Las montañas Patagonia se basan en una secuencia geológica compleja que muestra una actividad magmática e hidrotermal extendida y episodios superpuestos de deposición de minerales. El área ha producido recursos significativos de Zn, Pb, Cu, Ag, Mn y cantidades menores de Au, Mo, V y W de sistemas de metales básicos y preciosos. Las corrientes que drenan el área muestran procesos de generación de ácido, lixiviación de metales, precipitación de metales y atenuación que ocurren tanto en entornos naturales inalterados como en sitios de excavación industrial perturbados. Ambos depósitos de pórfido de cobre sin desminar, Red Mountain y Sunnyside, tienen una huella ambiental de generación de ácido natural, dispersión de metal y sulfato en aguas superficiales derivadas de la disolución de pirita-arsenopirita y reacciones secundarias en condiciones oxidantes cerca de la superficie provocadas por el destechado, la erosión y fractura de la permeabilidad de la roca. Las aguas en estos sistemas tienen los valores de pH más bajos, la conductancia específica moderada y el contenido de elementos traza moderadamente alto. Las áreas impactadas por minas, incluidas las minas World's Fair, Blue Nose y Lead Queen muestran bajos valores de pH, las más altas conductancias específicas y concentraciones más altas de elementos traza en manantiales y arroyos y están alojadas en rocas félsicas volcánicas e intrusivas. Aluminio, As, Cd, Cu, Fe, Mn, Ni, Pb y Zn se encuentran en altas concentraciones en muestras de agua y

sedimentos de corrientes de gradiente descendente de ambas ocurrencias. Otras minas y áreas mineralizadas alojadas en calizas y rocas asociadas muestran una disminución en la dispersión de metales pesados debido a la rápida auto-mitigación y neutralización. Un examen detallado de las condiciones de línea de base, así como de las vías sedimentarias e hidrológicas de las principales fases de mineralización presentes en la cordillera, puede ser clave para comprender los riesgos futuros de la variación climática y la actividad humana.

NOTE: A manuscript was not submitted to accompany this presentation.

Developing Microbial Bio-indicators of Soil Formation on Reclaimed Mine Tailings in Southern Arizona

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Mining reclamation aims to restore affected land to a condition capable of growing self-sustaining plant communities. A critical limitation to vegetation success in mining wastes is that these "soils" are deficient in the microbial communities necessary to support plant establishment. The goal of this research is to work with mining companies to develop microbial metrics that document soil formation improvements during the phytostabilization process. Metrics being evaluated include DNA biomass, particle size, pH, electrical conductivity, total nitrogen and 16S rRNA gene qPCR of bacterial abundance. By demonstrating temporal patterns that correlate with successful plant growth, we can understand which soil quality changes might indicate significant factors important to the selection of soil for mine waste coverage and long term plant establishment. Development of metrics for cover-material evaluation will facilitate more effective and economical reclamation strategies. Significant soil biogeochemical indicators have been identified over 4 years of data that correlate with successful plant growth on more established reclaimed areas. We have observed significant differences in some of these metrics that correlate with plant cover, demonstrating possible short term and long term indicators of re-vegetation success. While electrical conductivity and pH do not appear to be important indicators, we observed that nitrogen, biomass and 16S rRNA bacterial gene qPCR are positive metrics of successful plant cover that may be used to evaluate long term reclamation success.

Desarrollo de bioindicadores microbianos de la formación de suelos en relaves de minas recuperadas en el sur de Arizona

La recuperación minera busca restaurar la tierra afectada a una condición capaz de cultivar comunidades de plantas autosostenibles. Una limitación crítica para el éxito de la vegetación en los desechos mineros es que estos "suelos" son deficientes en las comunidades microbianas necesarias para apoyar el establecimiento de plantas. El objetivo de esta investigación es trabajar con compañías mineras para desarrollar métricas microbianas que documentan las mejoras en la formación del suelo durante el proceso de fitoestabilización. Las métricas que se evalúan incluyen la biomasa del ADN, el tamaño de partícula, el pH, la conductividad eléctrica, el nitrógeno total y el gen rRNA 16S qPCR de la abundancia bacteriana. Al demostrar los patrones temporales que se correlacionan con el crecimiento exitoso de las plantas, podemos entender qué cambios en la calidad del suelo pueden indicar factores importantes para la selección del suelo para la cobertura de desechos mineros y el establecimiento de plantas a largo plazo. El desarrollo de métricas para la evaluación del material de cobertura facilitará estrategias de recuperación más efectivas y económicas. Se han identificado indicadores biogeoquímicos significativos del suelo a lo largo de 4 años de datos que se correlacionan con el crecimiento exitoso de la planta en áreas recuperadas más establecidas. Hemos observado diferencias significativas en algunas de estas métricas que se correlacionan con la cobertura vegetal, lo que demuestra posibles indicadores a corto y largo plazo del éxito de la reforestación. Si bien la conductividad eléctrica y el pH no parecen ser indicadores importantes, observamos

que el nitrógeno, la biomasa y el rRNA bacteriano 16S rRNA qPCR son indicadores positivos de la cubierta de la planta con éxito que pueden utilizarse para evaluar el éxito de la recuperación a largo plazo.

NOTE: A manuscript was not submitted to accompany this presentation.

Comparative Macroinvertebrate Community Structure and Stable Isotopic Food Web Analyses of Bioaccumulation in an Acid Mine Drainage Watershed, AZ

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Mine drainages in the Patagonia Mountains, Arizona impact the composition and function of aquatic ecosystems because acidic, metal-laden water discharges can impact the invertebrate communities and these population impacts can affect food web dynamics. We examined water quality, invertebrates and utilized stable carbon and nitrogen isotopes to examine food web dynamics in three drainages in the Patagonia Mountains with different pH and contaminants. Alum Glutch (an AMD) and had low pH (3.1-4.6) and elevated levels of metals. Humboldt Canyon had low pH (2.7-3.7) with low contaminants, and Middle Harshaw had a neutral pH (7.3-8.6) and low metals. Impaired reaches, especially Alum Gulch, had an overall decrease in invertebrate taxa, dominated by Coleopterans and Hemipterans with a higher mean pollution tolerance level. The Ephemeroptera, Plecoptera, and Trichoptera disappeared. Food webs were dominated by predatory species (Dytiscidae) and a loss of lower trophic levels. Middle Harshaw Creek had the greatest diversity of macroinvertebrates and increased foodweb complexity. Stable isotopic showed a loss of lower trophic levels in impaired streams. To identify sources, bioaccumulation and transportation of contaminants, we collected fish and invertebrates from lakes and streams and used HR-ICP-MS to analyze tissues for 59 inorganic contaminants. Lead isotopic analysis was conducted with soil, water, and aquatic biota samples as a possible method to determine point source pollution locations in relation to known mine locations. Numerous contaminants were found at high levels in both invertebrates and fish near historic mining areas. Lead (Pb) and mercury (Hg) were elevated in predatory invertebrates and predatory sport fish.

Estructura de la Comunidad de Macroinvertebrados Comparativos y Análisis de Alimentos Isotópicos Estables de la Red de Bioacumulación en una cuenca hidrográfica de drenaje ácido, AZ

Los drenajes mineros en las montañas Patagonia, Arizona, impactan en la composición y función de los ecosistemas acuáticos porque las descargas de agua ácidas y cargadas de metal pueden afectar las comunidades de invertebrados y estos impactos de la población pueden afectar la dinámica de la red alimentaria. Examinamos la calidad del agua, los invertebrados y utilizamos isótopos estables de carbono y nitrógeno para examinar la dinámica de la red alimentaria en tres drenajes en las montañas Patagonia con diferentes pH y contaminantes. Alum Glutch (una AMD) y tenía un pH bajo (3.1-4.6) y niveles elevados de metales. Humboldt Canyon tenía un pH bajo (2.7-3.7) con bajos contaminantes, y Middle Harshaw tenía un pH neutro (7.3-8.6) y metales bajos. Los tramos dañados, especialmente Alum Gulch, tuvieron una disminución general en los taxones de invertebrados, dominados por coleópteros y hemíptero con un nivel de tolerancia a la contaminación medio más alto. Ephemeroptera, Plecoptera y Trichoptera desaparecieron. Las redes alimentarias estaban dominadas por especies depredadoras (Dytiscidae) y una pérdida de los niveles tróficos inferiores. Middle Harshaw Creek tenía la mayor diversidad de macroinvertebrados y una mayor complejidad de las redes alimentarias. El isótopo estable mostró una pérdida de niveles tróficos más bajos en las corrientes deterioradas. Para identificar fuentes, bioacumulación y transporte de contaminantes, recolectamos peces e invertebrados de lagos y arroyos y usamos HR-ICP-MS para analizar los tejidos en busca de 59 contaminantes inorgánicos. El análisis isotópico del plomo se llevó a cabo con

muestras de suelo, agua y biota acuática como un posible método para determinar ubicaciones de contaminación puntual en relación con ubicaciones de minas conocidas. Se encontraron numerosos contaminantes a altos niveles tanto en invertebrados como en peces cerca de áreas mineras históricas. El plomo (Pb) y el mercurio (Hg) se elevaron en invertebrados depredadores y peces deportivos depredadores.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 25: Engaging Communities

Interested community discussing invasive specie control, Coronado National Forest
(Photo Courtesy of the USDA Forest Service, Coronado National Forest)

Abstracts and Papers
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Living River of Words: Youth Arts and Science

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For Tucson area students a morning spent in the shade of mature willow trees on the banks of a flowing river is a very rare and special experience. Living River of Words: Youth Poetry and Art (LROW) sets the stage for learning, inspires science inquiry and excites creativity, while addressing the need for student exposure to living systems, through authentic experiences in nature. Established in 2003, this local interdisciplinary arts and science education program directly engages 1,000 K- 12 students and is a regional coordinator providing local support for the national and international River of Words. Thanks to the release of highly treated wastewater into the riverbed the lower Santa Cruz River is alive with perennial flows, lush riparian vegetation, and diverse wildlife. The Living River Project, conducted by Pima County and the Sonoran Institute, measures conditions of this valuable ecosystem, tracks the impacts of our community investment, and seeks to increase public understanding and perception of the value of effluent-dependent wetland ecosystems. In 2014 LROW began to make use of the effluent-dependent stretch of the lower Santa Cruz River as our primary field study site where students are introduced to the concept of watersheds and study wetland habitats through a series of science investigations and the practice of poetry and visual arts. The broader community is engaged and enriched by way of the annual Living River Celebration and traveling exhibit of award winning LROW: Youth Poetry and Art.

Living River of Words: Artes y Ciencias Juveniles

Para los estudiantes del área de Tucson, pasar una mañana a la sombra de los sauces maduros a orillas de un río es una experiencia muy rara y especial. Living River of Words: Poesía y arte juvenil (LROW) establece el escenario para el aprendizaje, inspira la investigación científica y estimula la creatividad, mientras aborda la necesidad de exponer a estudiantes a los ecosistemas, a través de experiencias auténticas en la naturaleza. Establecido en 2003, este programa local interdisciplinario de educación en artes y ciencias involucra directamente a 1,000 estudiantes de todos los niveles entre Kinder y Preparatoria mientras un coordinador regional proporciona apoyo local para el programa nacional e internacional River of Words. Gracias a la liberación de aguas residuales altamente tratadas en el lecho del río, el bajo río Santa Cruz está vivo con flujos perennes, exuberante vegetación ribereña y diversa vida silvestre. El Proyecto Living River, realizado por el Condado de Pima y Sonoran Institute, mide las condiciones de este valioso ecosistema, rastrea los impactos de nuestra inversión comunitaria y busca aumentar la comprensión y percepción pública del valor de los ecosistemas de humedales dependientes de efluentes. En 2014, LROW comenzó a utilizar el tramo dependiente del efluente del bajo río Santa Cruz como nuestro principal sitio de estudio de campo donde los estudiantes son introducidos al concepto de cuencas hidrográficas y estudian los hábitats de los humedales a través de una serie de investigaciones científicas y la práctica de poesía y Artes visuales. La comunidad en general participa y se enriquece a través de la celebración anual de Living River Celebration y la exhibición itinerante de galardonado LROW: Youth Poetry and Art.

NOTE: A manuscript was not submitted to accompany this presentation.

Successes and Challenges on a Spectrum of Stakeholder Engagement

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The USA National Phenology Network (USA-NPN) is a federally-funded, national-scale science and monitoring initiative focused on phenology as a tool to understand how plants, animals, and landscapes respond to environmental variation and change. A primary aim of the Network is to inform decisions in a diversity of realms, including natural resource management and human health. The Network provides a platform for data collection by professional and citizen scientists and delivers freely available quality-controlled data and products to improve decision-making at local to regional to continental scales. We facilitate informed decision-making by using stakeholder input to guide data product development and delivery. Here, we present three cases where we have employed varying levels of engagement and success using a co-production framework. In our first example, which involved tool development, we engaged stakeholders the least, developing the capacity to summarize animal activity via an online tool based on the intuition this form of data summary would have value to managers. In a second example, we developed phenology calendar visualizations mainly in-house, though based them heavily on input and ideas shared with us by stakeholders. In a third approach, we engaged stakeholders in a highly collaborative manner over the course of a project: USA-NPN staff, National Park Service staff, and researchers assessed advancement in spring onset and delivered results in formats suitable for park managers.

Éxitos y desafíos en un espectro de compromiso de las partes interesadas

La Red Nacional de Fenología de EE. UU. (EE. UU.-NPN, por sus siglas en inglés) es una iniciativa de monitoreo y ciencia financiada con fondos federales centrada en la fenología como una herramienta para comprender cómo las plantas, los animales y los paisajes responden a las variaciones y cambios ambientales. Un objetivo principal de la Red es informar las decisiones en una diversidad de ámbitos, incluida la gestión de los recursos naturales y la salud humana. La red proporciona una plataforma para la recopilación de datos por parte de científicos profesionales y ciudadanos y ofrece datos y productos de control de calidad de libre disponibilidad para mejorar la toma de decisiones a escala local, regional y continental. Facilitamos la toma de decisiones informada mediante el uso de los comentarios de las partes interesadas para guiar el desarrollo y la entrega de productos de datos. Aquí presentamos tres casos en los que hemos empleado diferentes niveles de compromiso y éxito utilizando un marco de coproducción. En nuestro primer ejemplo, que involucró el desarrollo de herramientas, se involucraron a las partes interesadas de una forma mínima, desarrollando la capacidad de resumir la actividad animal a través de una herramienta en línea basándonos en la intuición que esta forma de resumen de datos tendría valor para los gerentes. En un segundo ejemplo, desarrollamos visualizaciones de calendario de fenología principalmente internas, aunque las basamos en gran medida en las aportaciones e ideas compartidas con nosotros por los interesados. En un tercer enfoque, involucramos a las partes interesadas de una manera altamente colaborativa en el transcurso de un proyecto: el personal de USA-NPN, el personal del Servicio de Parques Nacionales e investigadores evaluaron el avance en la primavera y entregaron resultados en formatos adecuados para los gerentes de parques.

Note: Full Paper Follows

Successes and Challenges on a Spectrum of Stakeholder Engagement

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Abstract-- *The USA National Phenology Network (USA-NPN) is a federally-funded, national-scale science and monitoring initiative focused on phenology, the study of seasonal life cycle events, as an approach to understanding how plants, animals, and landscapes respond to environmental variation and change. Through the collection and curation of professional and citizen scientist-derived datasets, a primary aim of the Network is to inform decisions across a diversity of realms, from natural resource management and conservation to public health and human well-being. The Network does this by developing and delivering quality-controlled data and products designed to improve decision-making at local to regional to continental scales. These include heat accumulation and pest forecast maps, visualizations of phenology activity and customizable dashboards for partner organizations, and accessible descriptions of how the timing of spring is shifting across the National Park system. Furthermore, we facilitate informed decision-making by enabling partners and stakeholders to build their own data collection programs and engaging them early in the product development process. In this paper, we share challenges and lessons learned from our experiences over our initial 10 years. In particular, we examine a series of case studies through the lens of stakeholder engagement and collaboration. We found that one size doesn't fit all, but instead, successful engagement is context-specific and scale-dependent. As the Network looks to the future, we identify next steps for achieving "actionable" science through implementing robust evaluation methods and fostering enduring partner collaborations.*

INTRODUCTION

There has been an emerging recognition that using a co-production approach to knowledge creation -- in which scientists, decision-makers, and stakeholders work together as equal partners to develop research and tools to address a problem -- holds immense value to all parties involved. A number of useful frameworks and case studies have been described to guide and evaluate the efficacy and implementation of these processes, particularly in the context of climate adaptation projects and natural resource management (e.g. Dilling and Lemos 2011, Hegger et al. 2012, Kirchoff et al. 2013; Meadow et al. 2015, Reed et al. 2014, Wamsler 2017). Some basic principles that have been identified as best practices in conducting such work in order to increase the likelihood of success include collaboration, engagement, commitment, buy-in, communication, and decision-relevant outcomes (Enquist et al. 2017, Schlesinger 2010). Ideally, these approaches can solidify collective knowledge from individuals and organizations that have successfully demonstrated how research can be most effective and actionable.

The USA National Phenology Network (USA-NPN; www.usanpn.org) is a federally-funded, national-scale science and monitoring initiative focused on phenology, the study of the seasonal activity of plants and animals, as an approach to understanding how communities and landscapes respond to environmental variation and change. The Network consists of volunteers, scientists, natural resource managers, educators, students, and policy makers who collect, share, and use phenological data and information. Ultimately, the Network aspires to advance science and inform decisions across a variety of realms and disciplines. We achieve these goals by communicating and connecting with stakeholders and engaging diverse communities of practice across science, education, and management. The Network was established 10 years ago with an initial goal of collecting, storing and sharing phenological data and information. However, as we have become more sophisticated in data delivery and the volume of data we collect and share, we have expanded our focus in recent years to facilitate the use of the data in decision making. Our stakeholders often need phenological information to control invasive species, assess vulnerability in sensitive species, monitor keystone species, communicate with park visitors about the timing of wildflowers or leaf color change, assess health risks due to peaks in pollen production or activity of disease vectors, and a variety of other applications (Enquist et al. 2015). We wish to offer data products, tools, and resources that directly address these needs.

Thousands of professional and citizen scientists have volunteered their time over the past decade to contribute data using standardized protocols through the *Nature's Notebook* (www.naturesnotebook.org) platform (Denny et al. 2014; Rosemartin et al. 2013). This effort has resulted in a continually growing dataset of over 13 million observation records describing the seasonal activity of plants and animals across the United States. The Network offers these raw observations as well as derived, value-added products and datasets to more directly meet data users' needs. Data and products have been used for applications across a broad range of disciplines, from validating land surface phenology (Peng et al. 2017, 2018), understanding climatic drivers in water-limited ecosystems (Gerst et al. 2016; Mazer et al. 2015), and predicting activity in invasive species (Chapman et al. 2014, Wallace et al. 2016).

The USA-NPN: A Boundary Organization

The USA-NPN is uniquely situated to co-produce and deliver actionable science as we look forward to our next decade. As a boundary organization and a network with a diverse membership, we have the capacity to bring together scientists and land managers or other practitioners to shape phenology products to be highly credible and to be packaged for robust and deliberate decision making. From early in its history, the USA-NPN has recognized the need to build and sustain relationships with partners to create tools and products that meet the needs of practitioners on the ground (Kirchoff et al. 2013; Wall et al. 2017a); however, it has taken time to build the infrastructure and products to support deep collaborations (Schwartz et al. 2012; USA-NPN 2011, 2012). The National Coordinating Office (NCO) of the USA-NPN, which organizes the efforts of the USA-NPN, applies broad scientific knowledge and connections in the researcher communities to keep a pulse on advancements in the field and knowledge gaps while simultaneously identifying stakeholder needs through workshops, conferences, and relationship building within management agencies and individuals.

In recent years, the USA-NPN has engaged in a range of collaborative endeavors that ranged from limited initial stakeholder input to the cultivation of deep relationships; these collaborations have varied in their efficacy, longevity, and buy-in. Here, we assess USA-NPN projects using existing co-production frameworks and best practices. The goal of this paper is to reflect on lessons learned of engaging in a spectrum of engagement approaches by highlighting projects or tools where the USA-NPN strived to address stakeholder needs.

We chose to evaluate the pros and cons of six case studies projects by applying the four approaches to stakeholder engagement presented in Meadow et al. (2015): Contractual, Consultative, Collaborative, and Collegial. We chose this framework for this retrospective analysis because we recognized that the USA-NPN has delivered products that fit appropriately along this spectrum of co-production in terms of the origin of the research question or need, the nature of the relationship with researchers, and the involvement of stakeholders. Table 1 summarizes our experience with the four modes; below we describe the case studies in detail.

USA-NPN CASE STUDIES: TOWARD EFFECTIVE STAKEHOLDER ENGAGEMENT TO SUPPORT DECISION-MAKING

Maps of heat accumulation

Project details: In 2016, the USA-NPN began producing daily maps of the accumulation of heat across the country (Figure 1A; Crimmins et al. 2017). The Accumulated Growing Degree Day maps (AGDD; www.usanpn.org/data/aggd_maps) were developed because temperature is known to be a driver of phenology in many species. Many organisms respond to the accumulation of heat in the spring by transitioning into a phenophase, such as leafing or flowering, once the necessary amount of warmth has occurred (Panchen et al. 2014). The USA-NPN opted to offer these daily maps to "test applicability of new technology" (Meadow et al. 2015) and to demonstrate our capacity to deliver gridded maps of variables that drive phenology.

Engagement mode: While the USA-NPN effectively communicated about these maps to key audiences and received positive feedback, overall, stakeholders played a limited role in the scoping and development of the product. This

contractual mode of engagement was characterized by a unidirectional flow of information from the USA-NPN to potential end users.

Figures 1A & 1B

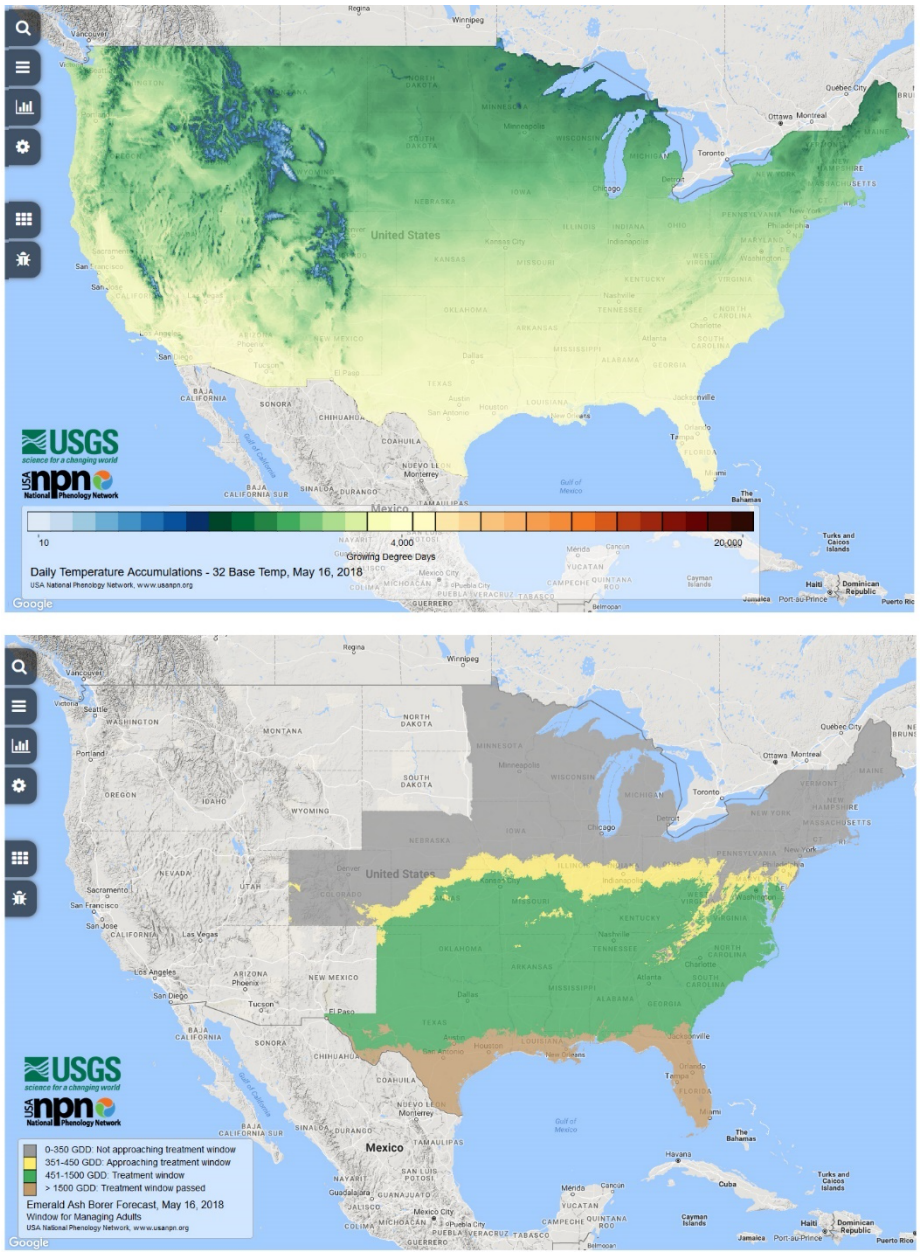

Figure 1A-- Daily Heat Accumulation maps produced by the USA-NPN.

Figure 1B-- Emerald Ash Borer pheno forecast map based on AGDD maps show the timing of predicted management windows up to 6 days in advance. Maps created on May 16, 2018.

Table 1-- Pros and cons of different modes of collaboration employed by the USA-NPN.

Mode of Collaboration	Tool or Project	Pros	Cons
Contractual	● Heat Accumulation maps	● Can generate products with relatively quick turn-around based on internal expertise ● Can prioritize internally without lengthy process to scope	● Unclear if or how products are being used by target audiences ● Less likely to get important parameters right for all audiences
Consultative	● Activity curve phenology visualization ● Pest Pheno Forecasts	● Products have use cases in mind during scoping process and are designed for broad appeal ● Input from target users on how to deliver information and at what scale	● Difficult to assess and evaluate use of information and products in decision-making context
Collaborative	● Custom U.S. Fish & Wildlife Service data dashboard ● Timing of Spring in National Parks research study	● Buy-in and engagement from partners ● Increased likelihood to use tool or information in decision-making	● Products are specialized to target agency partners and information not necessarily transferable ● Timeline/budget dependent on partner
Collegial	● Local Phenology Leader project planning process	● Sustained participation in *Nature's Notebook* is self-motivated and goal-oriented ● Can evaluate progress at site or local scale	● Return on investment may be on the timescale of years and difficult to quantify ● Loss of ability to track outcomes for participants that use resources independently

Outcomes and lessons learned: A benefit of this approach is that we could quickly generate a suite of map products that are both relevant and useful to society and also demonstrate the capacity offered by the USA-NPN to generate,

maintain, and deliver data products relevant to science and management applications. A drawback of taking this approach is that it can be difficult to assess the impact of this approach.

2. Pest management forecasts

Project details: When combined with documented heat accumulation thresholds, gridded AGDD layers can be transformed into maps that indicate when specific events are likely to occur. In 2017, the USA-NPN began generating predictive maps of phenological transitions based on the AGDD maps and published thresholds, thereby offering products that are more relevant for decision-makers. We opted to focus on species of concern to managers, particularly insect pests with known thresholds associated with stages when management action can be taken.

Engagement mode: In this effort, we undertook using a consultative mode of collaboration, characterized by researchers consulting with stakeholders to recognize the problem and brainstorm a solution. We reached out to dozens of managers, foresters, researchers, arborists and extension agents to learn about their needs for maps, existing information gaps, and species of interest in order to synthesize their experience and knowledge. This process largely involved discussions with stakeholders to understand both their needs and to get feedback on various iterations of the product prior to release.

Outcomes and lessons learned: This effort led to a pilot suite of daily pheno forecast maps that show, for five insect pests, up to 6 days into the future, *when* and *where* the vulnerable stage of the insect will occur in order to take management action (www.usanpn.org/data/forecasts; Figure 1B). We used existing scientific knowledge to solve an applied problem by presenting information in a digestible and accessible way. Largely this has been a successful effort in that it has shown a broader array of stakeholders our capacity so that future products can be shaped to be delivered and developed in a more involved co-production framework. In the future, these maps will be used to engage new stakeholder communities to expand phenological forecasts into broader applications, including human health and disease vectors. This will require nimbleness, as we have learned that what suits one community may be very different than another in terms of format, messaging, and timelines of product delivery.

Phenology visualizations

Project details: Data are collected through the *Nature's Notebook* observation program using "status" protocols; observers are asked to record positive observations of phenophases and their intensity as well as when phenophases are absent. This has enabled the USA-NPN to create an interactive, customizable feature called *Activity Curves* in the Visualization Tool (www.usanpn.org/data/visualizations). This visualization emerged from in-depth discussions with partners, including the Audubon Society (Figure 2). Activity curves allow users to display the seasonal magnitude and shape of observations through time across sites to explore how the timing and intensity of phenological stages compare between years, regions, species and phenophases. Managers can use this tool to watch for asynchrony between interacting species; for example, one can investigate potential mismatch between flowering and pollinators, or fruit availability and arrival of migratory birds.

Engagement mode: As in the case of developing the pheno forecast maps described above, this process was consultative, with iterative feedback from engaged audiences through the development process but lacking a research question driven by stakeholders.

Outcomes and lessons learned: We were limited in assessing the impact of this new tool in meeting the needs of the community, and there is the potential for the tool to not be broadly applicable. However, we maintain ongoing discussions with the targeted user community to learn if and how they are using the tool, and how to improve the tool in future iterations.

Custom interactive dashboards

Project details: The USA-NPN builds strong, trust-based relationships within land management agencies such as the U.S. Fish and Wildlife Service. One of the products that emerged from this collaboration is an online Dashboard that

allows individual refuges to customize summarized data from the USA-NPN database for both their own internal and external audiences (www.fws.usanpn.org/phenology-refuges). Refuge managers control the presentation and delivery

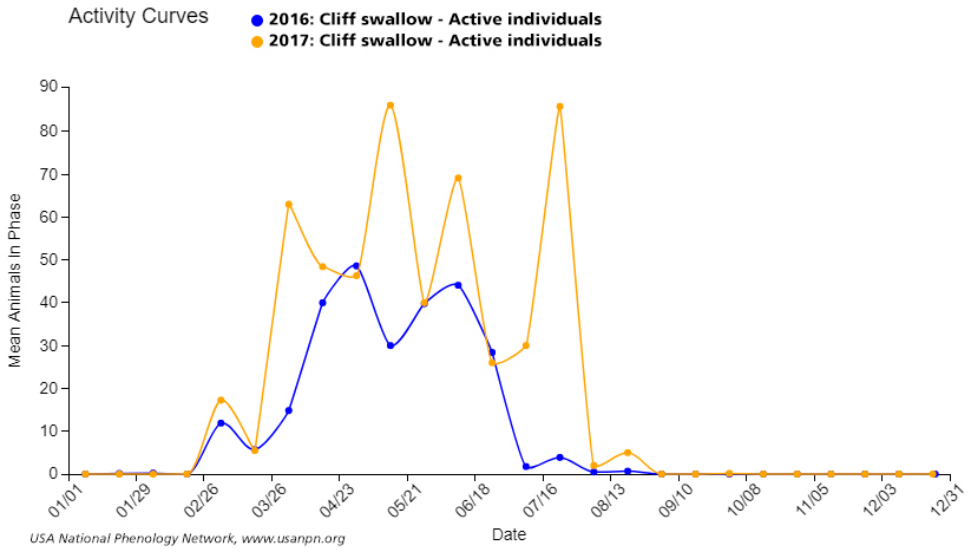

Figure 2-- Phenology Activity Curve visualization showing the timing and the magnitude of active birds in 2016 and 2017. This graphic shows cliff swallow data from BirdSeasons California (Audubon group).

of information for their refuge by customizing the design of a series of widgets, which include custom calendars and activity curves, that display select patterns on species of interest to the individual refuge in a meaningful timeframe and context (Figure 3).

Engagement mode: The approach to this partnership is largely within the **collaborative** mode of stakeholder engagement, characterized by stakeholders and researchers being equal partners throughout the process of the project, from conception to delivery. Here, partners guided the ultimate product and communication messages to their own stakeholders and staff and have ownership to build a refuge-specific dashboard that fits their needs while leveraging on the tools developed by the USA-NPN.

Outcomes and lessons learned: The Dashboards are used by refuge staff to plan management activities, inform visitors about active wildlife or plant life cycle events of interest, and effectively time monitoring. This has led to greater buy-in across the organization and provided an additional incentive for refuges to use the *Nature's Notebook* platform for phenology data collection. While these Dashboards were time intensive to develop and unique to the needs of this partner, certain aspects of the tool are transferable to other partners and projects.

5. Spring Index models serve a National-scale collaboration: Providing historical phenological status and trends of Spring for the National Park Service

Project details: The USA-NPN delivers historical and contemporary maps that show the onset of spring (Ault et al. 2015; Schwartz et al. 2006; www.usanpn.org/data/spring_indices). These models have been designated as national Climate Indicator by the Environmental Protection Agency, the National Climate Assessment, and the USGS Global Change Program and can be used to track how the timing of spring has changed over space and time.

Engagement mode: In 2014 the USA-NPN and the National Park Service launched a collaborative project to understand historical changes in the timing of spring for each park unit (Monahan et al. 2016). We approached the NPS Climate Change Response Program with our historical Spring Index maps, suggesting that they might be useful context for park management. NPS staff agreed, but clarified that results needed to be provided at the park unit level and backed

by a peer-reviewed publication. The study was jointly framed by USA-NPN and NPS staff, analyses were conducted by NPS staff, and academic researchers were engaged to ensure that the models were described and applied appropriately.

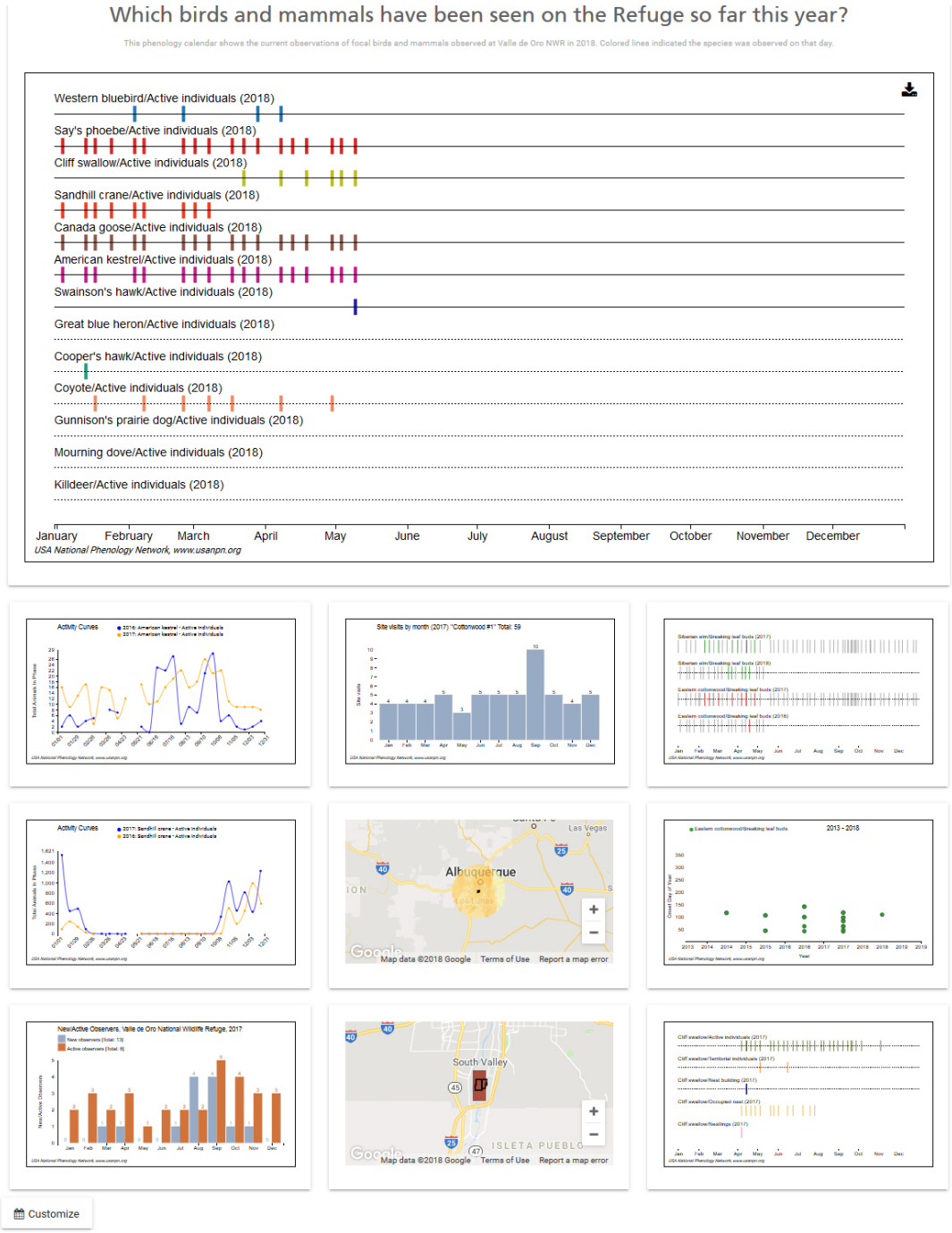

Figure 3--Refuge Dashboard for Valle de Oro National Wildlife Refuge. Custom-selected, dynamically-updated visualizations show phenological activity of focal plants and animals, status of spring onset and accumulated temperature at the Refuge, and metrics on observer recruitment and retention. Users of this tool can customize their calendars by location, year, species and phenophase of interest, to have a better understanding of when they might expect to find various phenological stages in an area.

Outcomes and lessons learned: This project revealed that, for 3 out of every 4 natural resource parks, spring has advanced in recent years relative to historic averages. Half of the parks are experiencing extremely early springs that exceed 95% of historical conditions. Results were disseminated by the NPS via a national event with a press release, a website (https://www.nps.gov/subjects/climatechange/springonset.htm), a resource brief and a national webinar. NPS staff use project results as part of the background information that parks review as they develop new resource stewardship strategies. This project provided relevant, contextual information to many parks to aid in planning. Although this kind of collaboration is time-intensive, the payoffs can substantial with proper communication and buy-in. However, we have learned that to properly scale results from a large-scale study down to a decision-making context is a challenge that must be addressed in a more local scale; this can be a limitation for the USA-NPN given the national-focus and small staff.

6. Cultivating a new generation of local phenology leaders: empowering partners through individualized program development training

Project details: The USA-NPN has recently begun investing heavily in providing partners with resources and support to identify questions, develop their own program, and evaluate successes. To create a site in *Nature's Notebook* for a group or organization where many people will be contributing data (e.g. at a nature preserve, school, botanical garden, or refuge), a local phenology leader must carry out a needs assessment to identify their goals and timelines. In addition, leaders have the opportunity to enroll in an 80-hour online course to receive advanced training and a certificate in the development of a successful phenology monitoring program, including identifying achievable outcomes and measurable success.

Engagement mode: This program planning process is facilitated by the USA-NPN and fits into a collegial mode of stakeholder engagement. This mode of engagement is characterized by researchers supporting and encouraging local project development and capacity. The course and program include a community of practice element with peer-to-peer learning. This helps new leaders learn from others who have experience coordinating a program and enhances new leaders' experiences.

Outcomes and lessons learned: We have seen a shift in the driving motivation of partners from a desire to contribute to a broader effort, to a desire to answer their own local research and management questions. This shift has resulted in greater retention and buy-in from groups that have received training and work closely with NCO staff to develop their own robust and self-sustaining program. In addition, this approach allows for greater tracking of progress of individual partners towards informing decisions and evaluating their success. While partners are asked to complete annual surveys describing their impacts and progress towards their goals, the nature of this mode of collaboration allows partners to independently move through the program planning and evaluation progress without reporting back to the USA-NPN.

CHALLENGES AND OPPORTUNITIES

The USA-NPN is a national organization with a relatively small staff; it can be challenging or even impossible to meet the needs of diverse communities across regions by engaging in deeply collaborative processes in all circumstances. As such, we strive to create tools and resources that can be readily adjusted and customized for a variety of applications, with the understanding that no one size fits all (Lemos and Morehouse 2005). We aim to balance a desire for short-term, rapid results and outcomes with the need for long-term datasets and vetted, high-quality science to ensure that decisions are informed with the best possible information; this requires a diverse set of approaches to the development of products and level of stakeholder input. We have learned in some circumstances our partners are best served by a streamlined production of generic, highly vetted scientific products, such as the continental-scale heat accumulation and Spring Index maps that can then be customized with a specific audience using a co-production approach. For example, our analyses investigating the timing of spring in National Parks and the delivery of pest forecast maps both build upon the more all-purpose Phenology maps that were generated with less stakeholder input. In essence, this allows us to help bridge the usability gap between ready-to-go research and information and the needs of different communities of users (Lemos et al. 2012).

Our experiences reveal that investing in highly collaborative or collegial modes of engagement such as the Local Phenology Leader course results in greater buy-in, stronger relationships, and higher likelihood of success. However, it has been challenging to quantify the return on investment of such relationship building in an era of shifting resources and priorities. This may be remedied by implementing a robust evaluation program in conjunction with training leaders to develop customized programs. Additionally, even if these activities do not directly result in immediate actionable science that is measurable, they lay the groundwork to ensure that the science and data collection being conducted are decision-relevant (Enquist et al. 2017).

CONCLUSIONS

The USA-NPN's focus has progressed over the past 10 years from creating platforms for data collection and resources to supporting researchers in accessing data, to applying these tools and data in management or applied contexts, to actively collaborating and listening to needs and letting this drive our actions and priorities. In the next decade, the USA-NPN will embark on a coordinated effort to seek input from new stakeholder audiences and cultivating relationships to co-development projects by connecting people early and often. We will also pursue opportunities to work with social scientists with expertise in collaborative decision-making. In doing so, we hope to better facilitate linkages between the needs of our communities, gaps in the production and availability of knowledge, communication between stakeholders and scientists, and the evaluation of successful progress towards broad strategic goals and project-specific outcomes. We recognize that, for our organization, one of the missing pieces is the need to set, track, and evaluate our programmatic goals related to knowledge co-production with stakeholders to ensure that our products and tools are useful to science and society, and to evaluate the process by which we can facilitate decision-making in a quantifiable framework (e.g. Wall et al. 2017b).

By investing in our future through engagement and collaboration with interdisciplinary teams, the USA-NPN aims to create and share a new generation of tools to allow phenological information to be more easily integrated into decision-making. We are becoming increasingly agile in our ability to effectively build and nurture such relationships and maintain societal and scientific relevance in a changing world. Future outcomes from these efforts will likely include the dissemination of forecasts to help determine when and where to anticipate phenological activity based on known relationships between climate, weather, and phenological transitions to inform short-term decisions and to support adaptation to climate change.

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Borderlands Activism - Organizing Guided by Science

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We will address the work that environmental nonprofits are doing to protect wildlife, public lands and communities in the borderlands, specifically in the Sonoran Desert. Presentation sections will focus on how our work is informed by natural resource experts, how the waiver of environmental and public health laws have impacted communities and wildlife in the borderlands, what the current outlook and funding scenario is related to President Trump's demand for an impermeable 2,000-mile border wall, and how species are already impacted and will be further imperiled by border policies and infrastructure that impede upon their habitat.

Activismo de Borderlands - Organización guiada por la ciencia

Abordaremos el trabajo que las organizaciones ambientales sin fines de lucro están haciendo para proteger la vida silvestre, los terrenos públicos y las comunidades en las tierras fronterizas, específicamente en el desierto de Sonora. Las secciones de presentación se centrarán en cómo nuestro trabajo está informado por expertos en recursos naturales, y cómo la exención de las leyes ambientales y de salud pública han afectado a las comunidades y la vida silvestre en las zonas fronterizas, lo que la perspectiva actual y el escenario de financiamiento están relacionados con la demanda del presidente Trump -el muro de la frontera, y cómo las especies ya están afectadas y se verán aún más amenazadas por las políticas fronterizas y la infraestructura que impiden su hábitat.

NOTE: A manuscript was not submitted to accompany this presentation.

Community Conservation Planning under the Endangered Species Act

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The Endangered Species Act (ESA) is one of the nation's most effective environmental laws and it enjoys broad public support. Despite this, the ESA remains highly controversial and has weathered repeated attacks from Congress, the number of which are on the rise. A common criticism fueling these attacks is that the ESA employs only a top-down approach, imposing burdensome federal rules on landowners and communities while providing no opportunity for local collaboration or input. However, Pima County's own experience with ESA compliance belies this complaint and paints a much different picture of how communities can use the ESA to engage in community-driven, collaborative planning efforts that protect imperiled wildlife while supporting economic development. Almost two decades ago, Pima County embarked on an ambitious effort to identify and protect native wildlife and other important resources. Working with the U.S. Fish and Wildlife Service, the County prepared a Multi-species Conservation Plan (MSCP) designed to protect a variety of species and habitats. In return for these commitments, the Service issued the County a Section 10 Permit, which streamlines ESA compliance, providing regulatory certainty for the county and private landowners and supporting economic development. The MSCP, with its foundation rooted in sound science, was developed locally, crafted with input from interested stakeholders across the region. While the MSCP set a new precedent for engaging and incorporating local stakeholder concerns, it has also set a national standard for advancing local control and community initiatives in response to federal requirements.

Planificación de la conservación comunitaria bajo la Ley de Especies en Peligro de Extinción

La Ley de Especies en Peligro (Endangered Species Act, ESA) es una de las leyes ambientales más efectivas de la nación y cuenta con amplio apoyo público. A pesar de esto, la ESA sigue siendo muy controversial y ha soportado reiterados ataques del Congreso, cuyo número va en aumento. Una crítica común que alimenta estos ataques es que la ESA emplea solo un enfoque de arriba hacia abajo, imponiendo reglas federales onerosas a los propietarios y las comunidades, al tiempo que no brinda la oportunidad de colaboración o aporte local. Sin embargo, la propia experiencia del condado de Pima con el cumplimiento de ESA desmiente esta queja y pinta una imagen muy diferente de cómo las comunidades pueden usar ESA para participar en esfuerzos de planificación colaborativa y comunitaria que protegen la vida silvestre en peligro y al mismo tiempo apoyan el desarrollo económico. Hace casi dos décadas, el Condado de Pima se embarcó en un ambicioso esfuerzo para identificar y proteger la vida silvestre nativa y otros recursos importantes. Trabajando con el Servicio de Pesca y Vida Silvestre de los EE. UU., el Condado preparó un Plan de Conservación de Múltiples Especies (MSCP por sus siglas en inglés) diseñado para proteger una variedad de especies y hábitats. A cambio de estos compromisos, el Servicio otorgó al condado un Permiso de la Sección 10, que simplifica el cumplimiento de la ESA, brindando seguridad reglamentaria para el condado y los propietarios privados y apoyando el desarrollo económico. El MSCP, con su base arraigada en la ciencia sólida, se desarrolló localmente, elaborado con la contribución de los interesados de toda la región. Si bien el MSCP sentó un nuevo precedente para involucrar e incorporar las preocupaciones de las partes interesadas locales, también estableció un estándar nacional para avanzar el control local y las iniciativas comunitarias en respuesta a los requisitos federales.

NOTE: A manuscript was not submitted to accompany this presentation.

Madrean Discovery Expeditions Education Program in Sonora, Mexico

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Since 2015 the Madrean Discovery Expeditions (MDE) of GreaterGood.org (GGO) has completed biotic inventories in the Sierras Buenos Aires, Elenita, Juriquipa, and el Tigre in northeastern Sonora, Mexico. The MDE Education program shares the results of the Expeditions with residents who live in the adjacent river valleys. Raising awareness about the amazing diversity of animals and plants will help protect these unique Sky Island mountain ranges for the future. MDE educators have given presentations to about 1300 students and 70 teachers in schools in 18 rural towns in northeastern Sonora. The schools are mostly telesecondarias – middle schools that receive class material via satellite. Power Point presentations on various aspects of the biodiversity, biogeography, and natural history of the Sky Islands Region were given to each class. Students were asked to identify animal photographs taken as part of GGOs Project WILDCAT in the lower Río Bavispe Valley south of Granados. The images included four native cats: jaguar (*Panthera onca*), ocelot (*Leopardus pardalis*), mountain lion (*Puma concolor*), and bobcat (*Lynx rufus*). Students in the smaller towns had better local knowledge of plants and animals than students from bigger, more urban towns. School visits included observing insects, flowers, and leaves under a binocular microscope, and students reading text about bats, hummingbirds, pollination, and migration. Materials given to each school included a booklet on Sonoran natural history in Spanish, hummingbird feeders, seeds for a pollinator garden, and a field guide to birds in Spanish.

Programa Educativo de Expediciones Madrean Discovery en Sonora, México

Desde 2015, Madrean Discovery Expeditions (MDE por sus siglas en inglés) de GreaterGood.org (GGO por sus siglas en ingléa) ha completado los inventarios bióticos en las Sierras de Buenos Aires, Elenita, Juriquipa y el Tigre en el noreste de Sonora, México. El programa de Educación de MDE comparte los resultados de las Expediciones con los residentes que viven en los valles de los ríos adyacentes. Concienciar sobre la increíble diversidad de animales y plantas ayudará a proteger estas cadenas montañosas de las Islas Serranas únicas para el futuro. Los educadores de MDE han dado presentaciones a aproximadamente 1300 estudiantes y 70 maestros en escuelas en 18 pueblos rurales en el noreste de Sonora. Las escuelas son principalmente telesecundarias: escuelas intermedias que reciben material de clase por satélite. Las presentaciones de Power Point sobre diversos aspectos de la biodiversidad, la biogeografía y la historia natural de la región de las Islas Serranas se dieron a cada clase. Se les pidió a los estudiantes que identificaran fotografías de animales tomadas como parte del Proyecto WILDCAT de GGO en el valle inferior del río Bavispe al sur de Granados. Las imágenes incluían cuatro gatos nativos: jaguar (Panthera onca), ocelote (Leopardus pardalis), puma (Puma concolor) y lince (Lynx rufus). Los estudiantes en las ciudades más pequeñas tenían un mejor conocimiento local de plantas y animales que los estudiantes de ciudades más grandes y urbanas. Las visitas escolares incluyeron observación de insectos, flores y hojas bajo un microscopio binocular, y estudiantes leyendo textos sobre murciélagos, colibríes, polinización y migración. Los materiales entregados a cada escuela incluyeron un folleto sobre la historia natural de Sonora en español, alimentadores de colibríes, semillas para un jardín de polinizadores y una guía de campo para aves en español.

Note: Full Paper Follows

Madrean Discovery Expeditions Education Program in Sonora, Mexico

Ana L. Reina-Guerrero, Thomas R. Van Devender, and J. Mario Cirett-Galán

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***Abstract**--Since 2015 the Madrean Discovery Expeditions (MDE) of GreaterGood.org (GGO) has completed biotic inventories in the Sierras Buenos Aires, Cucurpe, Elenita, Juriquipa, and el Tigre in northeastern Sonora, Mexico. The MDE Education program shares the results of the Expeditions with residents who live in the adjacent river valleys. Raising awareness about the amazing diversity of animals and plants will help protect these unique Sky Island mountain ranges for the future. MDE educators have given presentations to about 1751 students and 101 teachers in 25 schools in 22 towns in northeastern Sonora. Ten schools were telesecundarias – middle schools that receive class material via satellite. Power Point presentations on various aspects of the biodiversity, biogeography, and natural history of the Sky Islands Region were given to each class. Students were asked to identify animal photographs taken as part of GGO's Project WILDCAT in the lower Río Bavispe Valley south of Granados. The images included four native cats: jaguar (Panthera onca), ocelot (Leopardus pardalis), mountain lion (Puma concolor), and bobcat (Lynx rufus). Students in the smaller towns had better local knowledge of plants and animals than students from bigger, more urban towns. School visits included observing insects, flowers, and leaves under a binocular microscope, and students reading text about bats, hummingbirds, pollination, and migration. Materials given to each school included a booklet on Sonoran natural history in Spanish, hummingbird feeders, seeds for a pollinator garden, and a field guide to birds in Spanish.*

INTRODUCTION

Mexico and Sonora are mega-diversity country and state. The Sonoran Sky Islands are part of the Madrean Pine–Oak Woodland Hotspot, meaning that this area is recognized globally for its high diversity of plants and animals (The Critical Ecosystem Partnership Fund 2018). There are 55 Sky Islands or Sky Island complexes of mountain ranges connected by oak woodland in the Madrean Archipelago or Sky Islands Region between the Sierra Madre Occidental (SMO) in Sonora and the Mogollon Rim in Central Arizona (Van Devender et al. 2013). Each Sky Island is unique because of differences in area, elevational range, nearness to the SMO, substrates, etc. (Fig. 1). These isolated mountains are similar to oceanic islands. The lowland 'seas' around the Sky Islands are desertscrub, thornscrub, or tropical deciduous forest.

GreaterGood.org is an independent charitable organization working to protect people, pets, and the planet. It includes the Madrean Discovery Expeditions (MDE) Program to document the diversity of plants and animals of the Sky Islands in Sonora, Mexico. Through MDE expeditions, groups of 30-80 biologists, land managers, professors, students, and photographers document the flora and fauna on these isolated mountain ranges. All the records and images are publicly available in the MDE database (madreandiscovery.org).

As Baba Dioum once said, "In the end *we* will conserve *only* what *we love*; *we* will *love only* what *we* understand; and *we* will understand *only* what *we* are taught." Sharing the MDE information and new biological discoveries through the Sky Island Environmental Education Experience (SIEE) is an important component of the Madrean Discovery Expedition Program. The SIEE goal is to encourage pride in natural surroundings, profound sense of place, and motivation for a vision of nature protection in middle school students in the towns adjacent to the mountain ranges surveyed. Through class presentations that include bear, jaguar, deer, wild turkey, and hummingbirds, and habitats up to high forests with pines, oaks, and a myriad of wildflowers, the SIEE school visits raise awareness of the natural wonders that occur close to them. Here we summarize our environmental education activities in the Sky Island Region from 2016 to 2018.

Figure 1--Pine-oak forest view in the Sierra el Tigre. Photo by Sky Jacobs.

Environmental Education in the Sonoran Sky Islands

Environmental education is about the environment and the people's close relationship to nature (The Oregon Community Foundation 2006). According to the USA Environmental Protection Agency environmental education is a process that allows people to explore environmental issues, engage in solutions, and take action to improve the environment. Thus, individuals have a deeper understanding of environmental topics and have the skills to make educated and responsible decisions (United States Environmental Protection Agency 2018). To understand and appreciate the environment, basic knowledge of the diversity and natural history of animals, plants, habitats, and landscapes is crucial. Environmental education helps residents to value their natural heritage and make environmentally friendly decisions and actions in their lives.

Área de Protección de Flora y Fauna (APFF) Bavispe (formerly the Reserva Forestal Nacional y Refugio de Fauna Silvestre Ajos-Bavispe; equivalent to a combined National Forest and National Park in the United States) has an area of 456,382 acres and includes eight Sky Island mountain ranges. The APFF Bavispe educational staff has done outreach program in many towns in the area, including a 2006-2008 Pride Campaign by Rare (an international non-profit conservation organization). Workshops and surveys in seven communities addressed water use and conservation, river pollution, toxic waste, garbage, cleaning activities along river beds, etc. (Miranda-Álvarez 2008).

In the early 2000's, the Arizona-Sonora Desert Museum had a project on Migratory Pollinators that reached the town of Bacoachi in the Río Sonora. The Audubon Society and Sonoran Joint Ventures, Naturalia, and The Nature Conservancy had bird workshops for residents in the Río San Pedro. Naturalia, U. S. Fish and Wildlife Service, and Bat Conservation International had wildlife monitoring workshops for biologists in Rancho Los Fresnos. None of these activities were focused on broader regional biodiversity. Here we summarize visits to rural schools in the Sky Islands Region since 2009.

In the Mexican Sky Island region, the loss of habitat is mainly due to mining exploration and development, but is hardly noticed by people in the surrounding communities. Most of the students in these towns have not visited the nearby mountains and have little knowledge of the plants and animals that live in upland forests. The materials related to the environment available to the teachers are very limited, and often created in distant Mexico City, and not related to Sonora.

METHODS

School visits

The Sky Island Environmental Education Experience (SIEE) program started in April-May 2016, with visits to schools in rural towns near Sky Islands visited on Madrean Archipelago Biodiversity Assessment (MABA) Expeditions (Figure 2). A total of 221 students and 18 teachers were reached along the Río Bavispe on the east side of the Sierra el Tigre, including Bacerac, Bavispe, Colonia Morelos, Huásabas, and San Miguelito. SIEE part II was in January 2017, with visits to schools along the Río Sonora on the west side of the Sierras Buenos Aires and la Púrica, including Arizpe, Bacoachi, Cucurpe, and Sinoquipe (Figure 3). A total of 189 students and 12 teachers were reached on this trip. SIEE part III was in May 2017, with visits to schools along the Río Agua Prieta–Arroyo Coquiárachi-Arroyo Nacozari, drainages in the upper Río Yaqui Valley east of MDE Sierras de los Ajos, Buenos Aires, and La Púrica. The towns visited included Agua Prieta, Fronteras, Esqueda, and Nacozari. A total of 290 students and 20 teachers were reached on this trip. SIEE part IV was in December 2017, with visits to schools in northeastern Sonora, close to the Sierras de los Ajos, Elenita, and San José. Ímuris, Cuitaca, Cananea, Naco. Additionally, the same week, presentations on environmental education, and the horned lizards of Sonora were given in Moctezuma. In February 2018, the Colegio Nueva Galicia (private, bilingual middle school) was visited in Hermosillo, capital of Sonora. A total of 908 students, 39 teachers, and 8 local authorities were reached on the December and February trips. SIEE part V was in May 2018, with visits to schools in eastern Sonora close to the Sierras Bacadéhuachi, la Madera, and el Tigre. Schools in Bacadéhuachi, Nácori Chico, and el Sauz were visited. A total of 117 students and 14 teachers were reached on this trip.

Animal and plant diversity presentations

To raise awareness, a 45-minute Power Point presentation of the most exciting and colorful plants and animals observed on the MDE Expeditions to nearby mountain ranges and Project WILDCAT were given in each school (Fig. 4A). Identification tips for popular animals like monarch butterflies and coral snakes were mentioned. Unique or new species were highlighted. The students enjoyed guessing animals or features in the slide show and asking questions.

Project WILDCAT

The Power Point presentations included a series of slides about Project WILDCAT, a GreaterGood.org program to protect predators in the lower Río Bavispe Valley south of Granados. The mammals that the students commonly see are coyotes, deer, gray foxes, and ground squirrels (Fig. 4B). Wildlife camera images were shown to teach Sonoran common names of a variety of mammals, roadrunners, turkey vultures, and wild turkeys. The images of jaguars, ocelots, and bears were especially exciting to the students.

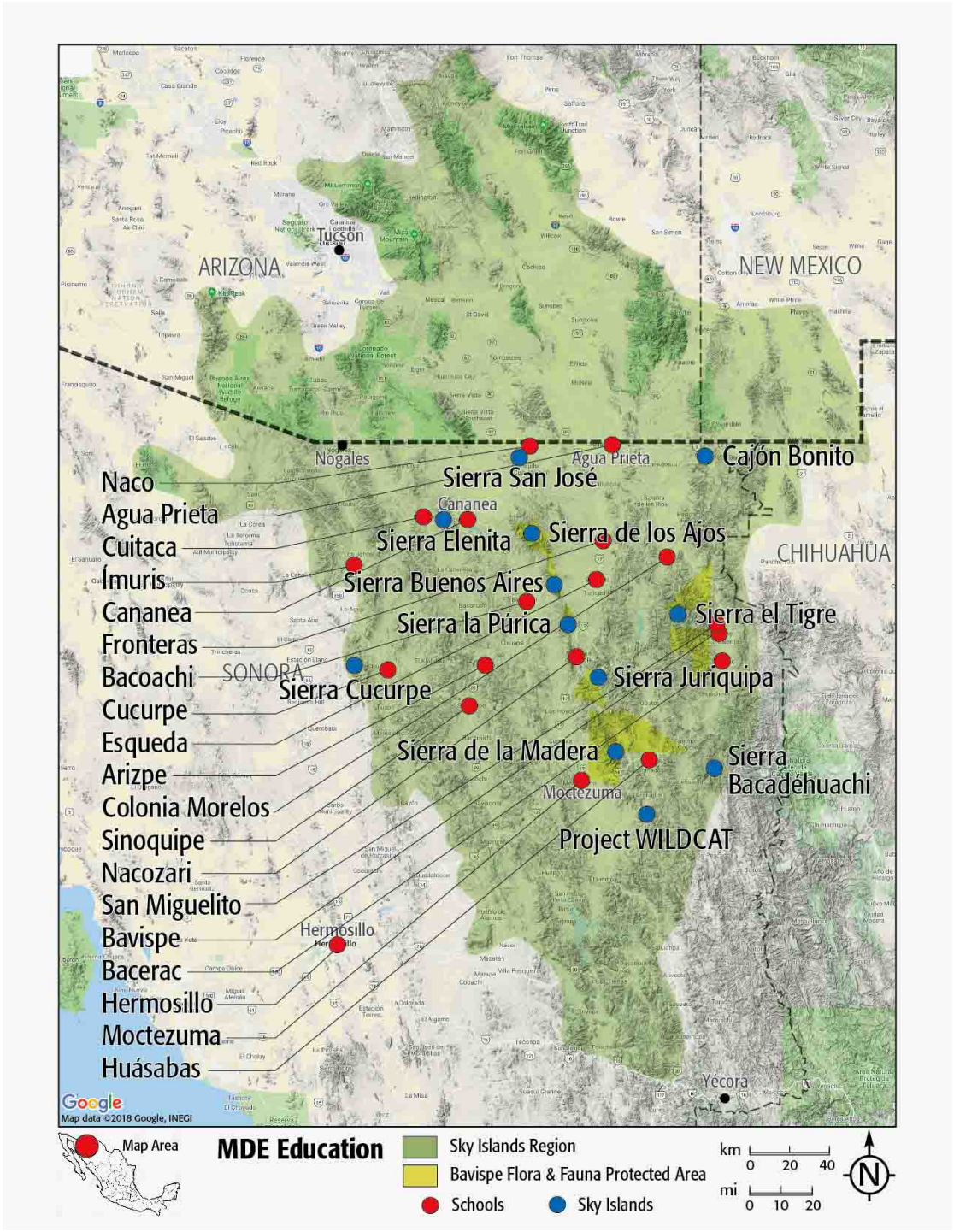

Figure 2--Map of the Madrean Archipelago. Blue dots are Sky Islands visited on MABA or MDE Expeditions. Red dots are towns visited on MDE school trips. Drafted by Dennis Caldwell.

Figure 3--Students and teachers in the Cucurpe *telesecundaria.* Photo by Ana L. Reina-G.

Figure 4. A: Students in the Bacadéhuachi *escuela secundaria* watching MDE presentation. Photo by Ana L. Reina-G. **B.** Wildlife camera image of jaguar (*Panthera onca*) from Rancho Pueblo Viejo. Photo by J. M. 'Memo' Galaz-G.

Observing nature

Students looked at leaves, scorpions, a butterfly, and their fingertips through a binocular microscope. They were excited by the scorpion's stinger, and especially their own fingerprints. Hummingbird feeders, sugar to prepare hummingbird food, and Sonoran natural history booklets were left at the schools. Bird field guides in Spanish provided by Sonoran Joint Ventures were left at many schools. After the activities indoor, students went out in the school campus to look for animals under rocks and check out the plants, in some schools. One of the objectives of the SIEE is to encourage

students to be better observers of animals and plants in the environment where they live, and to appreciate that everything looks different when observed in different ways. Hans Christian Andersen stated “Nature gives us all the things we need to be happy and we can become explorers who find meaning and beauty in nature’s diversity.”

Figure 5. A: Students reading natural history notes and **B:** looking through a microscope with Van Devender in the Bacadéhuachi *escuela secundaria.* Photos by Ana L. Reina-Guerrero.

Sonoran natural history booklet.

We prepared a 70-page natural history booklet in Spanish with essays written by specialists on the different habitats in the State of Sonora, including the Sky Islands Region. It also includes information about pollinators, bats, and gardens to attract hummingbirds and butterflies. This booklet has classroom activities on monarch butterflies, bats, and other animals. It is well illustrated with beautiful, color photographs from the MDE program. This booklet was well received by teachers and students, and two copies were given to teachers in each school. While students were taking turns looking through the microscope, the rest of the class read essays from the booklet on the life cycle of the monarch butterfly and the natural history of bats. After reading, students were asked questions from the text. Students who gave the right answer were rewarded with magnifying glasses or other small prizes. This is a very effective and fun way to get students attention and encourage them to learn about animals. As Kosova once remarked “Personal development of students is impossible without instilling in them environmental values” (Kostova 2003).

Pollinators

These have a very important role in natural environments. They carry pollen from one flower to another, from one plant to another, pollinating the flowers and helping set seeds. Many pollinators like flies and bees, are small and not easily observed. Hummingbirds are very active, highly visible, and not shy. Hummingbird feeders are an excellent way to get students to see these beautiful birds in their school or home. We left two hummingbird feeders, a feeder brush, sugar, and instructions on syrup preparation in each school. Two students were chosen to hang and take care of the feeders, while other students volunteered to take turns later. Butterflies are also important pollinators and excellent nature ambassadors. There are often flower gardens in homes in rural Sonora that attract a great variety of colorful butterflies. We usually left packages of flower seeds to start a garden.

Figure 6. A: Students in the Bacadéhuachi *escuela secundaria* with International Biodiversity Week poster, hummingbird feeder, and natural history book reading prizes. Photo by Ana L. Reina-Guerrero. **B:** Hummingbird feeder. Photo by Thomas R. Van Devender. **C:** Broad-billed hummingbird (*Cynanthus latirostris*) visiting chilicote (*Erythrina flabelliformis*) flowers. Photo by Stephen L. Minter.

RESULTS

Since SIEE started in April 2016, 1751 students, 101 teachers, and 25 schools in 22 towns (Table 1) in the Sky Island Region of Sonora, Mexico have participated in SIEE educational programs. Trips in May 2016 and 2018 coincided with the International Biodiversity week. Ten schools visited were *telesecundarias,* middle schools with one or two teachers in remote areas that receive most of their materials by satellite through a TV monitor. Nine schools were regular middle schools. One visit was to an elementary school. Also, two high schools, two *telebachilleratos,* and an undergraduate class were visited. To attract butterflies and hummingbirds to the school yards, 16 schools planted flowers and hung hummingbird feeders.

DISCUSSION

Visiting middle schools in rural towns in the Sonoran Sky Island region was a great experience for the students and us. The teachers are very receptive to these activities and welcomed us without hesitation, often on short notice. The interactive Power Point presentations, where students are encouraged to name the animals and plants, is a fun way to interact with the class. It helps us to understand how much time students have spent learning with adults in their lives, especially parents, extended family, or neighbors. Students who have explored their surrounding area or ranches with an experienced local person know regional local common names. We noticed that students in the smallest, more rural towns like Cucurpe, Cuitaca, Nácori Chico, and Sinoquipe know more traditional local common names than students in cities. Students in larger schools in Agua Prieta, Arizpe, Cananea, and Hermosillo misidentified regional animals as cheetahs, comodo dragons, and other names learned from cable channel programs like Animal Planet. Traditional common names for tigre, tigrillo, cholugo, escorpión, and chuparosa are being replaced by new names used in popular media and education material from Mexico City, e.g., jaguar, ocelote, coatimudi, monstruo de Gila, and colibrí. We think that it is very important that young Sonorans preserve local knowledge as part of their cultural inheritance, and that keeping local knowledge alive is an asset in our globalized world. Thus, on these school visits, we encourage teachers and their students to value and preserve local knowledge.

ACKNOWLEDGMENTS

We thank the dedicated teachers in the rural Sonoran schools for their hard work, interest, enthusiasm, and access to their students. Noah Horton and Liz Baker at GreaterGood.org encouraged and supported the school programs. We appreciate the Columbus Zoo and Aquarium support of Project WILDCAT. Reviews by Susan D. Carnahan and Guillermo Molina-Padilla greatly helped the paper.

Table 1. Schools visited during Madrean Discovery Expeditions Education Program.

School/town	Residents	Date	Students	Teachers
Agua Prieta	79,138	22-May-17	120	8
Arizpe	1,743	10-Jan-17	64	4
Bacadéhuachi	1,083	21-May-18	35	5
Bacerac	1,342	5-Apr-16	56	2
Bacoachi	924	9-Jan-17	59	4
Bavispe	710	6-Apr-16	95	12
Cananea	31,560	7-Dec-17	290	10
Colonia Morelos	156	8-Apr-16	18	1
Cucurpe	798	12-Jan-17	48	3
Cuitaca	424	5-Dec-17	30	2
Esqueda	6,749	24-May-17	70	4
Fronteras	834	23-May-17	20	2
Hermosillo	812,229	9-Feb-18	80	5
Huásabas	966	6-May-16	60	2
Imuris	9,921	4-Dec-17	60	3
Moctezuma	3,798	5-Dec-17	198	7
Naco	6,401	8-Dec-17	250	10
Nácori Chico	2,051	22-May-18	62	6
Nacozari	12,751	25-May-17	80	6
San Miguelito	550	7-Apr-16	18	2
Sauz	161	23-May-18	20	2
Sinoquipe	379	11-Jan-17	18	1
Total			**1751**	**101**

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Employing Rural Borderlands Youth to Restore Their Home Watersheds

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The Borderlands Earth Care Youth (BECY) Institute is a paid summer internship whose mission is to train the next generation of conservation leaders and rural land stewards. By weaving together watershed, ecosystem and community restoration, youth learn hands-on marketable job skills from a broad spectrum of innovative ecologically and socially-focused organizations and individuals to restore their home watersheds. Through steady exposure to working professionals and an educational curriculum designed to develop life skills and leadership capabilities, high school students living within the burgeoning restoration economy of the US/Mexico borderlands can better imagine a positive professional role in the communities where they have grown up. As of January 2018, 83 youth from Patagonia, Arizona to Douglas, Arizona have participated in the summer programming, many of whom have switch their career focus to fields within conservation. And this summer, we'll build upon past success and expand into a new community – Nogales, Arizona. Our grand vision is to foster sustainable conservation livelihoods on both sides of the US/Mexico border.

Emplear a jóvenes de las zonas fronterizas rurales para restaurar sus cuencas hidrográficas

El Instituto de Juventud de Borderlands Earth Care (BECY por sus siglas en inglés) es una pasantía de verano remunerada cuya misión es capacitar a la próxima generación de líderes de conservación y administradores de tierras rurales. Al entrelazar la cuenca hidrográfica, la restauración de los ecosistemas y la comunidad, los jóvenes aprenden destrezas prácticas de trabajo comercializables de un amplio espectro de organizaciones e individuos innovadores centrados en la ecología y la sociedad para restaurar sus cuencas hidrográficas. Mediante una exposición constante a profesionales que trabajan y un currículo educativo diseñado para desarrollar habilidades para la vida y capacidades de liderazgo, los estudiantes de secundaria que viven dentro de la floreciente economía de restauración de las tierras fronterizas de EE. UU. / México pueden imaginar un rol profesional positivo en las comunidades donde crecieron. A partir de enero de 2018, 83 jóvenes de Patagonia, Arizona a Douglas, Arizona, han participado en la programación de verano, muchos de los cuales han cambiado su enfoque profesional a los campos dentro de la conservación. Y este verano, aprovecharemos el éxito pasado y nos expandiremos a una nueva comunidad: Nogales, Arizona. Nuestra gran visión es fomentar medios de vida sustentables para la conservación en ambos lados de la frontera de los Estados Unidos y México.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Sessions 26 & 27: Beyond Documenting Trends: Integrating Monitoring Data into Natural Resource Management Decisions

Monitoring a high altitude cienega, Coronado National Forest
(Photo by Daniel G. Neary, USDA Forest Service, Rocky Mountain Research Station)

Abstracts and Papers
Bodner
Bushman
Holm
Swann
Studd

Managing grasslands through a decade of drought: responding to patterns and drivers of vegetation change at the Las Ciénegas National Conservation Area

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This study compiled monitoring data from southern Arizona's Las Ciénegas National Conservation Area, and was used to evaluate vegetation change in this semi-arid grassland. The study period, 2004-2014, was marked by extended drought and high temperatures. Changes included declines in C4 perennial grass basal cover with patchy grass mortality, leaf litter increases, shrub declines, and increases in non-native grass *Eragrostis lehmanniana*. Linear mixed-effects models identified precipitation during January-June "extended spring" as the best predictor of grass basal cover, especially when plots were grouped by soil and topographic features. Models showed that a decrease in extended spring precipitation from 150 to 50 mm was associated with loss of one-quarter to one-half of plots' total grass cover. Associating grass declines with this novel drought season is especially relevant because global circulation models predict steep declines in spring rainfall. Increasing *E. lehmanniana* dominance was also associated with native grass declines. There was little support over this time for predicted effects of livestock grazing or shrub encroachment. Managers have been using this data on an annual basis to make decisions on livestock stocking rate and rotation schedules, and to plan prescribed fire and other restoration actions. This study demonstrated how monitoring data from working landscapes can also improve longer-term ecological understanding of drought. Using this new understanding of seasonal drought effects to improve chances for sustaining resilience, managers at this site are now tracking rainfall by season, discussing implications with stakeholders, monitoring for mortality events, and contingency plans for various types of drought.

Manejo de pastizales a través de una década de sequía: respondiendo a patrones e impulsores del cambio de vegetación en el Área Nacional de Conservación Las Ciénegas

Este estudio compiló datos de monitoreo del Área Nacional de Conservación Las Ciénegas en el sur de Arizona y los utilizó para evaluar el cambio de vegetación en este pastizal semiárido. El período de estudio, 2004-2014, estuvo marcado por una sequía prolongada y por altas temperaturas. Los cambios incluyeron descensos en la cobertura basal de hierba perenne C4 con mortalidad de gramíneas irregulares, aumento de hojarasca, disminución de arbustos e incrementos en pasto no nativo Eragrostis lehmanniana. Los modelos de efectos mixtos lineales identificaron la precipitación durante la "primavera extendida" de enero-junio como el mejor predictor de la cobertura basal de la hierba, especialmente cuando las parcelas se agruparon por suelo y características topográficas. Los modelos mostraron que una disminución en la precipitación de primavera extendida de 150 a 50 mm se asoció con la pérdida de una cuarta parte o la mitad de la cobertura total de césped de las parcelas. La asociación de las disminuciones de la hierba con esta nueva temporada de sequía es especialmente relevante porque los modelos de circulación global predicen fuertes descensos en las precipitaciones de primavera. El aumento de la dominancia de E. lehmanniana también se asoció con la disminución de la hierba nativa. Hubo poco apoyo durante este tiempo para predecir los efectos del pastoreo de ganado o la invasión de arbustos. Los gerentes han estado usando esta información anualmente para tomar decisiones sobre el grado de concentración del ganado y los cronogramas de rotación, y para planificar incendios prescritos y otras acciones de restauración. Este estudio demostró cómo los datos de monitoreo de paisajes en función también pueden mejorar la comprensión ecológica a largo plazo de la sequía. Usando esta nueva comprensión de los efectos de la sequía estacional para mejorar las posibilidades de mantener la resiliencia, los administradores de este sitio ahora están rastreando las precipitaciones por temporada, discutiendo las implicaciones con las partes interesadas, monitoreando los eventos de mortalidad y los planes de contingencia para varios tipos de sequía.

NOTE: A manuscript was not submitted to accompany this presentation.

Upper San Pedro Monitoring to Inform River and Aquifer Management Decisions

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Monitoring within the Sierra Vista Subwatershed (SVSW) includes 14 indicators of ground and surface water condition. These results guide conservation efforts to support the Upper San Pedro River, its watershed and aquifers. The binational, citizen-science Wet/dry mapping program is among these indicators. Initiated in 1999 as a joint effort by the Bureau of Land Management (BLM) and The Nature Conservancy (TNC), partners and volunteers annually map the spatial extent of surface water in the San Pedro River. While the management objective that funded and guided this and other early monitoring efforts is now expired, monitoring continues to be supported by Upper San Pedro Partnership (USPP) members who, for a variety of reasons, remain committed to sustaining the San Pedro River as it flows through the BLM's San Pedro Riparian National Conservation Area and influences Army Fort Huachuca operations. Sustained funding and longevity of the data sets has positioned the SVSW monitoring to remain relevant and enable it to be leveraged as an essential part of a new conservation program. The Cochise Conservation and Recharge Network (CCRN) is a collaborative effort between the Cities of Sierra Vista and Bisbee, Cochise County, Hereford Natural Resource Conservation District, and TNC to implement a regional network of recharge projects designed to sustain multiple aspects of the hydrologic regime (baseflows, flood flows, and groundwater) along the San Pedro River. CCRN project monitoring is analyzed alongside SVSW data sets, and used with local ground and surface water modeling to estimate and later report on the impact of CCRN recharge projects. The Wet/dry record, springs and well data suggest that Sierra Vista's now 15-year old effluent recharge facility is sustaining perennial flows downstream of this CCRN project.

Monitoreo del Alto San Pedro para informar las decisiones de gestión de ríos y acuíferos

El monitoreo dentro de la subcuenca de Sierra Vista (SVSW) incluye 14 indicadores de las condiciones de las aguas subterráneas y superficiales. Estos resultados guían los esfuerzos de conservación para apoyar el Río San Pedro Superior, su cuenca y acuíferos. El programa de mapeo húmedo / seco binacional y de ciencia ciudadana se encuentran entre estos indicadores. Iniciado en el 1999 como un esfuerzo conjunto por la Oficina de Administración de Tierras (BLM) y The Nature Conservancy (TNC), los socios y voluntarios anualmente mapean la extensión espacial de las aguas superficiales en el río San Pedro. Si bien el objetivo de gestión que financió y guió este y otros esfuerzos tempranos de monitoreo ahora ha expirado, el monitoreo continúa siendo apoyado por los miembros de la Alianza Upper San Pedro (USPP) que, por diversas razones, siguen comprometidos con el mantenimiento del río San Pedro ya que fluye a través del Área de Conservación Nacional Ribereña San Pedro de BLM e influye en las operaciones del Área Militar Fort Huachuca. La financiación sostenida y la longevidad de los conjuntos de datos han posicionado el monitoreo SVSW para seguir siendo relevante y permitir que se aproveche como parte esencial de un nuevo programa de conservación. La Cochise Conservation and Recharge Network (CCRN) es un esfuerzo de colaboración entre las ciudades de Sierra Vista y Bisbee, el condado de Cochise, el distrito de conservación de recursos naturales Hereford y TNC para implementar una red regional de proyectos de recarga diseñados para sostener múltiples aspectos del régimen hidrológico (flujos de base, flujos de inundación y aguas subterráneas) a lo largo del río San Pedro. El monitoreo del proyecto CCRN se analiza junto con los conjuntos de datos SVSW, y se utiliza con el modelo local de agua subterránea y superficial para estimar y luego informar sobre el impacto de los proyectos de recarga CCRN. El registro húmedo / seco, y los datos de manantiales y pozos sugieren que la instalación de recarga de efluentes desde hace 15 años en Sierra Vista está manteniendo los flujos perennes aguas abajo de este proyecto CCRN.

NOTE: A manuscript was not submitted to accompany this presentation.

Organ Pipe Cactus National Monument's Ecological Monitoring Program: Balancing Long-term Goals and Short-term Management Needs

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The Ecological Monitoring Program (EMP) has monitored ecological indicators at Organ Pipe Cactus National Monument since 1993. The monitoring team supports many park programs including planning, compliance, GIS, integrated pest management, museum collections, training interpretive staff, public education, partnerships, conservation beyond park boundaries, wildlife management, and vegetation management. Due to the diverse outlets for these data, the EMP tries—with varying levels of success—to help park managers navigate through the complex landscape of opportunities and pitfalls that often arise with normal operations, major projects, and unanticipated situations. We describe examples of how monitoring data play a role in resource management, including human interactions with woodrats, declining water supply at the Quitobaquito oasis, and the effects of climate variation on biological communities. Although endangered species are a high priority for monitoring and management, we continue to monitor prominent plant and animal communities of the Sonoran Desert. In response to evolving management needs, the EMP has halted some protocols (e.g., cactus growth measurements) and implemented some new ones (e.g., biennial E-W transects to quantify ORV tracks and foot trails associated with cross-border migration and related law enforcement activities). Ultimately, we are constrained by budget, internal momentum, external pressures, and our ability to articulate the value and costs of the program. Despite these constraints, the EMP is one of the longest-running ecological monitoring programs in in the region.

Programa de Monitoreo Ecológico del Monumento Nacional Organ Pipe Cactus: Equilibrio entre los objetivos a largo plazo y las necesidades de gestión a corto plazo

El Programa de Monitoreo Ecológico (EMP por sus siglas en inglés) monitoreó indicadores ecológicos en el Monumento Nacional Organ Pipe Cactus desde 1993. El equipo de monitoreo apoya muchos programas de parques incluyendo planificación, cumplimiento, SIG, manejo integrado de plagas, colecciones de museos, capacitación de personal interpretativo, educación pública, asociaciones, conservación más allá de los límites del parque, manejo de la vida silvestre y manejo de la vegetación. Debido a los diversos medios para comunicar estos datos, el EMP intenta -con distintos niveles de éxito- ayudar a los gerentes de los parques a navegar a través del complejo panorama de oportunidades y dificultades que a menudo surgen con operaciones normales, proyectos importantes y situaciones imprevistas. Describimos ejemplos de cómo los datos de monitoreo desempeñan un papel en el manejo de los recursos, incluidas las interacciones humanas con las ratas-cambalacheras desérticas, la disminución del suministro de agua en el oasis de Quitobaquito y los efectos de la variación climática en las comunidades biológicas. Aunque las especies en peligro son una alta prioridad para el monitoreo y manejo, continuamos monitoreando comunidades de plantas y animales prominentes del Desierto de Sonora. En respuesta a las necesidades de gestión en evolución, el EMP ha suspendido algunos protocolos (por ejemplo, mediciones de crecimiento de cactus) e implementado algunos nuevos (por ejemplo, transectos EW bienales para cuantificar ORV pistas y senderos peatonales asociados con migración transfronteriza y actividades relacionadas con la aplicación de la ley). En última instancia, estamos limitados por el presupuesto, el impulso interno, las presiones externas y nuestra capacidad para articular el valor y los costos del programa. A pesar de estas limitaciones, el EMP es uno de los programas de monitoreo ecológico más antiguos en la región.

NOTE: A manuscript was not submitted to accompany this presentation.

Science and management of saguaros in Saguaro National Park during the past 8 decades

DON E. SWANN[1], Joshua L. Conver[2], Daniel E. Winkler[3], Theresa Foley[4], Kara O'Brien[1]

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Saguaro National Monument (now a national park) was established in 1933 to study, protect, and interpret the giant saguaro cactus and other Sonoran Desert plants. However, the decline of saguaros in the "Cactus Forest" in the Rincon Mountains, which was obvious by the early 1940s, was a major issue during the park's first few decades. This talk will first focus on the intersection of science and management of saguaros at Saguaro National Park during the past 80 years, which includes large-scale removal experiments; intense debates about saguaros and cattle grazing; successful NPS efforts to protect the plant by reducing wood-cutting and theft; long-term studies of saguaros and climate change; and (in the modern era) large-scale Citizen Science efforts. After years of decline, establishment of new saguaros in the Cactus Forest increased dramatically from the 1960s through the 1980s but has since declined during a period of long-term drought. In the current era of declining funding for science, we will discuss how Saguaro National Park has been successful in using citizen science to directly involve the public in learning how the population of this iconic plant has changed, is changing, and may be expected to change in the coming years.

Ciencia y manejo de saguaros en el Parque Nacional Saguaro durante las últimas 8 décadas

El Monumento Nacional Saguaro (ahora un parque nacional) se estableció en 1933 para estudiar, proteger e interpretar el gigante cactus saguaro y otras plantas del desierto de Sonora. Sin embargo, el declive de los saguaros en el "Bosque de Cactus" en las montañas Rincón, que era obvio a principios de la década de 1940, fue un problema importante durante las primeras décadas del parque. Esta charla se enfocará primero en la intersección de la ciencia y el manejo de los saguaros en el Parque Nacional Saguaro durante los últimos 80 años, que incluye experimentos de remoción a gran escala; intensos debates sobre saguaros y pastoreo de ganado; esfuerzos exitosos de NPS para proteger la planta al reducir la tala de árboles y el robo; estudios a largo plazo de saguaros y cambio climático; y (en la era moderna) esfuerzos de Ciencia Ciudadana a gran escala. Después de años de declive, el establecimiento de nuevos saguaros en el Bosque de Cactus aumentó drásticamente desde la década de 1960 hasta la década de 1980, pero desde entonces ha disminuido durante un período de sequía a largo plazo. En la era actual de financiamiento decreciente para la ciencia, discutiremos cómo el Parque Nacional Saguaro ha tenido éxito en el uso de la ciencia ciudadana para involucrar directamente al público en aprender cómo la población de esta planta icónica ha cambiado, está cambiando y se puede esperar que cambie en los próximos años.

NOTE: A manuscript was not submitted to accompany this presentation.

Using science to support effective park management in the American Southwest

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Integrating resource inventories and monitoring into the decision-making and management process of U.S. National Parks is a tall order, particularly for small and medium parks with limited staffing and modest budgets. We will describe three approaches that (through trial and error) have proven effective at meeting this challenge: (1) development of management assessment points to link monitoring results to management priorities by providing ecological context; (2) designing resource inventories - comprehensive "snapshots in time" of a particular resource - that complement and extend the interpretation of long-term monitoring results; and (3) integrating the interested public into park research through education programs and incorporating citizen science into our core monitoring activities. We will illustrate these three approaches using specific examples from the Sonoran Desert Network, and review "lessons learned" during the evolution of this long-term ecological monitoring program.

Uso de la ciencia para apoyar la gestión efectiva del parque en el suroeste de Estados Unidos

La integración de los inventarios de recursos y el monitoreo en el proceso de toma de decisiones y gestión de los parques nacionales de EE. UU. es una tarea difícil, particularmente para parques pequeños y medianos con personal limitado y presupuestos modestos. Describiremos tres enfoques que (a través de prueba y error) han demostrado ser efectivos para cumplir con este desafío: (1) desarrollo de puntos de evaluación de gestión para vincular los resultados del monitoreo a las prioridades de gestión proporcionando un contexto ecológico; (2) diseño de inventarios de recursos: "capturas instantáneas completas" de un recurso en particular, que complementan y amplían la interpretación de los resultados del monitoreo a largo plazo; y (3) integrar al público interesado en la investigación del parque a través de programas educativos e incorporar la ciencia ciudadana en nuestras actividades centrales de monitoreo. Ilustraremos estos tres enfoques utilizando ejemplos específicos de la Red del Desierto Sonorense y revisaremos las "lecciones aprendidas" durante la evolución de este programa de monitoreo ecológico a largo plazo.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 28: Invertebrates

***Microtia elva* Butterfly**

(Photo courtesy of the Sky Island Alliance, Tucson, Arizona)

Abstracts and Papers
Danforth
Eriksson
Franz
Johnston
Murray
Palting

Dynamic range extensions of seven Odonate species

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The Co-authors book "Damselflies and Dragonflies of Arizona and Sonora" discussed recent changes in Arizona/Sonora odonata distribution as exemplified by 7 species. Images for the 7 key species - *Orthemis discolor, Brechmorhoga pertinax, Erpetogomphus elaps, Aphylla protracta, Brachymesia gravida, Enallagma novaehispaniae,* and *Argia anceps* – are shown. Range maps from 2007 and 2017 for these 7 species are compared and contrasted. While all 7 species appear to have expanded their ranges during this 10-year period, references to regional climate change are made in some species but not in others.

Extensiones de rango dinámico de siete especies de Odonate

Los cambios recientes en la distribución odonata de Arizona / Sonora son discutidos y ejemplificados por 7 especies. Se muestran imágenes de las 7 especies clave: Orthemis discolor, Brechmorhoga pertinax, Erpetogomphus elaps, Aphylla protracta, Brachymesia gravida, Enallagma novaehispaniae y Argia anceps. Los mapas de rango de 2007 y 2017 para estas 7 especies son comparados y contrastados. Si bien las 7 especies parecen haber ampliado sus rangos durante este período de 10 años, las referencias al cambio climático regional se hacen en algunas especies pero no en otras.

Note: Full Paper Follows

Dynamic Range Extensions of Seven Odonate Species into Arizona

Rich Bailowitz[1] and Doug Danforth[2]

Tucson, AZ[1] and Bisbee, AZ[2]

Abstract-- *Distributions of Arizona odonata are undergoing change. Seven key species are examined and their changes are discussed and related to climate change and anthropogenic versus natural causes.*

INTRODUCTION

The distributions and diversity of Odonata (dragonflies and damselflies) in Arizona have been rapidly changing (Figure 1). Most of the species that were present in the state 60 years ago are still resident. But many other species of these aquatic flying insects are newcomers to Arizona, flying in to exploit available niches and in doing so establishing new populations. In writing this paper, we are calling attention to seven species of odonata that seem to have become Arizona residents, to one degree or another. We are attempting to document their changes in distribution during the years 2008 through 2018. Those 10 years appear to be a decade of great biological flux in the American Southwest and it will be interesting to use the decade as a baseline for other 10-year periods and their resulting distributional changes. While other species have made inroads into Arizona's biota, perhaps to a lesser degree, these seven stand out for reasons as discussed below.

Figure 1. Examples of Odonata (dragonflies and damselflies) in Arizona.

Aphylla protracta (Narrow-striped Forceptail)

Prior to 2008, the U.S. range for this species was shown (Paulson 2009) only as far as west central Texas. And in northern Mexico, records extended no farther north than east-central Sonora. The first documented occurrence of this

species in Arizona was in late July 2008 (Figure 2). That extended visit by a pair at San Bernardino NWR continued for more than two weeks. Subsequent reports, mostly of single individuals, occurred elsewhere in southeast Arizona in August 2012, August 2013, both July and August 2015, and in July 2017. Some of these sightings were documented from as far north as Roper Lake near Safford.

But most unusual during the past 10 years was the discovery in the summer of 2014 of a breeding population of this species south of Mammoth along the San Pedro River. As many as18 individuals in a day, both males and females, were recorded at that location, and the population has proved to be viable through the summer of 2017. Since visits to that location had not been made in prior years, it is uncertain exactly how long *A. protracta* has been resident in this area. Yearly visits will be continued to document this unusual resident of central Arizona.

Narrow-striped Forceptail (*Aphylla protracta*) distribution before 2008 (left) and 2017 (right)

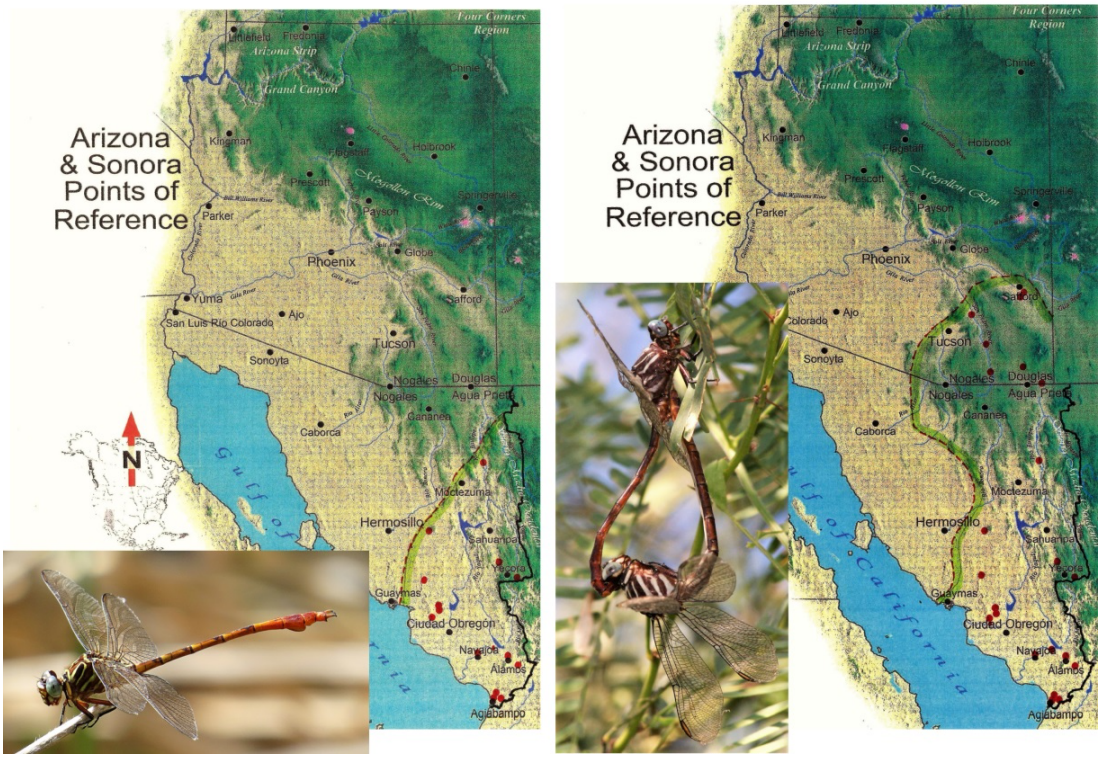

Figure 2. Narrow striped forceptail distribution in Arizona and northern Sonora before 2008 (left) and 2017 (right).

Erpetogomphus elaps (Straight-tipped Ringtail)

This small, mostly West-Mexican, ringtail species is a common resident as far north as east-central Sonora. It occurs at middle elevations along small, permanent creeks and rivers. So, in September of 2008, it was quite a surprise to discover the first AZ record along Parker Canyon Creek, Santa Cruz County (Figure 3, Danforth and Bailowitz 2008). For four years, that lone individual remained the only known record of this species in the state despite further searching in the area. But, beginning in 2012, additional sightings were reported along other nearby drainages. Then, in 2017, multiple individuals were observed in four localities spread across the International Border. This has culminated in extension of that species' range to Sonoita Creek and into the Atascosa Mountains, more than 50 km to the west. Several questions come to mind. Since regional collection and photography of odonata were done prior to 2008, and this ringtail

had not been recorded, what has changed? And will *E. elaps* remain, now that it has a foothold on those canyons, which seem to be located at the proper altitudes and with appropriate amounts of water?

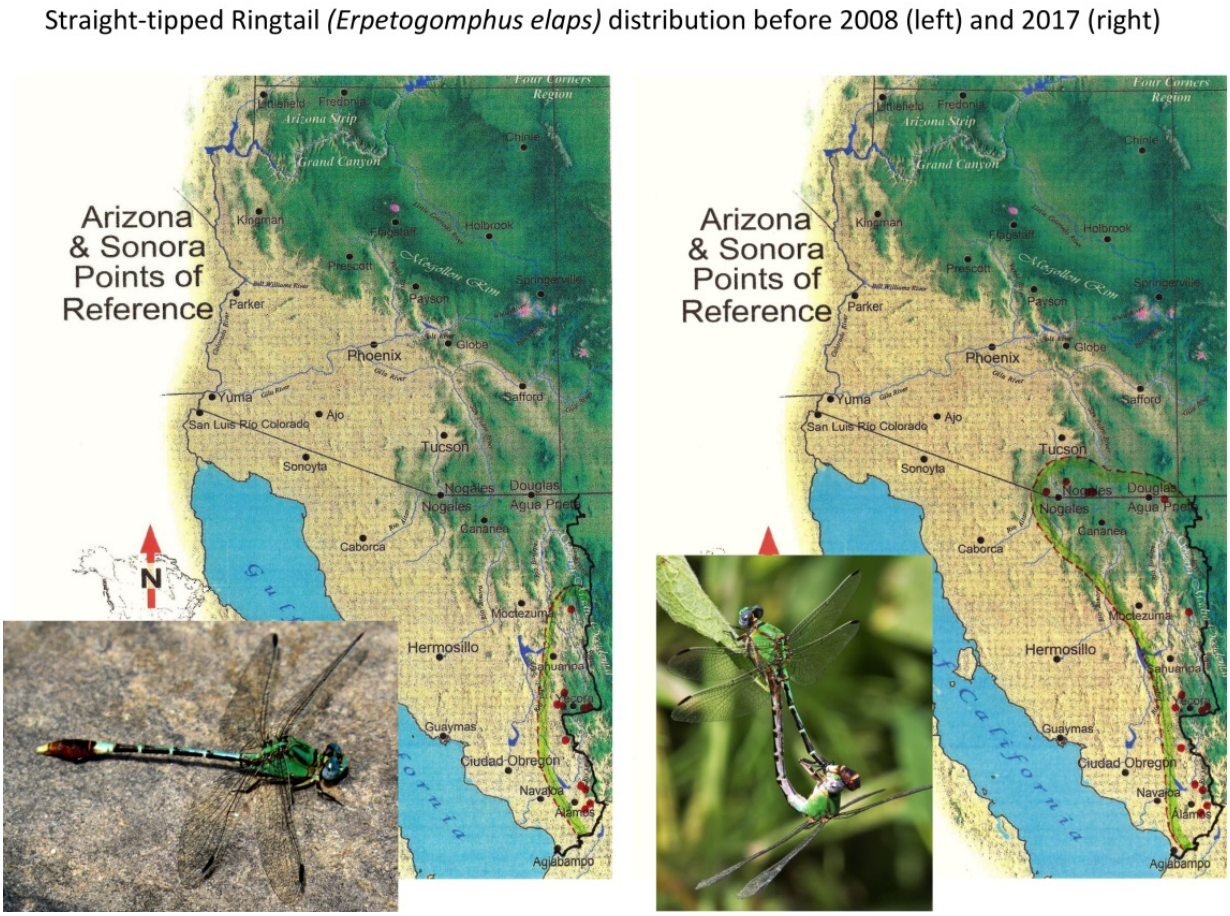

Figure 3. Straight-tipped ringtail (*Erpetogomphus elaps*) distribution in Arizona and northern Sonora before 2008 (left) and 2017 (right).

Brachymesia gravida (Four-spotted Pennant)

While most of the recent range expansions of odonata into Arizona have come from the south, this species' origin has been from the east. Prior to 2008, it had been reported west to eastern New Mexico but with an additional population at Roper Lake State Park near Safford, Arizona. A resident population was known as far back as the summer of 2001. The isolation of that population, several hundred kilometers west of the species' continuous distribution, coupled with regular stocking of Roper and Dankworth Lakes for fishing (with fish stocks from eastern states where the species is common), suggested the possibility that the population had been accidentally introduced. However, beginning in 2013, populations of *B. gravida* were discovered at Arivaca Lake and Patagonia Lake, more than 160 km southwest of Roper Lake State Park. By 2015, additional populations were recorded at ponds near St. David and in 2017, numerous members of this species were recorded at Peña Blanca Lake. Those reports of multiple individuals were in addition to singletons at Menager's Lake in southwest Arizona in 2015 and at Sweetwater Wetlands in west Tucson in 2017 that indicate the

species is a strong flier. It appears *B. gravida* could eventually populate most cattail-lined lakes and ponds in the southern half of the state.

Brechmorhoga pertinax (Masked Clubskimmer)

In June 1958, this predominantly Mexican and Central American species was documented in the United States for the first time, in the Chiricahua Mountains of southeast Arizona. A single specimen was then collected in 1992 in Madera Canyon in the Santa Rita Mountains but remained undiscovered in the University of Arizona insect collection for more than a decade. Then astoundingly, in the early 2000s, a breeding population was discovered along some of the permanent creeks below both Rims at Grand Canyon National Park! These northern populations continue to the present time. Prior to 2008, its only other appearance in the United States was of a few individuals during the summer of 2007 in the Chiricahua Mountains, nearly 50 years after its first discovery in the state. Then, during the early summer of 2015, the numbers of this clubskimmer exploded in Arizona's southeast corner with numerous reports from at least 5 drainages on both flanks of the Chiricahuas and from the east side of the Santa Rita Mountains as well. But, apparently none of the southeast Arizona populations have continued to flourish and, in fact, as of 2018, only the Grand Canyon populations persist. Perhaps the reliable water at the Grand Canyon allows those populations to thrive while the southeast Arizona colonies continually get wiped out, or nearly so, due to the ephemeral nature of the streams in those mountain ranges.

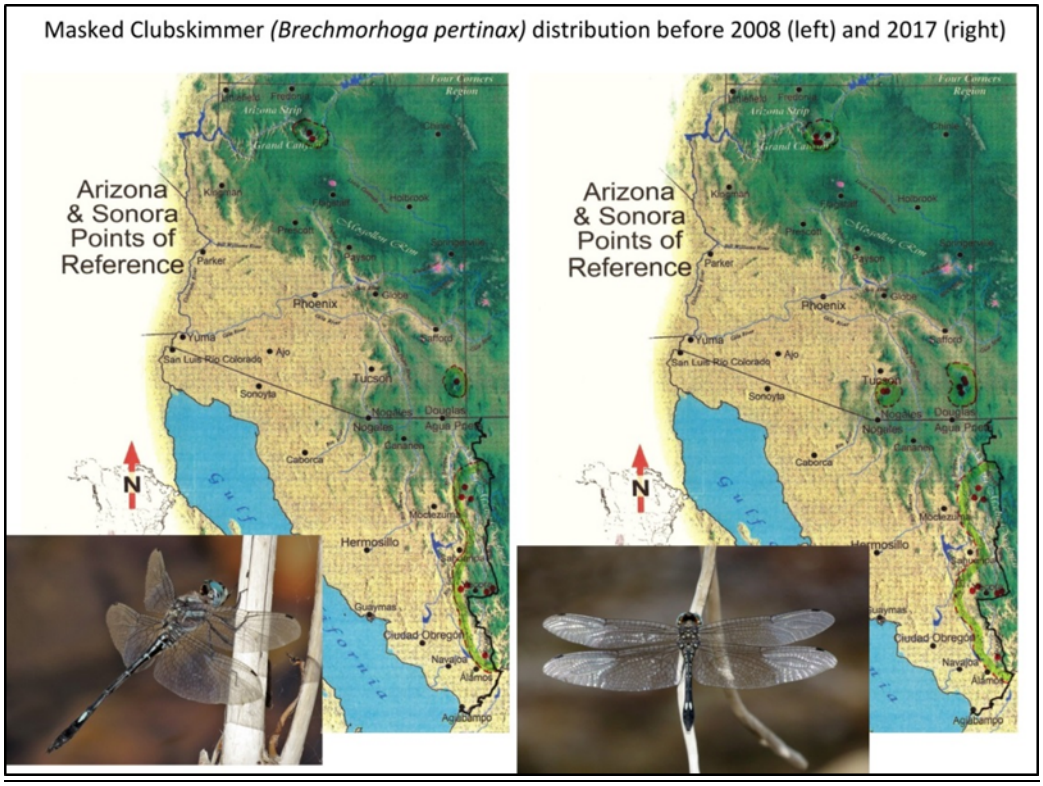

Figure 4. Masked club skimmer (*Brechmorphoga pertinax*) distribution in Arizona and northern Sonora before 2008 (left) and 2017 (right).

Orthemis discolor (Carmine Skimmer)

A close look-alike, *O. discolor* can be easily confused with its regionally common congener, *O. ferruginea* (Figure 5). The latter species occurs regularly in AZ, nearly statewide, and flies coast to coast across the southern United States. The more subtropical *O. discolor* occurs irregularly in south Texas but prior to 2008, it had only been known in Arizona from three reports. One of these reports, that of 2 males, was recorded in August of 1977 from Sycamore Creek northeast of Phoenix (Paulson 2004). After an absence of nearly 30 years, a single male was verified at Patagonia Lake in the fall of 2006 followed by another record at the southwest end of the Huachuca Mountains in the summer of 2007. Since 2008, an additional seven records of this species have been corroborated from Arizona, and all single individuals with the exception of a report of 2 males at Muleshoe Ranch north of Benson. It is certainly possible that a part of the reported increase in abundance for this skimmer is the recognition of the field marks necessary to separate it from the very similar O. ferruginea (see below). But it is also likely that the species may be responding to an altering climate, as it is becoming more common in southern Texas as well (Abbott 2016).

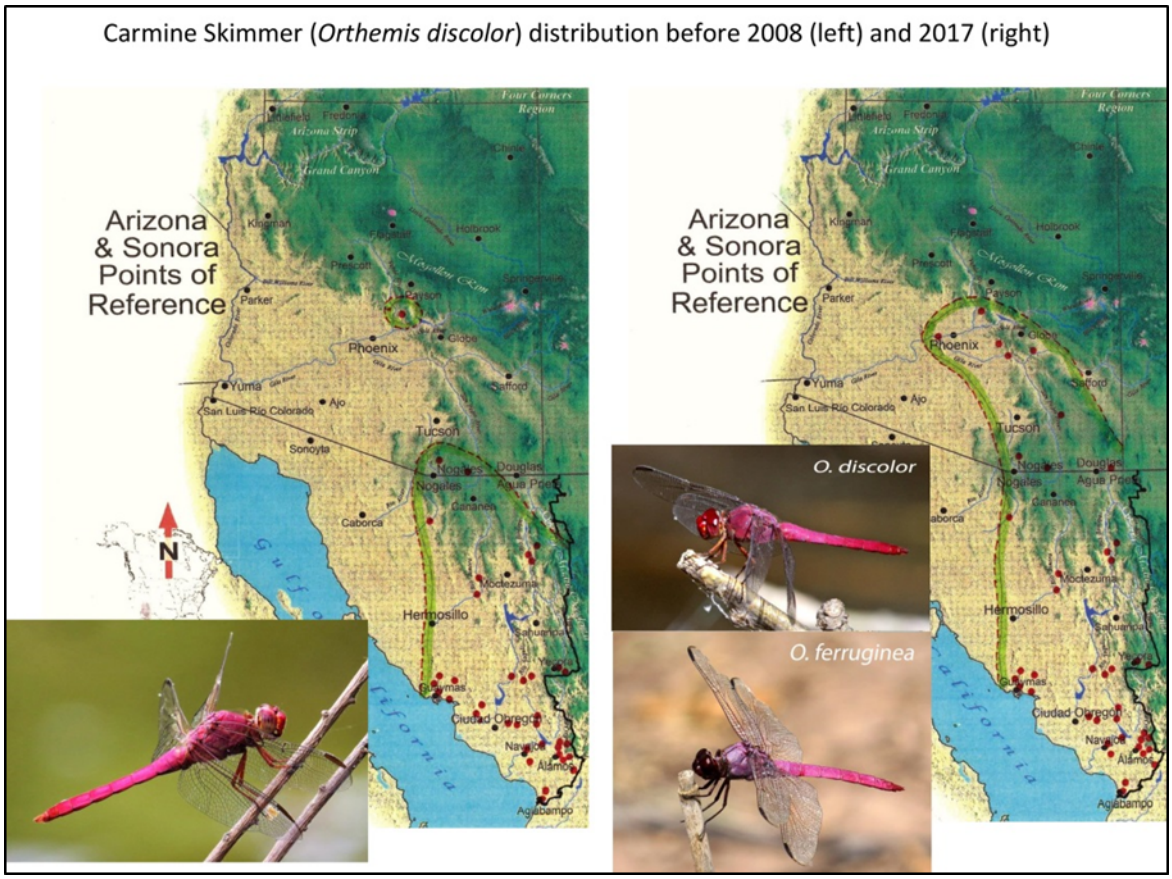

Figure 5. Carmine Skimmer (*Orthemis discolor*) distribution in Arizona and northern Sonora before 2008 (left) and 2017 (right).

Argia anceps **(Cerulean Dancer)**

This damselfly is a species that was unknown and even unanticipated in the United States prior to 2008 (Danforth et at. 2013, Figure 6). It was a regular species in northwestern Mexico and had been known as far north as central Sonora

(Bailowitz et al. 2015). In 2012, two Arizona specimens were photographed, one in Sycamore Canyon and another at Muleshoe Ranch, but both were misidentified as a similar species more typically found in Arizona. Early in 2013, after another specimen of this dancer was photographed and verified, the two records from the preceding year were re-examined and their true identities were confirmed. The range of this species has increased greatly over the last 5 or 6 years so that it has been now been recorded at close to 20 locations. In addition, ovipositing pairs have been observed on more than one occasion and as many as 24 individuals have been reported from a single location in a single day! The range now extends north at least to Aravaipa Creek, more than 160 km north of the United States border. The biggest question for A. anceps is whether this species' range will continue to expand or whether it will eventually succumb to a morphing climate scheme in AZ and disappear.

Cerulean Dancer *(Argia anceps)* distribution prior to 2008 (left) and by 2017 (right)

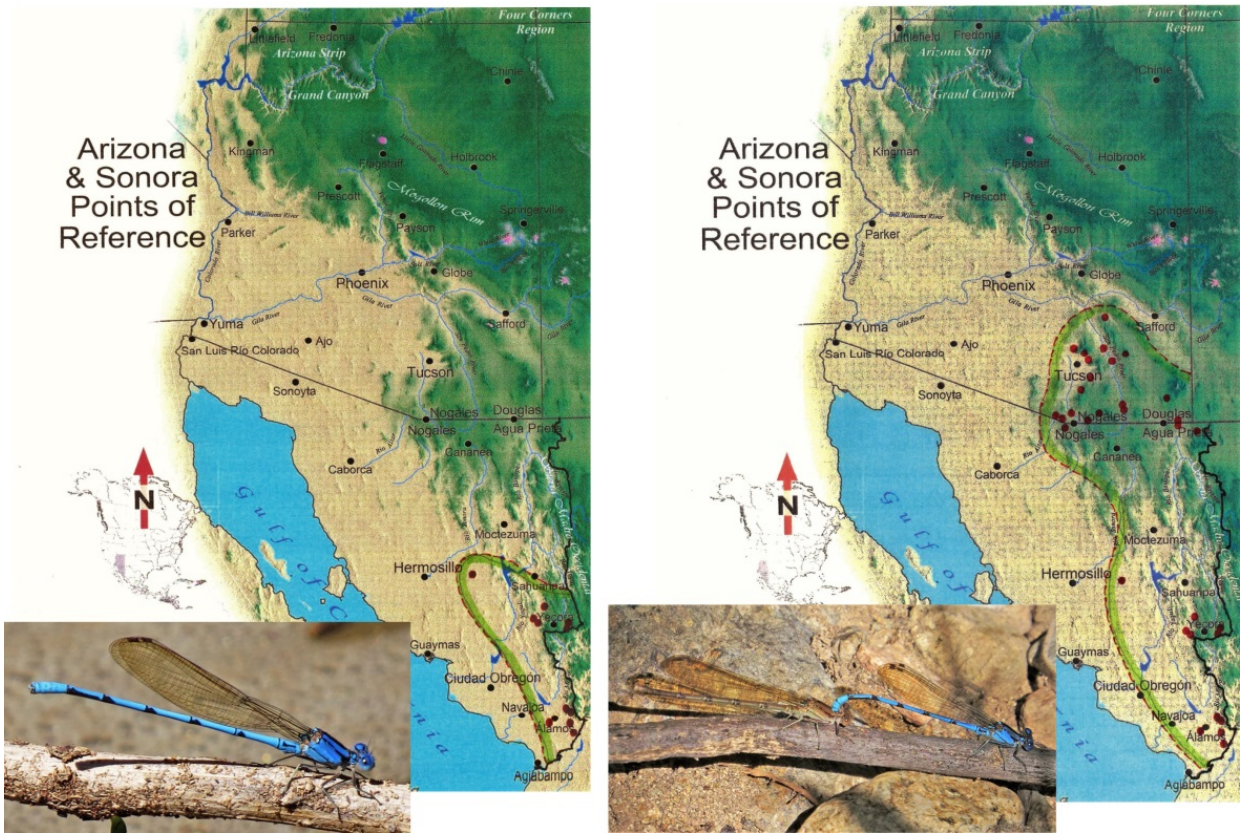

Figure 6. Cerulean dancer (Argia anceps) distribution in Arizona and northern Sonora prior to 2008 (left) and 2017 (right).

Enallagma novaehispaniae **(Neotropical Bluet)**

This lowland, tropical species occurs widely as far south as Argentina (Paulson 2002). But to the north, in the United States, it appeared to be confined to south and central Texas prior to 2008 (Abbott 2011, 2015). Sonora records approached the Arizona border within 100 km near Oquitoa, but Arizona reports were lacking. Then in the fall of 2010, two individuals were verified west of Gila Bend (Bailowitz 2010), a first for the state (Figure 7). Nearly five years later, in

2015, a few solitary individuals were recorded along the southern border of the state in several places to the east and west of Nogales. But it wasn't until late in 2016 that the cornerstone of this species' distribution was discovered. Huge numbers of *E. novaehispaniae* were found downstream from the sewage plants near Phoenix. In 2017, a large population was also discovered along the Santa Cruz River downstream from Tucson's water treatment plant. The combination of rapid flow, warmed water, and considerable growth of floating and emergent vegetation makes those habitats ideal for this bluet. We consider the species to be secure in Arizona, at least at the above locations, for the foreseeable future.

Neotropical Bluet *(Enallagma novaehispaniae)* distribution prior to 2008 (left) and 2017 (right)

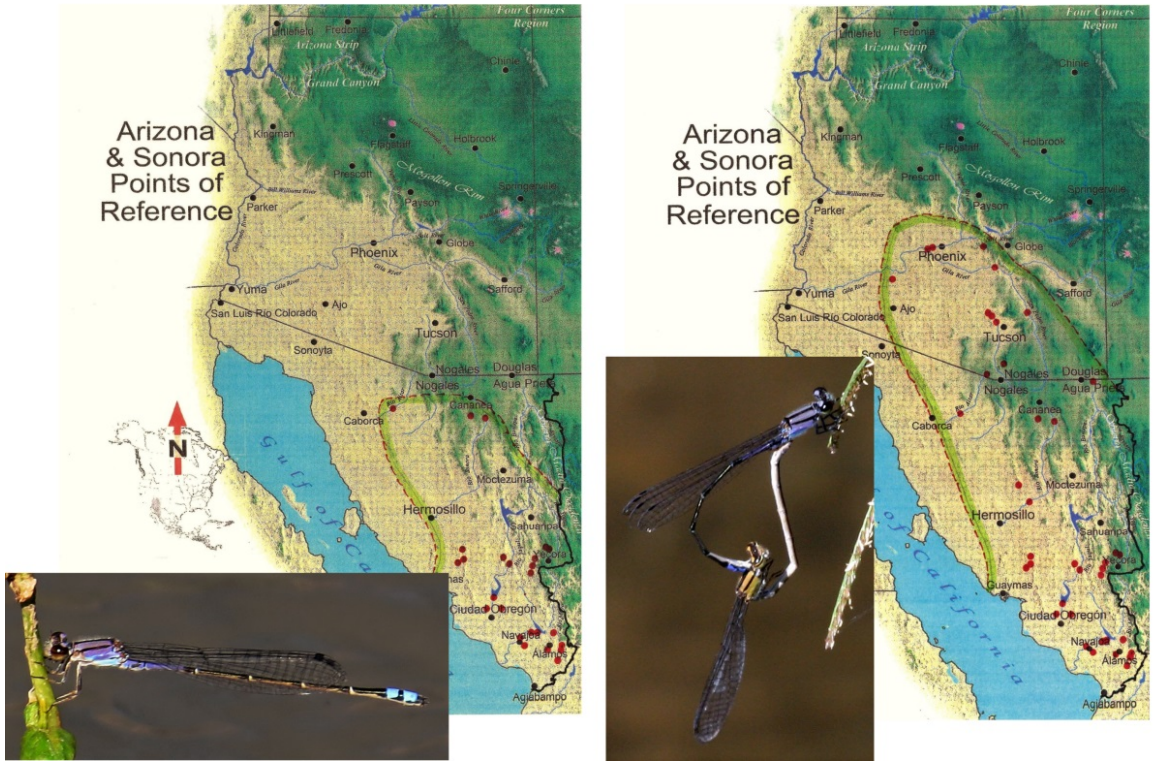

Figure 7. Neotropical Bluet (Enallagma novaehispaniaea) distribution in Arizona and northern Sonora prior to 2008 (left) and 2017 (right).

SUMMARY

The above observations suggest that the seven species we discuss here may have already become permanent fixtures in Arizona. However, numerous other species that have made appearances into Arizona in the past, even in numbers, have not become established. Overall, the long-term successes of Arizona's odonate populations remain, for the most part, unpredictable. It is generally agreed that a "climate change "of some significance is predicted for the American Southwest. With those predicted warmer climes, other subtropical odonate species known from Sonora may also attempt colonization within Arizona. While there may be some upcoming failures, some additional species, like these current seven, may also become resident in Arizona in the not too distant future.

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Variation in social and genetic structure in the honey ant *Myrmecocystus mendax*

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The colorful honey ant *Myrmecocystus mendax* is a charismatic member of mid-elevation ant communities in the American Southwest. On warm summer days, workers can be seen speeding back to the nest carrying dead arthropods or nectar, and more rarely engaging in territorial displays or raiding neighboring conspecific nests for brood. We recently discovered variation in social behaviors among queens in a case study of two allopatric populations. Whereas colonies in the Chiricahua Mountains are typically founded by a single queen, those in the Sierra Ancha Mountains are often polygynous and may contain three or more matrilines. To better understand the distribution of polygyny in this species, we studied genetic variation in 13 additional populations from Sonora and Arizona. Using multilocus microsatellite data, we found that matriline number differs between populations occurring in northern Arizona and those occurring in the Madrean Sky Islands, with colonies in the north more likely to contain multiple matrilines than those in the south. In addition, we found that genetic divergence was generally greater between northern and southern populations than within these regions, although two populations stood out as exceptions: colonies sampled from Mt. Lemmon appear to be more closely related to populations on or adjacent to the Mogollon rim, while those sampled from the area around Show Low were most closely related to several Sky Island populations. These exceptions aside, the genetic structure and behavioral polymorphism hint at a divergence between these regions, possibly as a result of drift and local adaptation.

Variación en la estructura social y genética en la miel hormiga Myrmecocystus mendax

La hormiga de miel colorida Myrmecocystus mendax es un miembro carismático de comunidades de hormigas de altura media en el suroeste de Estados Unidos. En los calurosos días de verano, se puede ver a los trabajadores regresar al nido con artrópodos muertos o néctar, y más raramente participar en exhibiciones territoriales o allanar nidos conespecíficos para crías. Recientemente descubrimos la variación en los comportamientos sociales entre reinas en un estudio de caso de dos poblaciones alopátricas. Mientras que las colonias en las montañas Chiricahua normalmente están fundadas por una sola reina, las de las montañas de Sierra Ancha a menudo son poligínicas y pueden contener tres o más matrilineales. Para comprender mejor la distribución de la poliginia en esta especie, estudiamos la variación genética en 13 poblaciones adicionales de Sonora y Arizona. Utilizando datos de microsatélites multilocus, encontramos que el número de matrilineas difiere entre las poblaciones que ocurren en el norte de Arizona y las que ocurren en las Islas Serranas, con las colonias en el norte más propensas a contener matrilineas múltiples que las del sur. Además, encontramos que la divergencia genética fue generalmente mayor entre las poblaciones del norte y del sur que dentro de estas regiones, aunque dos poblaciones se destacaron como excepciones: colonias muestreadas del monte Lemon parecen estar más estrechamente relacionados con las poblaciones en el borde de Mogollon o adyacentes, mientras que los muestreados en el área alrededor de Show Low estaban más estrechamente relacionados con varias poblaciones de las Islas Serranas. Dejando de lado estas excepciones, la estructura genética y el polimorfismo conductual apuntan a una divergencia entre estas regiones, posiblemente como resultado de la deriva y la adaptación local.

NOTE: A manuscript was not submitted to accompany this presentation.

Surveying the weevils of Sonora, Mexico

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We report on the early stages of a multi-year project to survey the diversity and distribution of the plant-feeding weevils (Curculionoidea sec. Bouchard et al. 2011) of the state of Sonora, Mexico. Prior to this survey, less than 50 species-level concepts had been documented for this state, when perhaps as many as 800-1,000 are expected based on floristic diversity relationships between Arizona and Sonora. The survey will develop as a collaboration between Arizona State University, the Universidad de la Sierra (Sonora), and the Universidad Nacional Autónoma de México (D.F.). The inventory aspires to be fully specimen-based, and involves research components that assess the evolutionary and ecological relationships between weevils and their endosymbiont bacteria, as well as a multi-faceted, binational education and outreach program. The dynamically published "Curcu-Sonora" checklist is available on-line at: http://scan-bugs.org/portal/checklists/checklist.php?cl=102. [Bouchard et al. 2011. Family-group names in Coleoptera (Insecta).]

Encuestando a los gorgojos de Sonora, México

Informamos sobre las primeras etapas de un proyecto de varios años para estudiar la diversidad y distribución de los gorgojos que se alimentan de las plantas (Curculionoidea, sección Bouchard et al. 2011) del estado de Sonora, México. Antes de esta encuesta, se habían documentado menos de 50 conceptos a nivel de especie para este estado, cuando tal vez se esperan entre 800 y 1,000 según las relaciones de diversidad florística entre Arizona y Sonora. La encuesta se desarrollará como una colaboración entre la Universidad Estatal de Arizona, la Universidad de la Sierra (Sonora) y la Universidad Nacional Autónoma de México (D.F.). El inventario aspira a estar completamente basado en muestras, e involucra componentes de investigación que evalúan las relaciones evolutivas y ecológicas entre los gorgojos y sus bacterias endosimbiontes, así como también un programa binacional y multifacético de educación y extensión. La lista de verificación "Curcu-Sonora" publicada dinámicamente está disponible en línea en: http://scan-bugs.org/portal/checklists/checklist.php?cl=102. [Bouchard et al. 2011. Nombres de grupos familiares en Coleoptera (Insecta).]*

NOTE: A manuscript was not submitted to accompany this presentation.

Correlating darkling beetle diversity and plant communities of Arizona and Sonora (*Coleoptera: Tenebrionidae*)

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Darkling beetles in the family Tenebrionidae represent a very diverse lineage with many species adapted for life in arid habitats. Large gaps exist in both our basic knowledge of what species exist in nature and how these species are distributed. To address these shortfalls, two studies are presented here. First, an updated list of tenebrionid species is presented for the Madrean Sky Islands and surrounding Sonoran desert, largely based on material collected from the Madrean Archipelago Biodiversity Assessment. Preliminary assessments of diversity based on habitat type and geographic regions are discussed. Second, the Arizona species of the Desert Stink Beetles in the genus *Eleodes* Eschscholtz

are analyzed for their habitat preference. Digitized specimen records are used to correlate beetle species distributions with plant distributions. These correlations are used to define biotic-community driven areas of endemism and are incorporated into a biogeographic reconstruction for the genus. The inferred evolutionary history hypothesizes an ancestral association with pine-dominated communities followed by multiple radiations into drier desert habitats.

Correlacionar la diversidad de escarabajos oscuros y las comunidades de plantas de Arizona y Sonora (Coleoptera: Tenebrionidae)

Los escarabajos oscuros de la familia Tenebrionidae representan un linaje muy diverso con muchas especies adaptadas para la vida en hábitats áridos. Existen grandes lagunas tanto en nuestro conocimiento básico de qué especies existen en la naturaleza tanto a cómo se distribuyen estas. Para abordar estas deficiencias, se presentan dos estudios aquí. Primero, se presenta una lista actualizada de las especies tenebriónidas para las Islas Serranas y el desierto de Sonora circundante, en gran parte en base al material recopilado de la Evaluación de Biodiversidad del Archipiélago Maduro. Se discuten las evaluaciones preliminares de diversidad basadas en el tipo de hábitat y las regiones geográficas. En segundo lugar, se analizan las especies de Arizona de los escarabajos hediondos del desierto en el género Eleodes Eschscholtz para su preferencia de hábitat. Los registros de especímenes digitalizados se utilizan para correlacionar distribuciones de especies de escarabajos con distribuciones de plantas. Estas correlaciones se utilizan para definir las áreas de endemismo impulsadas por la comunidad biótica y se incorporan en una reconstrucción biogeográfica para el género. La historia evolutiva inferida hipotetiza una asociación ancestral con comunidades dominadas por pinos seguidas de radiaciones múltiples en hábitats desérticos más secos.

NOTE: A manuscript was not submitted to accompany this presentation.

A rockslide to call home – Characteristics of talussnail (*Sonorella* sp.) habitat in Eastern Pima County

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Land snails in the genus *Sonorella* are rock-dwelling snails that occur in small and large mountain ranges throughout large portions of the Madrean Sky Island region in Mexico and the southwestern United States. Their common name, talussnail, comes from their propensity to be found within rockslides or talus deposits. Geographic isolation, poor dispersal capabilities, and sensitivity to hot and dry conditions has resulted in high talussnail species diversity and endemism. For example, mountainous regions throughout Pima County host many described as well as potentially undescribed species of talussnails. These biogeographically complex taxa are understudied due to their small size, cryptic nature, and abbreviated periods of surface activity. Additionally, different species of talussnails may be superficially similar in appearance, thereby making species identification difficult. One component of Pima County's Ecological Monitoring Program is to inventory and monitor this poorly studied group. To better understand the habitat requirements for these species, we present an analysis of site-specific environmental characteristics based on 800 documented dead and live talussnail observations across Pima County open space lands. This is the most extensive inventory effort of talussnails in eastern Pima County since the 1960s, and our effort will lay the foundation for monitoring populations and their habitats for decades to come.

Un desprendimiento de rocas para llamar hogar - Características del hábitat de Encuestando a los gorgojos de Sonora, México

Los caracoles terrestres del género Sonorella son caracoles que viven en rocas en cordilleras pequeñas y grandes a lo largo de grandes porciones de la región de las Islas Serranas Madrenses en México y el suroeste de los Estados Unidos. Su nombre común en inglés, talussnail, proviene de su propensión a encontrarse dentro de desprendimientos de rocas o depósitos de astrágalo. El aislamiento geográfico, la escasa capacidad de dispersión y la sensibilidad a las condiciones cálidas y secas han dado lugar a una gran diversidad de especies de talussnail y al endemismo. Por ejemplo, las regiones montañosas en todo el condado de Pima albergan muchas especies de talussnails descritas y potencialmente no descritas. Estos taxones biogeográficamente complejos son poco estudiados debido a su pequeño tamaño, naturaleza críptica y períodos abreviados de actividad superficial. Además, diferentes especies de talussnails pueden ser superficialmente similares en apariencia, lo que dificulta la identificación de especies. Un componente del Programa de Monitoreo Ecológico del Condado de Pima es inventariar y monitorear este grupo poco estudiado. Para comprender mejor los requisitos de hábitat para estas especies, presentamos un análisis de las características ambientales específicas del sitio basadas en 800 observaciones documentadas de vivas y en vivo en las tierras espaciales abiertas del Condado de Pima. Este es el esfuerzo de inventario más extenso de talussnails en el este del Condado de Pima desde la década de 1960, y nuestro esfuerzo sentará las bases para monitorear las poblaciones y sus hábitats en las próximas décadas.

NOTE: A manuscript was not submitted to accompany this presentation.

Montane Lepidoptera populations of special concern in the Sky Islands Region

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Localized populations of certain Lepidoptera species dependent on remnant high elevation habitats in the Sky Islands are species of special concern during a time of climate warming. As the post-Pleistocene climate of the Southwest changed (both in terms of temperature and rainfall patterns), these species have been driven to the uppermost peaks of the Sky Islands and have nowhere to go beyond this. While vertebrate species facing these challenges are generally well-known, the invertebrate species in jeopardy are less familiar and often overlooked. Here, we present species which are already a marginal part of the US Lepidoptera fauna that merit more attention, and include what has been learned about their distribution in the Sky Islands of Sonora as a result of the Madrean Assessment Biodiversity Assessment and Madrean Discovery Expeditions biodiversity initiatives.

Poblaciones de lepidópteros montanos de especial preocupación en la región de las Islas Serranas

Las poblaciones localizadas de ciertas especies de lepidópteros que dependen de hábitats remanentes de gran altitud en las Islas Serranas son especies de especial preocupación durante un tiempo de calentamiento climático. A medida que el clima del sudoeste de los Estados Unidos posterior al Pleistoceno cambió (tanto en términos de temperatura como de patrones de lluvia), estas especies han sido conducidas a los picos más altos de las Islas Serranas y no tienen a dónde ir más allá. Si bien las especies de vertebrados que enfrentan estos desafíos son generalmente bien conocidas, las especies de invertebrados en peligro son menos familiares y a menudo se pasan por alto. Aquí, presentamos especies que ya son una parte marginal de la fauna de lepidópteros de EE. UU. que merecen más atención e incluyen lo que se ha aprendido sobre su distribución en las Islas Serranas de Sonora como resultado de la Evaluación de Biodiversidad Madrense y la biodiversidad de Madrean Discovery Expeditions.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 29: Plants

Emory Oak woodland plants, Coronado National Forest
(USDA Forest Service, Rocky Mountain Research Station, Photo by Gerald J. Gottfried)

Abstracts and Papers
Roll
Van Devender
Van Devender
Van Devender

A preliminary checklist of the vascular plants of the Pat Hills desert grassland, Sulphur Springs Valley, Southeastern Arizona

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A preliminary checklist is provided for the vascular plant flora of the Pat Hills desert grassland located south of Willcox in the Sulphur Springs Valley of southeastern Arizona. The vegetation is desert grassland interspersed with shrubs that has been consistently grazed by cattle for at least 100 years. A total of 446 taxa of vascular plants in 272 genera and 71 families have been recorded in this area since March of 2015. Specimens are deposited into the University of Arizona Herbarium, and are available in SEINet (http://swbiodiversity.org/seinet/). *Bergia texana* and *Eleocharis atropurpurea* were collected from the moist soil around a stock pond in the Pat Hills. They are here reported as additions to the Arizona flora. Also, a new population of *Pediomelum pentaphyllum* was located. A petition to list this plant under the U. S. Endangered Species Act is currently under review.

Una lista de verificación preliminar de las plantas vasculares de las praderas del desierto Pat Hills, Sulphur Springs Valley, sudeste de Arizona

Se proporciona una lista de verificación preliminar para la flora de plantas vasculares del pastizal del desierto de Pat Hills, ubicado al sur de Willcox en el valle de Sulphur Springs, en el sureste de Arizona. La vegetación es pastizales desérticos intercalados con arbustos que han sido consistentemente pastoreados por el ganado durante al menos 100 años. Un total de 446 taxones de plantas vasculares en 272 géneros y 71 familias se han registrado en esta área desde marzo de 2015. Las muestras se depositan en el Herbario de la Universidad de Arizona, y están disponibles en SEINet (http://swbiodiversity.org/seinet). /). Bergia texana y Eleocharis atropurpurea fueron recolectadas del suelo húmedo alrededor de un estanque de existencias en Pat Hills, y aquí se reportan como adiciones a la flora de Arizona. Además, se localizó una nueva población de Pediomelum pentaphyllum. Actualmente se está revisando una petición para incluir esta planta bajo la Ley de Especies en Peligro de los EE. UU.

NOTE: A manuscript was not submitted to accompany this presentation.

Preliminary Flora and Vegetation of the Lower Río Bavispe Valley, Sonora, Mexico

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Project WILDCAT is predator conservation project on six ranches south of Granados in the Río Bavispe Valley, Municipios de Granados and Divisaderos, Sonora, Mexico. Plant lists were done at 14 wildlife camera sites, and additional sites throughout the area. A total of 731 observations are available in the Madrean Discovery Expeditions database (madreandiscovery.org). A total of 219 taxa of plants in 53 families were recorded. Dominant families are Fabaceae (26 taxa), Asteraceae (25 taxa), Poaceae (23 taxa + 6 non-native), Malvaceae (13 taxa), and Euphorbiaceae (10 taxa). Nine species (4.1%) are non-natives. The vegetation is foothills thornscrub dominated in some areas by *Acacia cochliacantha, Aloysia gratissima, Coursetia glandulosa, Dodonaea viscosa, Fraxinus gooddingii, Haematoxylum brasiletto, Mimosa distachya,* and *Prosopis velutina*. Riparian vegetation dominated by *Acacia occidentalis, Baccharis salicifolia, Hymenoclea monogyra, Populus fremontii,* and *Salix gooddingii* occurs along the Río Bavispe, Arroyo Bacadéhuachi, and larger

arroyos. *Agave ocahui* and *Mabrya geniculata* are noteworty rare species. Succulents in the Asparagaceae (10 taxa) and Cactaceae (10 taxa) are important life forms.

Flora y Vegetación Preliminar del Bajo Río Bavispe Valley, Sonora, México

El proyecto WILDCAT es un proyecto de conservación de depredadores en seis ranchos al sur de Granados en el Valle del Río Bavispe, Municipios de Granados y Divisaderos, Sonora, México. Se hicieron listas de plantas en 14 sitios de cámaras de vida silvestre y sitios adicionales en toda el área. Un total de 731 observaciones están disponibles en la base de datos de Discovery Expeditions de MADRID (madreandiscovery.org). Se registró un total de 219 taxones de plantas en 53 familias. Las familias dominantes son Fabaceae (26 taxones), Asteraceae (25 taxones), Poaceae (23 taxones + 6 no nativos), Malvaceae (13 taxones) y Euphorbiaceae (10 taxones). Nueve especies (4.1%) son no nativas. La vegetación es el pinto espinoso de las colinas dominado en algunas áreas por Acacia cochliacantha, Aloysia gratissima, Coursetia glandulosa, Dodonaea viscosa, Fraxinus gooddingii, Haematoxylum brasiletto, Mimosa distachya y Prosopis velutina. La vegetación ribereña dominada por Acacia occidentalis, Baccharis salicifolia, Hymenoclea monogyra, Populus fremontii y Salix gooddingii ocurre a lo largo del Río Bavispe, Arroyo Bacadéhuachi y arroyos más grandes. Agave ocahui y Mabrya geniculata son especies raras Notaworty. Las suculentas en Asparagaceae (10 taxa) y Cactaceae (10 taxa) son formas de vida importantes.

NOTE: A manuscript was not submitted to accompany this presentation.

Preliminary Flora and Vegetation of the Sierra Elenita-Mariquita Sky Island Complex, Sonora, Mexico

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The Sierra Elenita-Mariquita Sky Island complex is northeast of Cananea, Sonora, Mexico. The Sierra Elenita is owned by the Mina Buenavista del Cobre, with inholdings by Ejido Vicente Guerrero, Mina Frisco, and private property. La Catalina on the east edge of the Sierra Elenita is owned by Mina Buenavista del Cobre, Mina Frisco, and private property. The Sierra la Mariquita is owned by the Instituto Nacional de Astrofísica, Óptica y Electrónica (INOAE). In 2015 the Sierra la Mariquita was designated a Voluntary Land Conservation Area in the Comisión de Áreas Naturales Protegidas federal system. Aaron D. Flesch and Jeremy Russell recorded trees on bird transects in the Sierra la Mariquita in May-June 2009 and the Sierra Elenita in May 2011. We visted the Sierra Mariquita in June 2009, September 2010, and August 2013. The Madrean Discovery Expedition (MDE) Sierra Elenita was in April-May 2016; other visits were in September 2015 and August 2016. La Catalina was visited nine times in 2016-2018. A total of 1036 observations are available in the Arizona State University, Madrean Archipelago Biodiversity Assessment, MDE (madreandiscovery.org), Universidad de Sonora, and University of Arizona databases. A total of 305 plant taxa in 64 families were recorded. Dominant families are Asteraceae (55 taxa), Fabaceae (34 taxa), and Poaceae (39 taxa + 10 non-native). Nineteen species (6.1%) are non-native. The vegetation is grassland, oak woodland, and pine-oak forest. Noteworthy records are *Castilleja patriotica, C. minor, Draba helleriana, Pinus strobiformis, Poa fendleriana, Populus tremuloides, Potentilla subviscosa var. ramulosa,* and *Quercus gambelii*.

Flora y Vegetación Preliminar del Complejo Sierra Elenita-Mariquita en las Islas Serranas de Sonora, México

El complejo de las Isla Serrana Sierra Elenita-Mariquita está al noreste de Cananea, Sonora, México. La Sierra Elenita es propiedad de la Mina Buenavista del Cobre, con retenciones por el ejido Vicente Guerrero, Mina Frisco y propiedad privada. La Catalina en el borde este de la Sierra Elenita es propiedad de Mina Buenavista del Cobre, Mina Frisco y propiedad privada. La Sierra la Mariquita es propiedad del Instituto Nacional de Astrofísica, Óptica y Electrónica (INOAE). En 2015, la Sierra la Mariquita fue designada como Área Voluntaria de Conservación de Tierras en el sistema federal de la Comisión de Áreas Naturales Protegidas. Aaron D. Flesch y Jeremy Russell registraron árboles en transectos de aves en la Sierra la Mariquita en mayo-junio de 2009 y Sierra Elenita en mayo de 2011. Visitamos la Sierra Mariquita en junio de 2009, septiembre de 2010 y agosto de 2013. The Madrean Discovery Expedition (MDE) Sierra Elenita fue en abril-mayo de 2016; otras visitas fueron en septiembre de 2015 y agosto de 2016. La Catalina fue visitada nueve veces en 2016-2018. Un total de 1036 observaciones están disponibles en la Universidad Estatal de Arizona, la Evaluación de Biodiversidad del Archipiélago Madrense, MDE (madreandiscovery.org), la Universidad de Sonora y las bases de datos de la Universidad de Arizona. Se registró un total de 305 taxones de plantas en 64 familias. Las familias dominantes son Asteraceae (55 taxones), Fabaceae (34 taxones) y Poaceae (39 taxones + 10 no nativos). Diecinueve especies (6.1%) no son nativas. La vegetación es pastizales, bosques de robles y bosques de pino y encino. Los registros dignos de mención son Castilleja patriótica, C. minor, Draba helleriana, Pinus strobiformis, Poa fendleriana, Populus tremuloides, Potentilla subviscosa var. ramulosa y Quercus gambelii.

NOTE: A manuscript was not submitted to accompany this presentation.

Preliminary Flora and Vegetation of the Sierra Juriquipa, Sonora, Mexico

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The Sierra Juriquipa is ca. 15 kilometers southeast of Nacozari de García (in the municipality of the same name), Sonora, Mexico. It covers ca. 6,886 hectares of rugged mountainous terrain. The Sierra Juripquipa is owned by the Ejido Santo Domingo. The vegetation includes foothills thornscrub, desert grassland, oak woodland, and pine-oak forest. The east side of the range drains into the Río Bavispe. The western slopes drain into Arroyo de Nacozari, a major tributary of the Río Moctezuma (Río Yaqui drainage). The Madrean Discovery Expedition (MDE) Sierra Juriquipa was in July-August 2017. Plants were inventoried extensively near Ranchos Orégano Viejo and la Zulema, and Santo Domingo. Rancho la Zulema is close to the extensive Mina La Caridad open pit copper mine. A total of 483 observations are available in the Arizona State University, MDE (madreandiscovery.org), and University of Arizona databases. A total of 230 plant taxa in 62 families were recorded. Dominant families are Fabaceae (23 taxa), Asteraceae (21 taxa), Poaceae (15 taxa + 50 non-native), Euphorbiaceae (13 Taxa), Apocynaceae (12 taxa), and Convolvulaceae (10 taxa). Nine species (3.9%) are non-native. The vegetation is foothills thornscrub, desert grassland, oak woodland, and pine-oak forest. Noteworthy records are *Begonia gracilis, Browallia eludens, Matelea tristiflora, Solanum tridynamum,* and *Tigridia pavonia*.

Flora y Vegetación Preliminar de la Sierra Juriquipa, Sonora, México

La Sierra Juriquipa está ca. 15 kilómetros al sureste de Nacozari de García (en el municipio del mismo nombre), Sonora, México. Cubre ca. 6.886 hectáreas de terreno montañoso accidentado. La Sierra Juripquipa es propiedad del Ejido Santo Domingo. La vegetación incluye colinas cubiertas de espinas, pastizales desérticos, bosques de robles y bosques de pino y encino. El lado este de la cordillera desemboca en el río Bavispe. Las laderas occidentales drenan hacia el Arroyo de Nacozari, un importante afluente del Río Moctezuma (drenaje del Río Yaqui). Madrean Discovery Expedition (MDE) Sierra Juriquipa fue en julio-agosto de 2017. Las plantas fueron inventariadas extensamente cerca de Ranchos Orégano Viejo y la Zulema, y Santo Domingo. Rancho la Zulema está cerca de la extensa mina de cobre a cielo abierto Mina La Caridad.

Un total de 483 observaciones están disponibles en la Universidad Estatal de Arizona, MDE (madreandiscovery.org) y en las bases de datos de la Universidad de Arizona. Se registró un total de 230 taxones de plantas en 62 familias. Las familias dominantes son Fabaceae (23 taxones), Asteraceae (21 taxones), Poaceae (15 taxones + 50 no nativos), Euphorbiaceae (13 Taxa), Apocynaceae (12 taxa) y Convolvulaceae (10 taxa). Nueve especies (3.9%) no son nativas. La vegetación es el monte espinoso de las estribaciones, pastizales desérticos, bosques de robles y bosques de pino y encino. Los registros dignos de mención son Begonia gracilis, Browallia eludens, Matelea tristiflora, Solanum tridynamum y Tigridia pavonia.

NOTE: A manuscript was not submitted to accompany this presentation.

Session 30: Biodiversity

Cascabel Watersheds, Peloncillo Mountain Unit, Coronado National Forest, New Mexico
(Photo by Gerald J. Gottfried, USDA Forest Service, Rocky Mountain Research Station)

Abstracts and Papers
Blanco- Gutierrez
Cirett-Galan
Macias-Duarte
Silva-Kurumiya

Biotic Inventory of El Chilicote in the Sierra de los Ajos, Sonora, México

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APFF Bavispe is one of the oldest protected areas in Mexico (decreed in 1936-39). It was created to protect eight Sky Island mountain ranges with great biological diversity in high elevation areas, separated by lowland valleys with desert grasslands and foothills thornscrub. Sierra Los Ajos is part of APFF Bavispe Division 4. El Chilicote is located in the middle of the Sierra Los Ajos at 35.2 airline kilometers west-northwest of Fronteras. Elevations range from 1928 to 2206 m (6325-7238 ft.). Three old mine pits in the area have a high probability of being exploited in the near future. This project described the ecology of the site today. The site was visited in June, July, September, and November 2017. The vegetation is pine-oak forest on rocky mountain sides and in canyons, the runoff from this site feed the Bavispe river basin. The flora was studied on seven vegetation quadrants strategically located and through photography. A total of 82 species of plants records were obtained distributed in 40 families. Wildlife cameras were used to document nocturnal mammals. A total of 50 species of animals in 39 families were identified from camera images and field observations, 6 of them including *Choeronycteris mexicana, Leopardus pardalis,* and *Ursus americanus* have a threatened status in the NOM-059-SEMARNAT-2010, the Mexican endangered species law. This project was funded by the Madrean Discovery Expedition Scholarship Fund.

Inventario biótico de El Chilicote en la Sierra de los Ajos, Sonora, México

APFF Bavispe es una de las áreas protegidas más antiguas de México (decretada en 1936-39). Fue creada para proteger ocho cordilleras de las Islas Serranas con gran diversidad biológica en áreas de alta elevación, separadas por valles con pastizales desérticos y matorrales espinosos. Sierra Los Ajos es parte de APFF Bavispe División 4. El Chilicote está ubicado en el medio de la Sierra Los Ajos a 35.2 kilómetros de línea aérea al oeste-noroeste de Fronteras. Las elevaciones van de 1928 a 2206 m (6325-7238 pies). Tres viejos pozos mineros en el área tienen una alta probabilidad de ser explotados en el futuro cercano. Este proyecto describió la ecología del sitio hoy. El sitio fue visitado en junio, julio, septiembre y noviembre del 2017. La vegetación es bosque de pino y roble en las laderas rocosas de las montañas y en los cañones, la escorrentía de este sitio alimenta la cuenca del río Bavispe. La flora se estudió en siete cuadrantes de vegetación estratégicamente ubicados y mediante fotografía. Se obtuvieron un total de 82 especies de registros de plantas distribuidas en 40 familias. Se usaron cámaras de vida silvestre para documentar mamíferos nocturnos. Un total de 50 especies de animales en 39 familias fueron identificadas a partir de imágenes de cámara y observaciones de campo, 6 de ellas incluyendo Choeronycteris mexicana, Leopardus pardalis y Ursus americanus tienen un estado de amenaza en la NOM-059-SEMARNAT-2010, ley Mexicana de especie en peligro de extinción. Este proyecto fue financiado por el Fondo de Becas Madrean Discovery Expedition.

Note: Full Paper Follows

Mammals of El Chilicote in the Sierra de los Ajos, Sonora, Mexico

Anays C. Blanco-Gutiérrez[1]; Enrique Ballesteros-Valdez[1]; F. Isaías Ochoa-Gutiérrez[2]; Thomas R. Van Devender[3]

ITSC, Cananea, SON[1]; APFF Bavispe, Cananea, SON[2]; GreaterGood.org, Tucson, AZ[3]

***Abstract**--The Area de Protección de Flora y Fauna (APFF) Bavispe is one of the oldest protected areas in Mexico (decreed in 1936-39). It was created to protect eight sky island mountain ranges, of great biological diversity in high elevation areas, separated by lowland valleys with desert grasslands and foothills thornscrub in northeastern Sonora. Sierra Los Ajos is part of APFF Bavispe Division 4. El Chilicote is in the middle of the Sierra Los Ajos at 35.2 airline kilometers west-northwest of Fronteras. Elevations range from 1,928 to 2,206 m. Three old mine pits in the area have a high probability of being exploited in the future. This project described the current ecology of the site. The site was visited in June, July, September, and November 2017. The vegetation is pine-oak forest on rocky mountain sides and in canyons, the runoff from this site feed the Bavispe river basin. The flora was studied on seven strategically located vegetation quadrants and through photography. Wildlife cameras were used to document nocturnal mammals. A total of 50 species of animals were identified from camera images and field observations. Six of them have protected status in the NOM-059-SEMARNAT-2010, the Mexican endangered species law, including the mammals Choeronycteris mexicana, Leopardus pardalis, Sciurus arizonensis, and Ursus americanus.*

INTRODUCTION

The Madrean Archipelago between the Sierra Madre Occidental and the Mogollon Rim in central Arizona contains 55 isolated island mountain ranges or complexes of several ranges connected by oak woodland corridors (Van Devender et al. 2013a). These Sky Islands crowned with oak woodland or pine-oak forest emerge from lowland 'seas' of desert grassland, foothills thornscrub, or tropical deciduous forest. Since 2009, the Madrean Archipelago Biodiversity Assessment program at Sky Island Alliance, and the Madrean Discovery Expeditions program at GreaterGood.org have documented the biodiversity of 15 Sky Islands Region in Sonora. In this paper, we summarize the mammal fauna documented by wildlife camera images in the *El Chilicote* area in Sierra Los Ajos, Fronteras, Sonora.

Protection for the Sierras Los Ajos, Buenos Aires, and la Púrica began with a presidential decree in 1936. In 1939, it was re-enacted and expanded by President Lázaro Cárdenas under the name of Reserva Forestal Nacional y Refugio de Fauna Silvestre Ajos - Bavispe. Biotic communities in Sierra Los Ajos include mixed-conifer forest, pine-oak forest, montane meadows and grasslands, chaparral, oak woodland, and riparian forest. (Fishbein et al. 1995). In May 2017, the protected area was recategorized and renamed as Área de Protección de Flora y Fauna APFF Bavispe (DOF 2017).

STUDY AREA

The *El Chilicote* (30.93528°N -109.92389°W) study area in the Sierra los Ajos is ca. 35.2 km (56.3 mi) by air northwest of Fronteras (Figure 1). There are three old mine shafts, which currently have a high probability of being exploited.

The vegetation of *El Chilicote* is a second-generation pine-oak forest recovering from a 2013 forest fire on rocky slopes and in canyons at 1,928 to 2,206 m [6,555-7,237 ft.] elevation. The east slope of the Sierra Los Ajos drains into Arroyo Coquiárachi and the Río Cabullona, northern tributaries of the Río Bavispe-Yaqui system.

METHODS

El Chilicote was visited in June, July, September, and November 2017. Wildlife cameras were placed at ten stations in the area, six in June and four in July. Both still image and video cameras were placed at each station. Scoutguard and Bushnell cameras were used. No type of bait was used during the procedure. In September, batteries and SD memory

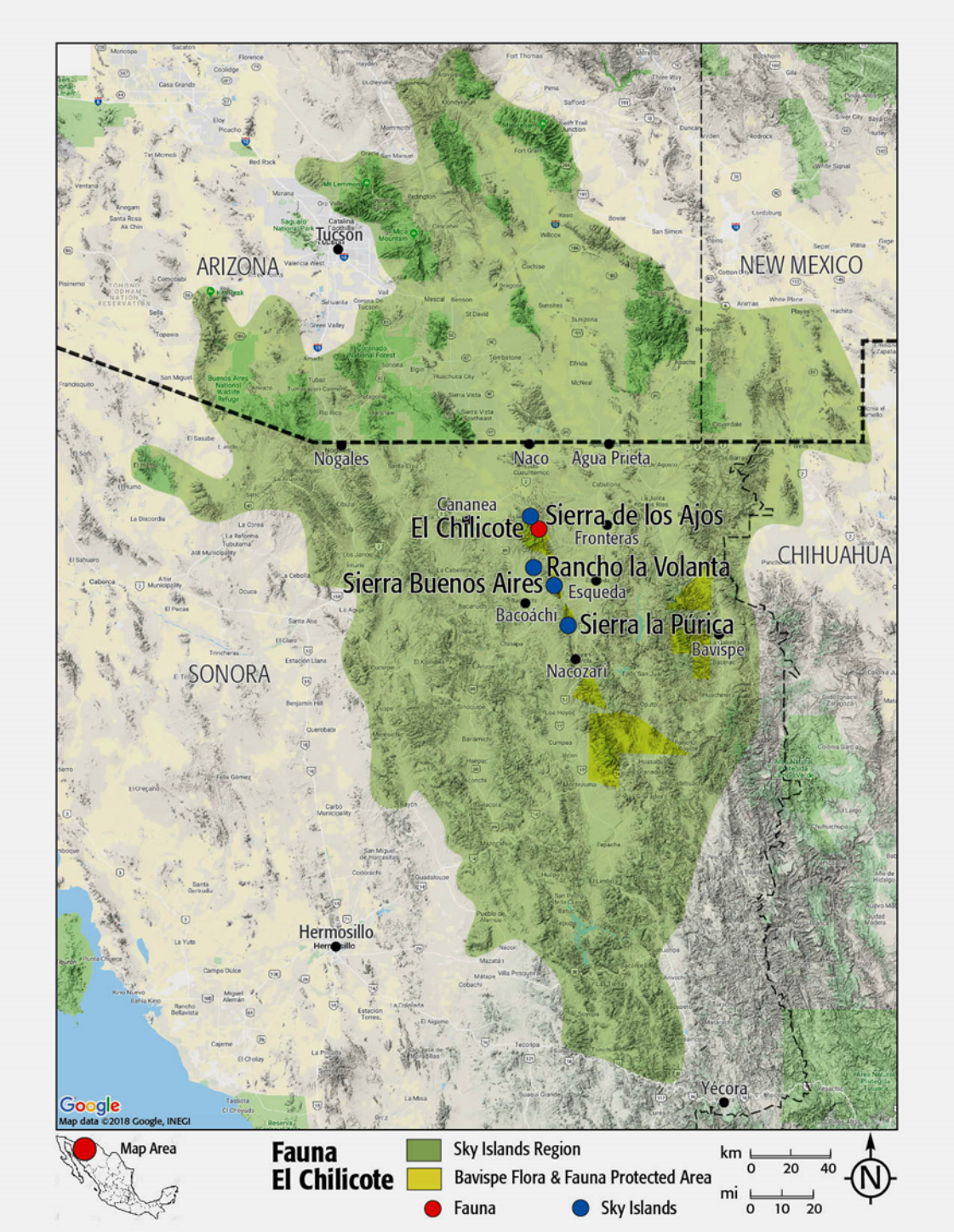

Figure 1. Map of El Chilicote, Sonora, Mexico, with relevant localities.

cards were replaced for every camera. The cameras were removed in November. Animals were also observed and photographed during the field trips.

Records and species identified from the camera images and observed are publicly available online in the Madrean Discovery Expeditions database (madreandiscovery.org). Wildlife monitoring records from APFF Bavispe-Sierra de los Ajos are in the Bavispe National Flora and Fauna Protected Area database (accessible in the MDE database, madreandiscovery.org).

RESULTS

To the date, a total of 48 species of fauna has been identified in the area, from wildlife camera images and field observations. This includes 16 mammals, 10 birds, 5 reptiles, and an amphibian and 16 invertebrates. With the use of wildlife cameras, 73 fauna records were described (considering for each station only one record per species) from 20 species including 14 mammals, 5 birds, and a butterfly. The mammals include one marsupial and 15 placental mammals in 11 families and 16 genera and species (Tables 1a and 1b). Felidae (cats) was represented by three species, followed by Mephitidae (skunks) and Procyonidae (ringtail, coatimundi) with two species. The cameras are efficient at capturing medium to large mammals. Most of the species recorded were medium-sized, with white-tailed deer (*Odocoileus virginianus*), mountain lion (*Puma concolor*), black bear *(Ursus americanus)* and collared peccary (*Pecari tajacu*) being the larger taxa while; North American opossum (*Didelphis virginiana*), Arizona gray squirrel (*Sciurus arizonensis*), Mexican long-nosed bat (*Choeronycteris mexicana*), and Townsend's big-eared bat (*Corynorhinus townsendii*) were the smaller mammals registered. Two bat species, from different families (Phyllostomidae, Vespertilionidae) were the only flying mammals identified.

The most common species photographed were white- tailed deer, gray fox, Arizona gray squirrel, eastern cottontail (*Sylvilagus floridanus*), and skunks (*Conepatus leuconotus and Mephitis mephitis*). Black bear was photographed at five of the ten stations, including solitary individuals and females with cubs. Native cats included mountain lion (four stations), bobcat (*Lynx rufus*; three stations), and a single ocelot (*Leopardus pardalis*).

Mammals in the fauna are mostly omnivorous (eight species), three herbivores, one insectivore and one nectarivore. Cats (Felidae) are the only relatively strict carnivores. The only photographs (2) of mammals feeding on prry were gray foxes eating eastern cottontails. Ringtails and opossums were rarely photographed. Jaguars (*Panthera onca*) were photographed in 2009, 2012, and 2013, less than 3 km [1.9 mi] south of El Chilicote in the APFF Bavispe monitoring program (Madrean Discovery Expedition Database).

DISCUSSION

The *El Chilicote* mammal fauna with 16 species is 13% of the mammal fauna of Sonora (Castillo-Gámez et al. 2010). All of the species also occur in Arizona. We consider the fauna to be a typical of the upland Sky Island mountain ranges. Four species have protected status in the NOM-059-SEMARNAT (2010), the mexican endangered species law, including *Leopardus pardalis* Figure 2), and *Ursus americanus* (Peligro de extinción [Endangered]) (Figure 3), and *Choeronycteris mexicana* (Figure 4) and *Sciurus arizonensis* (Amenazada [Threatened]) (Figure 5). Ocelot also has Endangered protection status under the Endangered Species Act in the United States.

Biological inventories help assess natural resources for sustainable use and establish a basis for selecting indicator species that determine the health of the natural area to carry out monitoring programs (Kremen et al. 1993). Based on our results we conclude that the *El Chilicote* area is in good condition and recovering well from the 2013 forest fire. Attempts to explore and begin new mineral extraction are important potential environmental threats to the diverse fauna presently using the habitat.

Figure 2. *Leopardus pardalis* - Peligro de extinción [Endangered] – STATION 5

Figure 3. *Ursus americanus* - Peligro de extinción [Endangered] – STATION 5

Figure 4. *Choeronycteris mexicana* - Amenazada [Threatened] – I.Ochoa – El Chilicote - 10-Sept-17

Figure 5. *Sciurus arizonensis - Amenazada* [Threatened] – STATION 5

Table 1a. Mammals observed and identified from wildlife camera images and field observations in the Sierra de los Ajos, Sonora, Mexico.

Family	Scientific Name	Common name	Nombre Español
Canidae	*Urocyon cinereoargenteus*	gray fox	zorrita gris
Cervidae	*Odocoileus virginianus*	white-tailed deer	venado cola blanca
Didelphidae	*Didelphis virginiana*	North American opossum	tlacuache, zarigüeya
Felidae	*Leopardus pardalis*	ocelot	ocelote, tigrillo
Felidae	*Lynx rufus*	bobcat	gato montés, cola pochi
Felidae	*Puma concolor*	mountain lion,	puma
Leporidae	*Sylvilagus floridanus*	eastern cottontail	conejo serrano
Mustelidae	*Conepatus leuconotus*	hog-nosed skunk	zorrillo espalda blanca
Mustelidae	*Mephitis mephitis*	striped skunk	zorrillo rallado
Phyllostomatidae	*Choeronycteris mexicana*	Mexican long-tongued bat	murciélago trompudo
Procyonidae	*Bassariscus astutus*	ringtail	cacomixtle
Procyonidae	*Nasua narica*	coatimundi	chulo, cholugo, solitario
Sciuridae	*Sciurus arizonensis*	Arizona gray squirrel	ardilla gris
Tayasuidae	*Pecari tajacu*	collared peccary	jabalí
Ursidae	*Ursus americanus*	black bear	oso negro
Vespertilionidae	*Corynorhinus townsendii*	Townsend's big-eared bat	murciélago orejón de Townsend

There are several basic references for the mammals of Sonora, beginning with William Caire's 1978 doctoral dissertation at the University of New Mexico on 'The Distribution and Zoogeography of Mammals of Sonora, Mexico'. Caire's !997) state mammal checklist was updated by Castillo-Gámez et al. (2010). Ceballos and Oliva's (2005) book "Los Mamíferos Silvestres de México" contains extensive descriptions on the mammal species in Sonora. Schwalbe and Lowe (2000) provided a list of the mammals in their paper on the amphibian and reptiles of the Sierra de Álamos and vicinity in southern Sonora. The vegetation in this area is tropical deciduous forest below oak woodland and pine-oak forest. General biotic inventories were reported in the Sierra de los Ajos (Alberti et al. 1998) and the Ciénega de Saracachi (Van Devender et al. 2013b), but wildlife cameras were not used, limiting mammal observations. Alberti et al. (1998) documented 13 mammal species, from which eight are listed in this paper, including Arizona gray squirrel, black bear, collard peccary, cottontail rabbit, gray fox, mountain lion, striped skunk, and white-tailed deer. Coronel-Arellano et al. (2016) summarized wildlife camera results from the Sierras Los Ajos, La Madera, and El Tigre in APFF Bavispe and Sierra

San Luis. In the Sierra Los Ajos they reported 15 species of mammals from 28 cameras left in the field for 39 days. They did not report the collared peccary nor North American opossum from Sierra de Los Ajos.

Table 1b. Mammals observed and identified from wildlife camera images and field observations Elsewhere in the Sierra de los Ajos (12)

Family	Scientific Name	Common name	Nombre Español
Canidae	*Canis latrans*	coyote	Coyote
Cricetidae	*Neotoma albigula*	white-throated, packrat	tori, rata-cambalachera garganta blanca
Cricetidae	*Peromyscus eremicus*	cactus mouse	ratón de cactus
Felidae	*Panthera onca*	jaguar	tigre, jaguar
Leporidae	*Lepus alleni*	antelope jackrabbit	liebre antílope
Mustelidae	*Mephitis macroura*	hooded skunk	zorillo encapuchado
Mustelidae	*Spilogale gracilis*	spotted skunk	zorillo moteado
Procyonidae	*Procyon lotor*	racoon	mapache, batepí
Sciuridae	*Otospermophilus variegatus*	rock squirrel	ardilla de roca
Vespertilionidae	*Eptesicus fuscus*	big brown bat	murciélago-moreno Norteamericano
Vespertilionidae	*Lasiurus blossevillii*	desert red bat	murciélago cola peluda de Blossevil
Vespertilionidae	*Lasiurus cinereus*	hoary bat	murciélago cola peluda canoso

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Preliminary Fauna of the Sierra Juriquipa, Nacozari de García, Sonora, Mexico

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The fauna of the Sierra Juriquipa in Northeastern Sonora, Mexico is poorly known, This Sky Island monutain range located ca. 15 kilometers southeast of Nacozari de Garcia in the municipality of the same name (30.2834°N, -109.5405°W) covers ca. 6,886 ha of rugged mountainous terrain. The vegetation includes foothills thornscrub, desert grassland, oak woodland, and pine-oak forest. The east side of the range drains into the Río Bavispe. The western slopes drain into Arroyo de Nacozari, a major tributary of the Río Moctezuma (Río Yaqui drainage). Animals were observed by 29 biologists for eight days in July and August 2017 on Madrean Discovery Expedition (MDE) trips. Wildlife cameras recorded mammals at three locations for three months. Observations of 488 animal species are available in the MDE database (madreandiscovery.org). The fauna includes 410 species of invertebrates, including moths (197 species), beetles (95 species), ants (27 species), and grasshoppers (10 species). A total of 78 species of vertebrates were observed, including 44 birds, 20 reptiles and amphibians, and 14 mammals. The fauna is typical for Sky Islands, but only moderately diverse. Lizards were rare, and wildlife cameras recorded low numbers and diversity of large mammals, possibly reflecting the proximity of the extensive Mina La Caridad open pit copper mine. Noteworthy animals included *Crotalus willardi* subsp*. silus, Myrmecophilus manni, Rana tarahumare,* and *Ursus americanus. Salvadora bairdi* is a northern range extensión of a Sierra Madre Occidental species. *Boa constrictor* and *Gopherus agassizii* in oak woodland are unusual habitat records.

Fauna Preliminar de la Sierra Juriquipa, Nacozari de García, Sonora, México

La fauna de la Sierra Juriquipa en el noreste de Sonora, México es poco conocida. Esta cadena montañosa de las Islas Serranas se encuentra aprox. 15 kilómetros al sureste de Nacozari de García en el municipio del mismo nombre (30.2834 ° N, -109.5405 ° O) cubre ca. 6.886 hectáreas de terreno montañoso accidentado. La vegetación incluye colinas cubiertas de espinas, pastizales desérticos, bosques de robles y bosques de pino y encino. El lado este de la cordillera desemboca en el río Bavispe. Las laderas occidentales drenan hacia el Arroyo de Nacozari, un importante afluente del Río Moctezuma (drenaje del Río Yaqui). Los animales fueron observados por 29 biólogos durante ocho días en julio y agosto de 2017 en los viajes de Madrean Discovery Expedition (MDE). Las cámaras de vida salvaje registraron mamíferos en tres lugares durante tres meses. Las observaciones de 488 especies de animales están disponibles en la base de datos MDE (madreandiscovery.org). La fauna incluye 410 especies de invertebrados, incluyendo polillas (197 especies), escarabajos (95 especies), hormigas (27 especies) y saltamontes (10 especies). Se observó un total de 78 especies de vertebrados, incluyendo 44 aves, 20 reptiles y anfibios y 14 mamíferos. La fauna es típica de las Islas Serranas, pero solo moderadamente diversa. Las lagartijas fueron raras, y las cámaras de vida silvestre registraron números bajos y diversidad de mamíferos grandes, posiblemente reflejando la proximidad de la extensa mina de cobre a cielo abierto Mina La Caridad. Los animales dignos de mención incluyeron Crotalus willardi subsp. silus, Myrmecophilus manni, Rana tarahumare y Ursus americanus. Salvadora bairdi es una extensión del rango norte de una especie de la Sierra Madre Occidental. Boa constrictor y Gopherus agassizii en bosques de robles son registros inusuales de hábitat.

NOTE: A manuscript was not submitted to accompany this presentation.

Status of the Golden Eagle in the Sky Islands of Sonora, Mexico

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The Golden Eagle (*Aquila chrysaetos*) is regarded as Threatened by the NOM-059-SEMARNAT-2010 and is a priority species for conservation. Recently, individuals of the Golden Eagle have been detected in northeastern Sonora. This region is of great importance since it is immersed in a continuous corridor that includes the National Forest Reserve and Wildlife Refuge Ajos Bavispe, and several Areas Voluntarily Destined for Conservation. The objective of this study was to determine the population status of the Golden Eagle in the Sky Islands of Sonora. We established a design with 196 sampling units of 25 km^2 throughout the study area, from which 17 units were systematically surveyed for Golden Eagle. We located eagles in 5 out of those 17 units, generating an occupation estimate of territories of 29.4% ± 11.0% (IC95%: 7.8-51.1%). Our results helped us define a protocol for Golden Eagle monitoring at Los Ajos-Bavispe. Within this protocol, the first 5 years of monitoring should focus on finding all possible eagle pairs or nests and delineating breeding territories to subsequently transit from monitoring-based on sampling units to monitoring-based on breeding territories. It is possible that the Golden Eagle is declining or stable at low population levels in the region. It is necessary to follow up mining development projects in Sierra El Tigre and carry out actions that help reduce the risk of electrocution of Golden Eagles.

Estado del águila real en las Islas Serranas de Sonora, México

El águila real (Aquila chrysaetos) está amenazada por la NOM-059-SEMARNAT-2010 y es una especie prioritaria para la conservación. Recientemente, individuos del águila real han sido detectados en el noreste de Sonora. Esta región es de gran importancia ya que está inmersa en un corredor continuo que incluye la Reserva Forestal Nacional y el Refugio de Vida Silvestre Ajos Bavispe, y varias Áreas Voluntariamente Destinadas a la Conservación. El objetivo de este estudio fue determinar el estado de la población del Águila real en las Islas Serranas de Sonora. Establecimos un diseño con 196 unidades de muestreo de 25 km2 en toda el área de estudio, desde el cual se estudiaron sistemáticamente 17 unidades para el Águila real. Ubicamos águilas en 5 de esas 17 unidades, generando una estimación de ocupación de territorios de 29.4% ± 11.0% (IC95%: 7.8-51.1%). Nuestros resultados nos ayudaron a definir un protocolo para el monitoreo del águila real en Los Ajos-Bavispe. Dentro de este protocolo, los primeros 5 años de monitoreo deben enfocarse en encontrar todos los posibles pares o nidos de águila y delinear los territorios de reproducción para luego pasar del monitoreo basado en unidades de muestreo al monitoreo basado en territorios de reproducción. Es posible que el águila real esté disminuyendo o sea estable a niveles de población bajos en la región. Es necesario hacer un seguimiento de los proyectos de desarrollo minero en Sierra El Tigre y llevar a cabo acciones que ayuden a reducir el riesgo de electrocución de águilas reales.

NOTE: A manuscript was not submitted to accompany this presentation.

Fauna wealth in El Corralito, municipality of Moctezuma, Sonora.

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The determination of the faunal wealth in the "El Corralito" property, municipality of Moctezuma, was obtained through camera traps and direct sightings by transects. The count was carried out from August 15 to December 3, 2016. As for the cameras, eight cameras were placed in three monthly campaigns, the first without the use of attractants and the subsequent two using vanilla and sardine as bait. Simultaneously six transects were carried out in lengths from 630 to 1345. From the phototraping there was a richness of four bird species and fourteen species of mammals, highlighting the presence of *Leopardus pardalis*, a species that falls under the category of protection (P). During the tours, twelve species were observed; five of the amphibian class, four reptilia, one mammalia and two birds, including species such as *Cyrtonyx montezumae, Boa constrictor, Gopherus agassizii, Thamnophis cyrtopsis* and *Lithobates yavapaiensis*. It highlights the importance of the area for the study of populations, since five of the 30 registered species are under some category of protection according to NOM-059.

Riqueza faunística en predio El Corralito, municipio de Moctezuma, Sonora.

La determinación de la riqueza faunística en el predio "El Corralito", municipio de Moctezuma, se obtuvo mediante trampas cámara y avistamientos directos por transectos. El recuento se llevó a cabo a partir del 15 de agosto al 3 de diciembre de 2016. En cuanto a las cámaras, fueron colocadas ocho cámaras en tres campañas mensuales, la primera sin el uso de atrayentes y la dos posteriores usando vainilla y sardina como cebo. Simultáneamente se realizaron seis transectos en longitudes de 630 a 1345. Del fototrampeo se tuvo una riqueza de cuatro especies de aves y catorce especies de mamíferos, destacando la presencia de Leopardus pardalis, especie que se encuentra bajo la categoría de protección (P). Durante los recorridos se observaron doce especies; cinco de la clase amphibia, cuatro reptilia, una mammalia y dos aves, incluyendo especies como Cyrtonyx montezumae, Boa constrictor, Gopherus agassizii, Thamnophis cyrtopsis y Lithobates yavapaiensis. Resalta la importancia del área para el estudio de poblaciones, ya que cinco de las 30 especies registradas, se encuentran bajo alguna categoría de protección según la NOM-059.

Note: Full Paper Follows

Breve recuento de fauna en el predio El Corralito, municipio de Moctezuma, Sonora.

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***RESUMEN**--La determinación de la riqueza faunística en el predio "El Corralito", municipio de Moctezuma, se obtuvo mediante trampas cámara y avistamientos directos por transectos. El estudio se llevó a cabo a partir del 15 de agosto al 3 de diciembre de 2016. La metodología utilizada en el presente trabajo consistió en el uso de métodos directos e indirectos. Fueron colocadas ocho cámaras en tres campañas mensuales, la primera sin el uso de atrayentes y la dos posteriores usando vainilla y sardina como cebo atrayente. Simultáneamente se realizaron seis transectos en longitudes de 630 a 1,345 m. Como resultado de la combinación de los métodos, se obtuvo un total de 30 especies de fauna registrada. Del fototrampeo se tuvo una riqueza de 18 especies, cuatro especies de aves y catorce especies de mamíferos, destacando la presencia de Leopardus pardalis, especie que se encuentra bajo la categoría de protección (P) de acuerdo a la Norma Oficial Mexicana NOM-059.SEMERNAT-2010. Los registros obtenidos en los transectos fueron de 12 especies; 5 anfibios, 4 reptiles, un mamífero y 2 aves, incluyendo especies como Cyrtonyx montezumae, Boa constrictor, Gopherus agassizii, Thamnophis cyrtopsis y Lithobates yavapaiensis. Resalta la importancia del área para el estudio de poblaciones, ya que seis de las 30 especies registradas, se encuentran bajo alguna categoría de protección según la NOM-059.SEMERNAT-2010.*

INTRODUCCIÓN

El municipio de Moctezuma, Sonora, se encuentra enclavado en el macizo montañoso de la Sierra Madre Occidental (SMO), presentando una heterogeneidad del paisaje dado por los relieves ondulados del pie de monte, hasta alcanzar altitudes de más de 2000 metros, conllevando a patrones de diversidad de ecosistemas. En este caso particular, la combinación de una faja tropical y subtropical en faldas de la SMO y la faja templada hacia las montañas del este del estado de Sonora (Martínez-Yrízar et al. 2009). En parte de esa región altitudinal elevada del municipio, se encuentra la Fracción V del Área de Protección Flora y Fauna Bavispe, Sierra La Madera, la cual forma parte del Archipiélago Madrense o Islas Serranas (Van Devender et al. 2013).

Castellanos-Villegas et al. (2009) hacen referencia al inicio de la ganadería extensiva en la región central de Sonora en las primeras décadas del siglo XVI, específicamente en la región de Moctezuma. Esta actividad ha trasformado el paisaje de pastizales semiáridos, matorrales espinosos y encinares abiertos, a matorrales semiáridos, con pérdida de la calidad del hábitat.

La ganadería, al igual que la agricultura, deforestación, crecimiento poblacional, comercio ilegal, entre otras, amenazan la biodiversidad (CONABIO 1998). En cuanto a las amenazas para la fauna silvestre, estriba en que algunos la consideran competidores del ganado, como ocurrió para el perrito de la pradera (Miller et al. 1994), o bien, que consideran a los carnívoros como la principal amenaza para la actividad productiva (Castillo-Gámez. et al. 2010). Pese a estas amenazas, existen regiones en el estado que aún presentan fragmentos de vegetación natural donde es posible registrar la presencia de especies con valor biológico y ecológico, como es el caso del predio El Corralito, en Moctezuma, Sonora.

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El predio El Corralito, localizado a 15 km al suroeste de la Fracción V Sierra La Madera de la Reserva de Protección de Flora y Fauna Bavispe, representa un área de influencia ecológica para el paso de fauna silvestre. El presente trabajo tuvo como objetivo realizar el registro de la riqueza faunística utilizando métodos directos e indirectos como trampas cámara y transectos.

ÁREA DE ESTUDIO

El Corralito se encuentra entre los paralelos 29° 49.989' y 29° 49.048' de latitud norte; los meridianos 109° 46.492' y 109° 43.673' de longitud oeste; en una altitud entre 800 y 1,100 m, dentro del municipio de Moctezuma, Sonora (Figura 1). Abarca una extensión territorial de 513 ha, las cuales son utilizadas para la ganadería con manejo mixto (extensivo e intensivo) dependiendo de las condiciones del terreno. Cuenta con dos represos y cinco aguajes permanentes, utilizados como fuente de agua para el ganado. De acuerdo a INEGI (2016) la vegetación presente en el área es matorral subtropical en la totalidad del área, y en trabajo de campo se registró remanentes bosque de encino, a partir de los 1000 m. En relación con la base de datos de Madrean Discover Expedition database, madreandiscovery.org (MABA, 2016; Van Devender y Reina-Guerro 2016), se maneja una fauna potencial de 16 especies de mamíferos, 99 aves, 41 reptiles y siete anfibios.

METODOLOGÍA

El estudio de fauna en el predio El Corralito, consistió en el uso de métodos directos y métodos indirectos, basados en Aranda (2012); Chávez y cols. (2013); Díaz-Pulido y Payán-Garrido (2012); Gallina-T. y López-G. (2011); Maffei et al. (2002) y Monroy-Vilchis et al. (2011).

Métodos directos.

Consistió fototrampeo y avistamientos directos. La técnica de fototrampeo, se llevó a cabo durante tres campañas de agosto a diciembre de 2016. Se colocaron ocho trampas cámara en lugares específicos en donde se han observado especímenes de animales, o bien sitios aptos para la actividad de fauna. Las trampas cámara se mantuvieron en los mismos puntos durante las tres campañas de fototrampeo, únicamente cambiando pilas y memorias SD (Tabla I y Figura 1). En cada una de las estaciones de muestreo se colocó una sola cámara a una distancia de entre 600 y 1000 m según las características del terreno siguiendo la recomendación de Díaz-P. y Payán-G. (2012**).** Las campañas estuvieron diferenciadas en la técnica: en la primera campaña (15 de agosto al 20 de septiembre de 2016), se optó por no hacer uso de atrayentes, mientras que, en las campañas subsecuentes, sí se hizo uso de él, a fin de compararlas y determinar su eficacia. Así como valorar la relación costo-beneficio entre uso de atrayentes y su impacto en los resultados.

Avistamientos

Se realizaron recorridos en transectos para la observación directa de fauna silvestre, capturando su registro mediante cámara fotográfica convencional. El transecto consistió en una ruta de que varío de 630 a 1,345 m de longitud, dicha variación se debió a lo escabroso del terreno. Cada ruta se visitó al menos dos veces, dando un total de 46 recorridos. Los recorridos se realizaron cada 15 días, sin visitar todos los transectos en un solo día (excepto una ocasión); dichos recorridos se llevaron a cabo de las 8:00 a las 14:00 h.

Métodos indirectos.

Utilizando las mismas rutas y recorridos para la observación directa, solo que en este caso se iban levantando indicios de fauna silvestre, por ejemplo: astas, huellas, restos óseos y marcas. Los especímenes fueron identificados utilizando la base de datos de MABA (2016), y las guías de identificación de Farrand (1993); Rorabaugh y Lemos-E. (2016); y Whitaker (1996). Para la obtención de las coordenadas de los sitios se utilizó GPS Garmin Rhino® 650, registrando latitud y longitud

en coordenadas Universal Transversal de Mercator (UTM) con Datum WGS84 y para la elaboración de mapas se utilizó el programa ArcGIS 10.2.

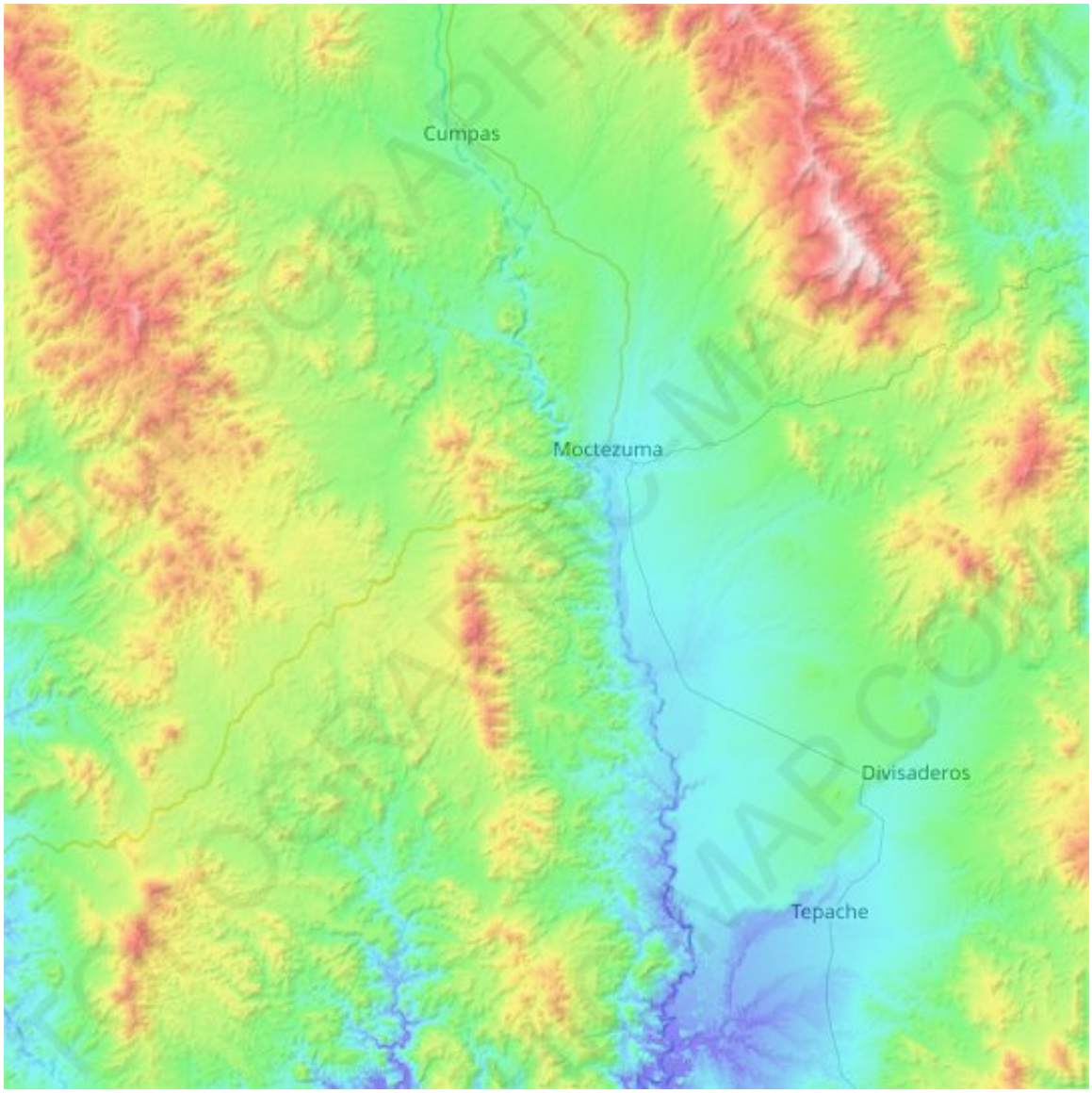

Figura 1. Mapa topográfico, Moctezuma, Sonora, Mexico.

Tabla 1. Listado de herpetofauna en Rancho La Montosa, con su categoría en la Norma Oficial Mexicana de protección de especies y CITES.

ORDEN	FAMILIA	GÉNERO Y ESPECIE	NOMBRE COMÚN	NOM-059-SEMARNAT-2010[a]	CITES[b]
Squamata	Boidae	*Boa constrictor*	Boa constrictor	A, (NE)	II
Squamata	Colubridae	*Thamnophis cyrtopsis*	Culebra de agua	A, (NE)	
Squamata	Phrynosomatidae	*Phrynosoma ditmarsi*	Lagartija-cornuda de roca		
Squamata	Scincidae	*Plestiodon callicephalus*	Eslizón de la sierra madre occidental		
Testudines	Kinosternidae	*Kinosternon integrum*	Tortuga pecho quebrado mexicana	Pr, (E)	II
Testudines	Kinosternidae	*Kinosternon sonoriense*	Tortuga pecho quebrado sonorense		II
Anura	Bufonidae	*Anaxyrus punctatus*	Sapo de puntos rojos		
Anura	Hylidae	*Hyla arenicolor*	Rana arborícola, sapo blanco		
Anura	Microhylidae	*Gastrophryne mazatlanensis*	Ranita olivo	Pr, (NE)	
Anura	Ranidae	*Lithobates magnaocularis*	Rana leopardo del noroeste		

a. Categoría de riesgo en la NOM-059-SEMARNAT-2010:
A = Amenazado,
Pr = Protección Especial,
P = Peligro de extinción,
E = Probablemente extinta en el medio silvestre,
(E) = Endémico,
(NE) = No endémico.

b. Apéndices de la Convención sobre el Comercio Internacional de Especies Amenazadas de Fauna y Flora Silvestres (CITES), vigente a partir del 01 de julio de 2008:
I. Incluye especies en peligro de extinción. En términos generales, el intercambio con fines comerciales está restringido.
II. Incluye especies no necesariamente amenazadas de extinción, pero cuyo comercio debe controlarse para evitar que así sea. También incluye especies que necesitan regularse por su similitud con otras. El comercio internacional se permite bajo ciertos requisitos.

RESULTADOS

Utilizando métodos directos e indirectos para el inventario de fauna en el predio El Corralito, se registraron 6 órdenes de mamíferos y 10 familias; 5 órdenes de aves con 5 familias; 3 órdenes de reptiles y 4 familias; y 1 orden de anfibios con 3 familias. En total se cuantificaron 15 especies de mamíferos, 6 de aves, 5 especies para anfibios y 4 para reptiles. Del total de especies, 6 se encuentran en alguna categoría de protección de acuerdo a la NOM-059-SEMARNAT-2010.

Los taxones con mayor número de registros por fototrampeo, fueron *Lepus alleni* y *Odocoileus virginianus*. Por transecto las especies más observadas (directa o indirectamente) fueron *Callipepla gambelii* y *Lithobates yavapaiensis.* La técnica de fototrampeo resultó eficaz para la obtención de la riqueza de fauna silvestre puesto que se identificaron

14 especies de mamíferos de 16 que se tenían contempladas potencialmente dentro del área, basada en revisiones bibliográficas. El uso de atrayentes resulta ventajoso para el inventario faunístico mediante dicha técnica, ya que en la primera campaña (sin uso de atrayentes) el número de registros de taxones fue menor (5), que en las siguientes dos campañas usando atrayente (12 en la segunda y 6 en la tercera). Por otra parte, la distancia entre las trampas cámara es relativa a los objetivos planteados al inicio de un estudio, pues depende, tanto de las especies que se quiera registrar su presencia, como de las condiciones del terreno en el que se desea realizar el estudio.

Por otro lado, la evidencia que generan las trampas cámara (con o sin cebo), es de gran ayuda en la toma de decisiones para la conservación de especies y sus poblaciones. En este caso, el registro de ocelote (*Leopardus pardalis*), especie bajo categoría de protección en peligro de extinción, promueve al sitio como área de interés para estudios de poblaciones.

En cuanto a los avistamientos directos, este tiene ventajas con respecto al fototrampeo, que se basa en la espera del animal, mientras que, durante los recorridos, es ir bajo la expectativa de observar un espécimen. Gracias a este principio se encontraron especies terrestres que difícilmente son capturadas con trampas cámara, como lo son: *Lithobates yavapaiensis*, sujeta a protección especial (Pr), *Gopherus agassizii,* Amenazada (A) y *Thamnophis cyrtopsis* Amenazada (A), de acuerdo a la Norma oficial Mexicana de protección de especies (NOM-059-SEMARNAT-2010).

En cuanto al área de estudio, es importante resaltar que se trata de un predio de agostadero con manejo intensivo, sin embargo, presenta seis especies bajo categoría de protección, lo que resalta su importancia en la conservación.

CONCLUSIONES

A pesar de la amenaza que representa la actividad ganadera sobre la biodiversidad, aún se pueden encontrar sitios que funcionan como refugio de especies en categoría de protección. Tal es el caso de el predio El Corralito. Por encontrarse en una zona de transición entre matorral espinoso y bosque de encino; por tener un marcado gradiente altitudinal; por presentar especies en peligro de extinción, amenazadas y bajo protección especial; y por funcionar como un área de amortiguamieno y un posible corredor biológico hacia las islas serranas, es necesario, que autoridades (CONANP oficina Moctezuma) y centros de investigación, se acerquen a los propietarios para darles a conocer los diferentes insentivos económicos apegados a la política ambiental, a fin de motivar su interés para la conservación.

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Session Abstracts and Papers / *Resúmenes y Articulos*

Session 31: Current Research on Herpetofauna of the Sonoran Desert and Sky Islands, Part #1

Huachuca Mountains landscape, Coronado National Forest, Arizona
(Photo courtesy of the USDA Forest Service, Coronado National Forest)

Abstracts and Papers
Edwards
Holm
Jimenez-Canale
Repp
Sullivan
Zylstra

Assessment of Gila Monster (*Heloderma suspectum*) population genetics at Saguaro National Park, Arizona provides a baseline for monitoring population trends

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Gila monsters (*Heloderma suspectum*) are large, venomous reptiles native to the southwestern United States and northern Mexico. They are secretive and challenging to survey so population status throughout their range is generally unknown. We present the first population genetic study of Gila monsters conducted at Saguaro National Park, Tucson, Arizona. We used 18 microsatellite markers, along with 1195 bp of sequence data from the mitochondrial DNA 12S locus to examine genetic diversity, assess demographic history and estimate effective population size. In conjunction, we used capture-recapture methods to estimate total population size of the approximately 80 km^2 study area. We determined that this population is healthy and robust, which we attribute to the success of protective measures in the National Park and under Arizona state laws. These data provide a crucial population genetic baseline for this protected species which can be used to monitor population trends here and throughout their range. We present these data in relation to other reptile species that share habitat and have similar natural histories such that their shared biogeography may be used to infer a common evolutionary history and inform management decisions for conservation.

La evaluación de la genética de poblaciones del monstruo de Gila (Heloderma suspectum) en el Parque Nacional Saguaro, Arizona, proporciona una línea base para monitorear las tendencias de la población

Los monstruos de Gila (Heloderma suspectum) son reptiles grandes y venenosos nativos del suroeste de los Estados Unidos y el norte de México. Son reservados y desafiantes para realizar encuestas, por lo que el estado de la población en todo su rango es generalmente desconocido. Presentamos el primer estudio genético poblacional de monstruos de Gila realizado en el Parque Nacional Saguaro, Tucson, Arizona. Usamos 18 marcadores de microsatélites, junto con 1195 pb de datos de secuencia del locus 12S mitocondrial de ADN para examinar la diversidad genética, evaluar la historia demográfica y estimar el tamaño efectivo de la población. En conjunto, utilizamos métodos de captura-recaptura para estimar el tamaño total de la población de aproximadamente 80 km2 de área de estudio. Determinamos que esta población es saludable y robusta, lo cual atribuimos al éxito de las medidas de protección en el Parque Nacional y bajo las leyes estatales de Arizona. Estos datos proporcionan una base genética poblacional crucial para esta especie protegida que se puede usar para monitorear las tendencias de la población aquí y en todo su rango. Presentamos estos datos en relación con otras especies de reptiles que comparten hábitats y tienen historias naturales similares, de modo que su biogeografía compartida puede usarse para inferir una historia evolutiva común e informar las decisiones de manejo para la conservación.

NOTE: A manuscript was not submitted to accompany this presentation.

Herpetological studies at Organ Pipe Cactus National Monument

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A rich herpetofauna and dramatic landscapes have attracted biologists to this heart of the Sonoran Desert since the monument was established in 1937. Species recorded in the 331,000-acre monument include 25 snakes, 16 lizards, 3 turtles, and 5 anurans. National Park Service employees and partners monitor the status and trends of herpetological communities and special status species populations using standardized lizard transects, mud turtle censuses, a pitfall trap array for snakes and other small animals, desert tortoise plots, radio telemetry, and wildlife cameras. Results are providing a better understanding of community ecology, demography, biogeography, and the effects of climate variation.

Estudios herpetológicos en el Monumento Nacional Organ Pipe Cactus

Una rica herpetofauna y paisajes dramáticos han atraído a los biólogos a este corazón del desierto de Sonora desde que el monumento fue establecido en 1937. Las especies registradas en el monumento de 331,000 acres incluyen 25 serpientes, 16 lagartijas, 3 tortugas y 5 anuros. Los empleados y socios del Servicio de Parques Nacionales supervisan el estado y las tendencias de las comunidades herpetológicas y poblaciones de especies de estado especial utilizando transectos de lagartos estandarizados, censos de tortugas de lodo, trampas para serpientes y otros animales pequeños, parcelas de tortugas del desierto, radio telemetría y cámaras de vida silvestre. Los resultados proporcionan una mejor comprensión de la ecología de la comunidad, la demografía, la biogeografía y los efectos de la variación climática.

NOTE: A manuscript was not submitted to accompany this presentation.

Herpetofauna biodiversity of famous trekking and hiking sites in Hermosillo, Sonora, Mexico

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In the past few years outdoor activities such as trekking, hiking and walking through man made paths in the outskirts of Hermosillo city in Sonora, Mexico have gained a lot of popularity. As such, reports of the presence of exotic fauna has increased, especially that of venomous reptiles such as pit vipers, gila monsters and some colubrids, as well as non-venomous reptiles and amphibians. The biodiversity of the herpetofauna in the city of Hermosillo, Sonora was studied in order to provide preliminary information of its status in three different famous hiking and trekking places. Monthly expeditions were made from 2017 through 2018 in each of the places located in the North ("Cerro del Bachoco"), West ("Estadio Sonora") and Southeast ("Cerro de la Cementera"), alternating schedules. We identified each of the reptiles and amphibians seen and took photographs as evidence of their presence. We found that the West area had the most richness, with a total of 16 different species and 80 observed specimens, in contrast with the area with the least richness, Southeast, with a total of 2 different species and 42 observations. North area had the most sightings, with a total of 113. West area proved to be the most biodiverse one, located around a baseball stadium, new police headquarters and a water park project under construction, making it less isolated and the most susceptible area for human activity.

Herpetofauna Biodiversidad de famosos sitios de Trekking y Senderismo en Hermosillo, Sonora, México

En los últimos años, las actividades al aire libre como el trekking, el excursionismo y el senderismo a través de caminos artificiales en las afueras de la ciudad de Hermosillo en Sonora, México, han ganado mucha popularidad. Como tal, han aumentado los informes de la presencia de fauna exótica, especialmente de reptiles venenosos como víboras, monstruos gila y algunos colúbridos, así como reptiles y anfibios no venenosos. Se estudió la biodiversidad de la herpetofauna en la

ciudad de Hermosillo, Sonora, a fin de proporcionar información preliminar de su estado en tres lugares diferentes de senderismo y trekking. Las expediciones mensuales se realizaron desde 2017 hasta 2018 en cada uno de los lugares ubicados en el Norte ("Cerro del Bachoco"), Oeste ("Estadio Sonora") y Sureste ("Cerro de la Cementera"), alternando los horarios. Identificamos a cada uno de los reptiles y anfibios vistos y tomamos fotografías como evidencia de su presencia. Descubrimos que el área oeste tenía la mayor riqueza, con un total de 16 especies diferentes y 80 especímenes observados, en contraste con el área con la menor riqueza, sureste, con un total de 2 especies diferentes y 42 observaciones. El área norte tuvo la mayor cantidad de avistamientos, con un total de 113. El área oeste resultó ser la más biodiversa, ubicada alrededor de un estadio de béisbol, nuevas jefaturas de policía y un proyecto de parque acuático en construcción, lo que lo hace menos aislado y el área más susceptible para actividad humana.

NOTE: A manuscript was not submitted to accompany this presentation.

More luck than brains: The opportunistic discovery of hatchling Gila Monsters in a semi-urban nest

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Despite the iconic status that the Gila Monster (*Heloderma suspectum*) maintains as an inhabitant of the Sonoran Desert, very little is understood about its reproductive and nesting behaviors. In late October of 2016, a construction crew digging a footing for a house addition accidently uncovered five hatchlings that were either still in the egg or had just emerged. The author was blessed to receive the phone call from the field crew, and was on scene within forty minutes. The authors close relationship with the DeNardo lab at ASU allowed for collaboration between what they learned through radio telemetry at their discovered nesting sites, and the information that was acquired at the dig site. Preliminary findings indicate that Heloderma suspectum may be the only lizard species in the world to lay their eggs in early summer, hatch in mid fall, overwinter out of the egg, and emerge to become surface active in the spring. The nest itself is the first ever to be documented in the history of mankind, and we continue to learn from the hatchlings, which are being kept by the DeNardo lab. The color change of the young from whitish-yellow to orange has already been documented, and a watchful eye for pattern change is being applied. The metrics of the hatchlings will be discussed, as will the physical aspects of the nest itself.

Más suerte que inteligencia: el descubrimiento oportunista de la cría de monstruos de Gila en un nido semi-urbano

A pesar del estatus icónico que el Monstruo de Gila (Heloderma suspectum) mantiene como un habitante del Desierto Sonorense, se comprende muy poco acerca de sus comportamientos reproductivos y de anidación. A finales de octubre de 2016, un equipo de construcción que estaba cavando un pie para una casa adicional descubrió accidentalmente cinco crías que todavía estaban en el huevo o que acababan de salir. El autor recibió la bendición de recibir la llamada telefónica de la tripulación, y estuvo en escena en cuarenta minutos. La estrecha relación de los autores con el laboratorio DeNardo en ASU permitió la colaboración entre lo que aprendieron a través de la telemetría de radio en sus sitios de anidación descubiertos y la información que se adquirió en el sitio de excavación. Los hallazgos preliminares indican que Heloderma suspectum puede ser la única especie de lagarto en el mundo que pone sus huevos a comienzos del verano, eclosiona a mediados de otoño, invernan fuera del huevo y emergen para volverse activos en la superficie en la primavera. El nido en sí es el primero en ser documentado en la historia de la humanidad, y seguimos aprendiendo de las crías, que se mantienen en el laboratorio DeNardo. Ya se ha documentado el cambio de color de los jóvenes de blanco amarillento a naranja, y se

está aplicando un ojo vigilante para el cambio de patrón. Se discutirán las métricas de las crías, al igual que los aspectos físicos del nido en sí.

NOTE: A manuscript was not submitted to accompany this presentation.

Annual variation in activity and recruitment in two iconic Sonoran Desert reptiles

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We have monitored small populations of Sonoran Desert Tortoises (SDT) and Regal Horned Lizards (RHL) over the past eight years using mark-recapture, radio-telemetry and visual observation on the eastern edge of the Union Hills along the Cave Creek floodplain near Phoenix. Our findings document some activity in every month of the year for SDTs, but a surprising level of inactivity of RGLs for as many as six months (October to April) each year. We hypothesize that activity and reproductive recruitment of both species were impacted by short-term drought albeit in dissimilar fashions. Drought during the monsoon dramatically reduced activity in SDTs, but not RHLs; reproductive recruitment may have been impacted for RHLs due to nest failure. Though SDTs appeared to successfully reproduce following a dry monsoon, a dry winter may have resulted in mortality of all young "hatchling" (1-3 yrs) SDTs under visual observation from October to April; there was no apparent impact of a dry winter on mortality of radio-tracked RHL adults or juveniles. As noted by many researchers over the past forty years, until study organisms are radio-tracked intensively (daily), their behavioral ecology remains obscure. Further evaluation of these potential drought-related impacts will require even longer term study, and experimentation with these critical early life stages.

Variación anual en actividad y reclutamiento en dos reptiles icónicos del Desierto de Sonora

Hemos monitoreado pequeñas poblaciones de tortugas del desierto de Sonora (SDT por sus siglas en inglés) y lagartos de cuernos reales (RHL por sus siglas en inglés) en los últimos ocho años utilizando marca-recaptura, radio-telemetría y observación visual en el borde oriental de Union Hills a lo largo de la llanura aluvial de Cave Creek cerca de Phoenix . Nuestros hallazgos documentan alguna actividad en cada mes del año para los SDT, pero un sorprendente nivel de inactividad de los RHL durante seis meses (de octubre a abril) cada año. Nuestra hipótesis es que la actividad y el reclutamiento reproductivo de ambas especies se vieron afectados por la sequía a corto plazo, aunque en modas diferentes. La sequía durante el monzón redujo drásticamente la actividad en los SDT, pero no en los RHL; el reclutamiento reproductivo puede haber sido afectado por RHL debido a la falla del nido. Aunque los SDT parecieron reproducirse con éxito después de un monzón seco, un invierno seco puede haber resultado en la mortalidad de todos los SDT jóvenes "de crías" (1-3 años) bajo observación visual de octubre a abril; no hubo un impacto aparente de un invierno seco en la mortalidad de adultos o jóvenes con RHL radio-rastreados. Como lo notaron muchos investigadores en los últimos cuarenta años, hasta que los organismos del estudio son rastreados de manera intensiva (diariamente), su ecología del comportamiento permanece oscura. La evaluación adicional de estos impactos potenciales relacionados con la sequía requerirá incluso un estudio a más largo plazo, y la experimentación con estas etapas críticas de la vida temprana.

NOTE: A manuscript was not submitted to accompany this presentation.

Drought governs metapopulation dynamics of lowland leopard frogs in the Sky Island region

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Understanding how natural and anthropogenic processes affect dynamics of species with patchy distributions is critical to developing reliable conservation strategies, especially in light of climate change. We used 22 years of data collected across eight canyons in southern Arizona to explore factors that explain changes in the distribution of lowland leopard frogs (*Lithobates yavapaiensis*). Local populations were more likely to go extinct (Pr [extinction] > 0.11) during periods of extreme drought (PDSI below -4), particularly at sites that lacked deep or spring-fed pools that held water reliably. When larval or dispersal periods were drier than normal, frogs were less likely to colonize unoccupied sites (Pr [colonization] ≤ 0.12). Further, colonization rates were low where sediments released by high-elevation wildfires exceeded 25% of pool volume. Between 1996 and 2008, frogs occupied 20% to 61% of sites in each of the two watersheds we surveyed. Between 2009 and 2017, however, occupancy in one of the watersheds declined markedly, and we observed no frogs in this watershed after 2015. Although a multi-year drought affected dynamics of frogs in both watersheds, frogs persisted only where sediment levels were low and surface water was reliable. In recent decades, lowland leopard frogs have persisted in the Sky Island region because dispersing individuals have recolonized sites where populations had been extirpated. If future increases in drought frequency or severity limit the number of inhabitable sites or reduce the permeability of the landscape to dispersing frogs, population persistence is likely to be reduced or to require intensive management.

La sequía rige la dinámica de metapoblación de las ranas leopardo de las tierras bajas en la región de las Islas Serranas

Comprender cómo los procesos naturales y antropogénicos afectan la dinámica de las especies con distribuciones irregulares es fundamental para desarrollar estrategias de conservación confiables, especialmente a la luz del cambio climático. Utilizamos 22 años de datos recolectados en ocho cañones del sur de Arizona para explorar factores que explican los cambios en la distribución de las ranas leopardo de las tierras bajas (Lithobates yavapaiensis). Las poblaciones locales tenían más probabilidades de extinguirse (Pr [extinción]> 0.11) durante períodos de sequía extrema (PDSI por debajo de -4), particularmente en sitios que carecían de charcos profundos o alimentados por manantiales que contenían agua de manera confiable. Cuando los periodos de larva o dispersión eran más secos de lo normal, las ranas tenían menos probabilidades de colonizar sitios desocupados (Pr [colonización] ≤ 0.12). Además, las tasas de colonización fueron bajas donde los sedimentos liberados por los incendios forestales de gran altura excedieron el 25% del volumen de la piscina. Entre 1996 y 2008, las ranas ocuparon del 20% al 61% de los sitios en cada una de las dos cuencas hidrográficas que encuestamos. Entre 2009 y 2017, sin embargo, la ocupación en una de las cuencas hidrográficas disminuyó marcadamente, y no observamos ranas en esta cuenca después de 2015. Aunque una sequía multianual afectó la dinámica de las ranas en ambas cuencas, las ranas persistieron solo donde los niveles de sedimentos eran bajos y el agua superficial era confiable. En las últimas décadas, las ranas leopardo de las tierras bajas han persistido en la región de las Islas Serranas debido a que las ranas dispersas han recolonizado sitios donde las poblaciones han sido extirpadas. Si los futuros aumentos en la frecuencia o severidad de la sequía limitan la cantidad de sitios habitables o reducen la permeabilidad del paisaje a la dispersión de las ranas, es probable que la persistencia de la población se reduzca o requiera una gestión intensiva.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 32: Current Research on Herpetofauna of the Sonoran Desert and Sky Islands, Part #2

Coronado National Forest Landscape (Huachuca Mountains)
(Photo courtesy of the USDA Forest Service, Coronado National Forest).

Abstracts and Papers
Morales
Silva-Kurumiya
Turner
Villa

Horned Lizards (*Phrynosoma*) of Sonora, Mexico

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Sonora, with eight species, has the greatest diversity of horned lizards (*Phrynosoma*) of any state in Mexico or the United States, six of them occur in the Sky Islands area. Species live from sea level to over 2,600 m elevation. *Phrynosoma goodei* and *P. mcallii* occur in Sonora coast and Gran Desierto de Altar area in desertscrub, *P. solare* is widely distributed in the state, including the Sky Island region. *P. cornutum* and *P. modestum* in northeastern in desert grassland and Chihuahuan desertscrub, and three upland species can be found in the Sky Island area, *P. orbiculare, P. hernandesi* and *P. ditmarsi*, the last two can co-occur in Sierra La Púrica and Sierra Nacozari. *P. hernandesi* and *P. orbiculare* live in pine-oak forest, but in different Sky Islands. Only two species are listed as Threatened (Amenazada) in the Mexican endangered species law (NOM 059), *P. orbiculare* and *P. mcallii*. More field work is needed to better understand the distribution and ecology of species, very little information about *Phrynosoma* species in the Sky Islands region of Sonora has been published. This project will serve as a reference for future work and the monitoring of their populations. Part of the project is environmental education in schools in favor of horned lizard conservation, due to many people keep them as pets in Sonora.

Lagarto Cornudo (Phrynosoma) de Sonora, México

Sonora, con ocho especies, tiene la mayor diversidad de lagartos cornudos (Phrynosoma) de cualquier estado en México o los Estados Unidos, seis de ellos se encuentran en el área de las Islas Serranas. Las especies viven desde el nivel del mar hasta más de 2,600 m de altitud. Phrynosoma goodei y P. mcallii se encuentran en la costa de Sonora y en matorrales dentro del área del Gran Desierto de Altar, P. solare está ampliamente distribuida en el estado, incluida la región de las Islas Serranas. P. cornutum y P. modestum en el noreste en pastizales desérticos y matorrales desérticos de Chihuahua, y tres especies de tierras altas se pueden encontrar en el área de las Islas Serranas, P. orbiculare, P. hernandesi y P. ditmarsi, las dos últimas pueden ocurrir simultáneamente en Sierra La Púrica y Sierra Nacozari. P. hernandesi y P. orbiculare viven en bosques de pino y encino, pero en diferentes Islas Serranas. Solo dos especies están enlistadas como Amenazada en la ley mexicana de especies en peligro de extinción (NOM 059), P. orbiculare y P. mcallii. Se necesita más trabajo de campo para comprender mejor la distribución y ecología de las especies, se ha publicado muy poca información sobre las especies de Phrynosoma en la región de las Islas Serranas de Sonora. Este proyecto servirá como referencia para el futuro trabajo y el monitoreo de sus poblaciones. Parte del proyecto es la educación ambiental en las escuelas a favor de la conservación de los lagartos cornudos, debido a que muchas personas los mantienen como mascotas en Sonora.

NOTE: A manuscript was not submitted to accompany this presentation.

Rancho la Montosa, a special place for teaching herpetology

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Rancho La Montosa in the municipality of Moctezuma, Sonora, is known for its hunting, hiking, cabin, and ecotourism tours. It is also a unique field laboratory for undergraduate biolgy students at the University of the Sierra. The vegetation at 950 to 1,250 m elevation in hilly terrain ranges from a mesquite scrub oak woodland. Amphibians and reptiles are easily seen along a five kilometer transcect in Cañada La Carabina, where there are several pools seasonal pools. On September 21-22, 2017, biology students captured and photographed four species of amphibians and six reptiles. The species observed were: *Anaxyrus punctatus, Gastrophryne mazatlanensis, Hyla arenicolor, Lithobates magnaocularis, Boa constrictor, Kinosternon integrum, K. sonoriense, Plestiodon callicephalus, Phrynosoma ditmarsi* and *Thamnophis cyrtopsis*. Observations and images are available in the Madrean Discovery Expeditions database (madreandiscovery.org).

Rancho la Montosa, un lugar especial para enseñar herpetología

Rancho La Montosa in the municipality of Moctezuma, Sonora, is known for its hunting, hiking, cabin, and ecotourism tours. It is also a unique field laboratory for undergraduate biolgy students at the Universidad de la Sierra. The vegetation at 950 to 1,250 m elevation in hilly terrain ranges from a mesquite scrubto oak woodland. Amphibians and reptiles are easily seen along a five kilometer transcect in Cañada La Carabina, where there are several pools seasonal pools. On September 21-22, 2017, biology students captured and photographed four species of amphibians and six reptiles. The species observed were: Anaxyrus punctatus, Gastrophryne mazatlanensis, Hyla arenicolor, Lithobates magnaocularis, Boa constrictor, Kinosternon integrum, K. sonoriense, Plestiodon callicephalus, Phrynosoma ditmarsi and Thamnophis cyrtopsis. Observations and images are available in the Madrean Discovery Expeditions database cyrtopsis.

Note: Full Paper Follows

Rancho la Motosa, Un Lugar Especial Para Enseñar Herpetología

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Universidad de la Sierra[1]

Resumen--*Rancho La Montosa, se localiza en el municipio de Moctezuma, es conocido en Sonora por su actividad cinegética y recorridos ecoturísticos. Para la licenciatura en biología de la Universidad de la Sierra es un lugar único para la realización de prácticas y salidas de campo. La vegetación es mezquital, bosque de mezquite-encino y bosque de encino. Realizar una caminata en práctica de campo por Cañada La Carabina en un trayecto ascendente de cinco kilómetros, es posible encontrar anfibios y reptiles fácilmente, ya que, en el recorrido se encuentran varias pozas por toda la cañada, resultado de las lluvias de verano, por lo que, dichas pozas se convierten en refugios para anfibios y reptiles. El 21 y 22 de septiembre del 2017, al inicio del otoño se realizó una salida de campo, con alumnos de la licenciatura en biología, al final del recorrido se logró observar y en su caso capturar para fotografía a cuatro especies de anfibios y seis reptiles. Los organismos observados son: Anaxyrus punctatus, Boa constrictor, Gastrophryne mazatlanensis, Hyla arenicolor, Kinosternon integrum, K. sonoriense, Lithobates magnaocularis, Phrynosoma ditmarsi, Plestiodon callicephalus y Thamnophis cyrtopsis. De las especies localizadas, cuatro se encuentran enlistadas dentro de la Norma Oficial Mexicana de protección de especies (NOM-059-SEMARNAT-2010), B. constrictor, T. cyrtopsis en la categoría de Amenazada (A), G. mazatlanensis y K. integrum en la categoría de Protección Especial (Pr). Dentro del apéndice II de CITES se encuentran: B. constrictor, K. integrum y K. sonoriense. Las imágenes y observaciones se encuentran disponibles en la base de datos de Madrean Discovery Expeditions (madreandiscovery.org).*

INTRODUCCIÓN

Rancho La Montosa pertenece al municipio de Moctezuma, Sonora. Se localiza al suroeste de la cabecera municipal en las coordenadas 29.8° latitud norte y -109.7° longitud oeste. Está registrado como Unidad de Manejo para la Conservación de la Vida Silvestre (UMA), para aprovechamiento de Venado Cola Blanca (*Odocoileus virginianus*), Jabalí (*Pecari tajacu*) y Guajolote Silvestre (*Meleagris gallopavo*; Dirección General Forestal y de Fauna Silvestre 2018). La localidad se encuentra a una altitud de 944 m (3,096 ft) sobre el nivel del mar, entre lomeríos que van desde los 950 a los 1,250 m (3116 a 4,100 ft) de altitud. La vegetación va desde mesquital, mesquite-encino y bosque de encino (Figura 1). Cuenta con cinco represos que conservan agua todo el año en las inmediaciones del rancho. Las actividades principales son el turismo cinegético, y los recorridos ecoturísticos.

El 21 y 22 de septiembre del 2017, al inicio del otoño se realizó una salida de campo, con alumnos de la licenciatura en biología de Universidad de la Sierra. El objetivo fue poner en práctica, los métodos y herramientas para captura e identificación de herpetofauna, además de reconocer en campo las características del hábitat donde se localizan, con la finalidad de que el estudiante alcance un aprendizaje significativo (Amórtegui et al. 2010). Durante el recorrido se encuentran varias pozas distribuidas a lo largo de la cañada, resultado de las lluvias de verano por lo que se convierten en refugios para anfibios y reptiles. Al final del recorrido se logró observar, y en su caso capturar para fotografía a cuatro anfibios y seis reptiles. Para identificar los organismos se utilizó la guía de Rorabaugh y Lemos-Espinal (2016).

RESULTADOS

Al término del ejercicio práctico para la localización, captura e identificación de especies se registraron: La herpetofauna localizada consistió de tres órdenes **(**Anura, Squamata, Testudines**)**, nueve familias (Boidae, Bufonidae, Colubridae, Hylidae, Kinosternidae, Microhylidae, Phrynosomatidae, Ranidae y Scincidae), y diez especies (*Anaxyrus punctatus*, *Boa constrictor, Gastrophryne mazatlanensis, Hyla arenicolor, Kinosternon integrum, K. sonoriense, Lithobates*

Figura 1. Vista parcial de una poza y panorámica de la cañada.

magnaocularis, Phrynosoma ditmarsi, Plestiodon callicephalus, y Thamnophis cyrtopsis; (Tabla 1) (Turner et al. 2017). De las diez especies cuatro se encuentran enlistadas en la NOM-059-SEMARNAT-2010: del orden Squamata: *Boa constrictor* y *Thamnophis cyrtopsis* en la categoría de Amenazada (A), no endémica (NE); del orden Anura: *Gastrophryne mazatlanensis* en la categoría de Protección Especial (Pr), no endémica; por último, del orden Testudines: *K. integrum* en la categoría de Protección Especial (Pr), endémica (E). De acuerdo con la Convención sobre el Comercio Internacional de Especies Amenazadas de Fauna y Flora Silvestres (CITES), tres especies se encuentran en el Apéndice II (Incluye especies que no se encuentran necesariamente en peligro de extinción, pero cuyo comercio debe controlarse a fin de evitar una utilización incompatible con su supervivencia): *Boa constrictor, Kinosternon integrum y K. sonoriense.*

Figura 2. Boa contrictor. Rancho La Montosa**.**

Figura 3. Thamnophis cyrtopsis. Rancho La Montosa**.**

Tabla 1- Listado de herpetofauna en Rancho La Montosa, con su categoría en la Norma Oficial Mexicana de protección de especies y CITES.

ORDEN	FAMILIA	GÉNERO Y ESPECIE	NOMBRE COMÚN	NOM-059-SEMARNAT-2010[a]	CITES[b]
Squamata	Boidae	*Boa constrictor*	Boa constrictor	A, (NE)	II
Squamata	Colubridae	*Thamnophis cyrtopsis*	Culebra de agua	A, (NE)	
Squamata	Phrynosomatidae	*Phrynosoma ditmarsi*	Lagartija-cornuda de roca		
Squamata	Scincidae	*Plestiodon callicephalus*	Eslizón de la sierra madre occidental		
Testudines	Kinosternidae	*Kinosternon integrum*	Tortuga pecho quebrado mexicana	Pr, (E)	II
Testudines	Kinosternidae	*Kinosternon sonoriense*	Tortuga pecho quebrado sonorense		II
Anura	Bufonidae	*Anaxyrus punctatus*	Sapo de puntos rojos		
Anura	Hylidae	*Hyla arenicolor*	Rana arborícola, sapo blanco		
Anura	Microhylidae	*Gastrophryne mazatlanensis*	Ranita olivo	Pr, (NE)	
Anura	Ranidae	*Lithobates magnaocularis*	Rana leopardo del noroeste		

Categoría de riesgo en la NOM-059-SEMARNAT-2010:
A = Amenazado,
Pr = Protección Especial,
P = Peligro de extinción,
E = Probablemente extinta en el medio silvestre,
(E) = Endémico,

DISCUSIONES

El recorrido resultó muy interesante, debido que se localizaron varios organismos, lo cual permitió a los estudiantes poder conocer, manipular, fotografiar y liberarlos para proceder en gabinete a identificarlos. La participación en salidas de campo (Amórtegui et al. 2010) permite al estudiante valorar las técnicas de muestreo, las herramientas de campo utilizadas, en conjunto con los instrumentos administrativos (Rancho La Montosa esta registrado como UMA) así como, los instrumentos normativos (NOM-059-SEMARNAT-2010, CITES), los cuales interactúan en conjunto en sinergia. Es importante resaltar que dicha sinergia es motivada inicialmente con la obtención de datos científicos que colaboren en la toma de decisiones en favor de la conservación de la biodiversidad.

CONCLUSIONES

Los organismos observados son: *Anaxyrus punctatus, Gastrophryne mazatlanensis, Hyla arenicolor, Lithobates magnaocularis, Boa constrictor, Kinosternon integrum, K. sonoriense, Plestiodon callicephalus, Phrynosoma ditmarsi y Thamnophis cyrtopsis.* La riqueza de especies encontrada resulta interesante, el número de especies en el futuro puede incrementarse ya que los hábitats presentes son muy variados. Rancho La Montosa, puede incrementar las especies o mantener su programa de manejo actual para venado, jabalí y guajolote, ya que las actividades e infraestructura

establecidas, pudieran estar funcionando como especies sombrilla beneficiando a otros vertebrados e incluso invertebrados silvestres. Con el manejo del hábitat (mantenimiento de pozas y represos), durante el verano, indirectamente se conserva la riqueza de la zona y puede ser un indicador de la salud ecosistémica del lugar.

AGRADECIMIENTOS

Se agradece a la División de Ciencias Biológicas de Universidad de la Sierra su apoyo para la realización de la práctica y salida de campo a Rancho La Montosa. A Dora Luz de Maldonado por las facilidades otorgadas en Rancho La Montosa. A Humberto Santacruz, capataz de Rancho La Montosa por todo su apoyo y asesoría dentro de las instalaciones. A Tomas R. Van Devender, PhD, Director del Programa de Biodiversidad de GreaterGood.org, por su apoyo en la identificación de especies y su amable invitación para agregar las imágenes y observaciones a la base de datos de Madrean Discovery Expedition (madreandiscovery.org), así como por sus comentarios y revisión al manuscrito. Al Dr. Jorge Ramírez-Acosta, Director de Universidad Pedagógica Nacional, Unidad Mexicali, B. C., por sus comentarios y sugerencias para mejorar el documento.

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Filling the gaps: recent discoveries about reptiles and amphibians in Sonora

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Sonora, Mexico, has a wonderfully diverse fauna thanks to its complex topography and intersections of tropical and temperate biomes. In 1945, Bogert and Oliver listed 110 species of reptiles and amphibians but predicted that was likely no more than two-thirds of the actual herpetofauna. We currently know of approximately 200 described species of reptiles and amphibians in Sonora, more than any of its adjacent states, but the collective understanding of Sonora's herpetofauna is growing rapidly. Recent efforts have begun to fill in our knowledge of species distributions and ecology, including several long-term inventory projects. From 2006 through 2017, the results can be seen in 12 publications on reptiles and amphibians of Sonora as a whole, along with 7 on herpetofauna of specific regions. We know of 10 new species in the state, not including those created by taxonomic revisions. There have been at least 46 published articles on species distribution, 12 natural history accounts, and 24 genetic studies. Conservation of those species and loss of their habitat are growing concerns, as described in 14 studies. We will highlight some important discoveries, emergent properties, and some of the important questions that remain.

Llenar las lagunas: descubrimientos recientes sobre reptiles y anfibios en Sonora

Sonora, México, tiene una fauna maravillosamente diversa gracias a su compleja topografía e intersecciones de biomas tropicales y templados. En 1945, Bogert y Oliver enumeraron 110 especies de reptiles y anfibios pero predijeron que probablemente no eran más de dos tercios de la herpetofauna real. Actualmente conocemos aproximadamente 200 especies descritas de reptiles y anfibios en Sonora, más que cualquiera de sus estados adyacentes, pero la comprensión colectiva de la herpetofauna de Sonora está creciendo rápidamente. Los esfuerzos recientes han comenzado a completar nuestro conocimiento sobre la distribución de especies y la ecología, incluidos varios proyectos de inventario a largo plazo. Desde 2006 hasta 2017, los resultados se pueden ver en 12 publicaciones sobre reptiles y anfibios de Sonora en conjunto, junto con 7 sobre herpetofauna de regiones específicas. Sabemos de 10 nuevas especies en el estado, sin incluir las creadas por revisiones taxonómicas. Se han publicado al menos 46 artículos sobre distribución de especies, 12 historias de historia natural y 24 estudios genéticos. La conservación de esas especies y la pérdida de su hábitat son preocupaciones crecientes, como se describe en 14 estudios. Destacaremos algunos descubrimientos importantes, propiedades emergentes y algunas de las preguntas importantes que permanecen.

NOTE: A manuscript was not submitted to accompany this presentation.

Tortuga de la Sierra Madre: In search of the Spotted Box Turtle (*Terrapene nelsoni*)

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The Mexican endemic Spotted Box Turtle (*Terrapene nelsoni*) is one of the most unknown North American chelonians. Basic and to-date information on this species will be presented, including taxonomy, morphology, natural history, biogeography and distribution, folk knowledge, and comments on threats and conservation.

Tortuga de la Sierra Madre: en busca de la tortuga de caja moteada (Terrapene nelsoni)

La tortuga de caja moteada endémica de México (Terrapene nelsoni) es uno de los quelonios norteamericanos más desconocidos. Se presentará información básica y actualizada sobre esta especie, que incluye taxonomía, morfología, historia natural, biogeografía y distribución, conocimiento popular y comentarios sobre amenazas y conservación.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 33: Current Research on Herpetofauna of the Sonoran Desert and Sky Islands, Part #3

Dragoon Mountains Landsape, Coronado National Forest
(Photo courtesy of the USDA Forest Service, Coronado National Forest).

Abstracts and Papers
Huerta
Murphy
Murray
Radke

Effects of Urbanization on Herpetofauna

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Urban development has various effects on biotic communities, often leading to a decrease in native species, and a loss of biodiversity. This research focuses on the effects of urban development on herpetofauna at Stone Canyon, a residential community and golf course located at the base of the Tortolita Mountains near Oro Valley, Arizona. We conducted nightly road and golf cart path surveys to document snakes throughout the development. We obtained environmental (e.g., temperature, relative humidity) and location data (in UTM coordinates) for each capture. We brought snakes into the lab for processing, which included measuring snout-to-vent length and mass, implanting microchips for individual identification, determining age class and sex, and obtaining fecal and tissue samples. We quantified time spent and distance covered during surveys, which allowed for calculation of animals captured per unit effort. To examine potential relationships between relative abundance of animals with environmental variables, we set up data loggers and rain gauges at sites on and away from the golf course to record data on temperature, humidity, and precipitation. We compared data collected in 2017 with our long-term (2002-2014) data set from the same site to make inferences about effects of urbanization on relative abundance, diversity and distribution of snakes. We discuss our results as they relate to anthropogenic change and increased human presence, with an emphasis on information that should lead to more effective conservation and management strategies for herpetofauna living on the urban fringe.

Efectos de la urbanización en la herpetofauna

El desarrollo urbano tiene diversos efectos en las comunidades bióticas, que a menudo conducen a una disminución de las especies nativas y a una pérdida de biodiversidad. Esta investigación se enfoca en los efectos del desarrollo urbano sobre la herpetofauna en Stone Canyon, una comunidad residencial y campo de golf ubicado en la base de las montañas Tortolita cerca de Oro Valley, Arizona. Realizamos encuestas nocturnas por caminos y carritos de golf para documentar las serpientes durante el desarrollo. Obtuvimos datos ambientales (por ejemplo, temperatura, humedad relativa) y de ubicación (en coordenadas UTM) para cada captura. Trajimos serpientes al laboratorio para su procesamiento, que incluía medir la longitud y la masa del hocico a la ventilación, implantar microchips para la identificación individual, determinar la clase de edad y el sexo, y obtener muestras fecales y de tejido. Cuantificamos el tiempo gastado y la distancia recorrida durante las encuestas, lo que permitió el cálculo de los animales capturados por unidad de esfuerzo. Para examinar las posibles relaciones entre la abundancia relativa de animales con variables ambientales, configuramos registradores de datos y pluviómetros en sitios alejados del campo de golf para registrar datos de temperatura, humedad y precipitación. Comparamos los datos recopilados en 2017 con nuestro conjunto de datos a largo plazo (2002-2014) del mismo sitio para hacer inferencias sobre los efectos de la urbanización sobre la abundancia relativa, la diversidad y la distribución de las serpientes. Discutimos nuestros resultados en relación con el cambio antropogénico y el aumento de la presencia humana, con énfasis en la información que debería conducir a estrategias de conservación y manejo más efectivas para la herpetofauna que vive en la periferia urbana.

NOTE: A manuscript was not submitted to accompany this presentation.

The status of the Arizona population of the Brown Vine Snake (Reptilia: Colubridae)

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The Brown Vine Snake, *Oxybelis aeneus*, has a distribution extending from southern Arizona southward through Central America and into South America to southeastern Brazil, covering more than 58º of latitude, a distance of more than 9000 km on a north-south axis, and about 12 million square kilometers (~8% of the Earth's surface), making it one of the most widespread snake species on the planet. *Oxybelis aeneus* has an elevational range extending from sea level to at least 2500 m and is currently considered a single species. In this study, we conduct the first phylogeographic assessment of the Brown Vine Snake throughout much of its range. We implement multiple phylogenetic analyses using multigene datasets, including both nuclear (nDNA) and mitochondrial (mtDNA) DNA sequences, to assess the evolutionary history and timing of species diversification within the genus *Oxybelis*. Our analyses recovered numerous distinct species-level clades and we combined these results with morphological data to revise the species-level taxonomy of *O. aeneus*. This study resurrects several synonyms as distinct species while also describing several novel taxa. The Arizona population of *Oxybelis* is the northernmost extension of a species that occurs southward along the west coast of Mexico as far south as Oaxaca.

El estado de la población de Arizona de la Bejuca Café (Reptilia: Colubridae)

La bejuca café , Oxybelis aeneus, tiene una distribución que se extiende desde el sur de Arizona hacia el sur a través de América Central y Sudamérica hacia el sureste de Brasil, cubriendo más de 58º de latitud, una distancia de más de 9000 km en un eje norte-sur, y aproximadamente 12 millones de kilómetros cuadrados (~ 8% de la superficie de la Tierra), por lo que es una de las especies de serpientes más extendidas en el planeta. Oxybelis aeneus tiene un rango de elevación que se extiende desde el nivel del mar hasta al menos 2500 m y actualmente se considera una sola especie. En este estudio, realizamos la primera evaluación filogeográfica de la Bejuca Café en gran parte de su rango. Implementamos análisis filogenéticos múltiples utilizando conjuntos de datos multigeno, que incluyen secuencias de ADN nuclear (nDNA) y mitocondrial (mtDNA), para evaluar la historia evolutiva y el momento de diversificación de especies dentro del género Oxybelis. Nuestros análisis recuperaron numerosos clados distintos a nivel de especie y combinamos estos resultados con datos morfológicos para revisar la taxonomía a nivel de especie de O. aeneus. Este estudio resucita varios sinónimos como especies distintas al tiempo que describe varios taxones nuevos. La población de Oxybelis en Arizona es la extensión más al norte de una especie que se encuentra hacia el sur a lo largo de la costa oeste de México hasta el sur de Oaxaca.

NOTE: A manuscript was not submitted to accompany this presentation.

Unraveling desert Box Turtle ecology using isotopes and ibuttons

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Field biologists have an ever-growing variety of tools at their disposal to better understand how species function in their environment. The desert box turtle, *Terrapene ornata luteola*, is a terrestrial turtle that occurs in open desert-grassland

habitats in the southwestern United States and northern Mexico, including in many of the open areas in between some of the Madrean sky islands. However, much remains to be learned about this secretive species. We used miniature temperature data loggers (ibuttons) attached to box turtle carapaces to estimate the effect that temperature had on the amount of time that box turtles remained surface active outside of their burrows in New Mexico. We also used tissue stable isotopes of nitrogen and carbon to explore the trophic dynamics of desert box turtles living in grasslands both ungrazed and grazed by cattle. Our results suggest that soil surface temperatures play a critical role in determining how long turtles remain active aboveground; in our study, average surface activity decreased from a high of ~4.5 hours at temperatures between 23°C and 26°C to a low of ~1.5 hours at temperatures 36°C. Tissue isotope data suggested that turtles in an ungrazed grassland had a wider dietary niche compared to turtles in an adjacent grazed grassland, and that turtles in the ungrazed grasslands relied on a food web incorporating more C3 forbs than those in the grazed grassland.

Descubriendo la Ecología de la Tortuga del Desierto usando Isótopos e Ibuttons

Los biólogos de campo tienen a su disposición una variedad cada vez mayor de herramientas para comprender mejor cómo funcionan las especies en su entorno. La tortuga de caja del desierto, Terrapene ornata luteola, es una tortuga terrestre que se encuentra en hábitats abiertos de pastizales desérticos en el suroeste de los Estados Unidos y el norte de México, incluso en muchas de las áreas abiertas entre algunas de las Islas Serranas Madrenses. Sin embargo, queda mucho por aprender sobre esta especie secreta. Usamos registradores de datos de temperatura en miniatura (ibuttons) pegados a los caparazones de las tortugas de caja para estimar el efecto que tuvo la temperatura sobre la cantidad de tiempo que las tortugas de caja permanecieron activas en superficie fuera de sus madrigueras en Nuevo México. También utilizamos isótopos estables de nitrógeno y carbono en el tejido para explorar la dinámica trófica de las tortugas de caja del desierto que viven en pastizales pastoreados y pastizales no pastoreados. Nuestros resultados sugieren que las temperaturas de la superficie del suelo juegan un papel crítico para determinar cuánto tiempo las tortugas permanecen activas en la superficie; en nuestro estudio, la actividad superficial promedio disminuyó de un máximo de ~ 4.5 horas a temperaturas entre 23 ° C y 26 ° C a un mínimo de ~ 1.5 horas a temperaturas de 36 ° C. Los datos de isótopos sugieren que las tortugas en un pastizal sin pastoreo tenían un nicho más amplio en comparación con las tortugas en pastizales adyacentes, y que las tortugas en los pastizales sin pastoreo dependían de una red alimentaria que incorporaba más herbicidas C3 que aquellas en los pastizales.

NOTE: A manuscript was not submitted to accompany this presentation.

Information contributing to knowledge of Gila Monster Population ecology

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Gila monsters (*Heloderma suspectum*) occur in portions of Sonora and Sinaloa in the Republic of Mexico, and in portions of Arizona, New Mexico, California, and Utah in the United States. These large, venomous lizards appear to be rather uncommon throughout their geographic range, but our knowledge of their exact population status is complicated by the fact that they spend most of their lives underground and very little of their time actively moving through their preferred upland habitat. Gila monsters in Cochise County, Arizona have been opportunistically monitored by staff working at San Bernardino and Leslie Canyon National Wildlife Refuges since 2000. When an individual monster is encountered by a refuge staff member, it is temporarily abducted, measured, weighed, sexed, photographed, PIT-tagged to allow individual identification, and then released at the same capture site. Capture sites are recorded and mapped. A total of 218 different monsters (308 total captures including 90 recaptures) have been captured and "processed" by refuge staff between 2000 and 2017. Recaptured monsters provide growth and general health information, and can provide information regarding longevity, habitat use, individual movement, and home range size. Such basic population ecology

information can be gathered easily and economically by refuge staff, and the information will ultimately help wildlife managers make more informed decisions regarding this species.

Información que contribuye al conocimiento de la ecología de la población del Monstro De Gila

Los monstruos de Gila (Heloderma suspectum) se encuentran en partes de Sonora y Sinaloa en la República de México, y en partes de Arizona, Nuevo México, California y Utah en los Estados Unidos. Estas lagartijas grandes y venenosas parecen ser poco comunes en todo su rango geográfico, pero nuestro conocimiento del estado exacto de la población se complica por el hecho de que pasan la mayor parte de sus vidas bajo tierra y muy poco de su tiempo moviéndose activamente a través de su hábitat preferido. Los monstruos de Gila en Cochise County, Arizona, han sido monitoreados de manera oportunista por personal que trabaja en San Bernardino y Leslie Canyon National Wildlife Refuges desde el año 2000. Cuando un miembro del personal de refugio encuentra a un monstruo individual, es secuestrado temporalmente, medido, pesado, sexado, fotografiado , etiquetado con PIT para permitir la identificación individual, y luego liberado en el mismo sitio de captura. Los sitios de captura se graban y mapean. Un total de 218 monstruos diferentes (308 capturas incluyendo 90 recapturas) han sido capturados y "procesados" por el personal del refugio entre los años 2000 y 2017. Monstruos recapturados proporcionan información sobre crecimiento y salud general, y pueden proporcionar información sobre la longevidad, el uso del hábitat y el movimiento individual, y el tamaño del hogar. Dicha información básica de ecología de la población puede ser colectada fácil y económicamente por el personal del refugio, y la información en última instancia ayudará a los administradores de vida silvestre a tomar decisiones más informadas con respecto a esta especie.

Note: Full Paper Follows

Monitoring Gila Monster (*Heloderma suspectum*) Populations in Southeastern Cochise County, Arizona.

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Abstract --*Gila Monsters (Heloderma suspectum) are symbolic species of the desert landscapes of the southwestern United States and Mexico. These large, venomous lizards appear to be rather uncommon throughout their range, but our understanding of their population status is complicated by the fact that they spend most of their lives underground rather than actively moving through their preferred upland habitat. Personnel and volunteers from the U.S. Fish and Wildlife Service have opportunistically monitored Gila Monsters in the vicinity of San Bernardino and Leslie Canyon National Wildlife Refuges in southeastern Cochise County, Arizona, from 2000-2017. Lizards were captured, measured, weighed, sexed, photographed, PIT-tagged, and then released at the capture site. Data from 222 different Gila Monsters (313 total captures, including 91 total recaptures) provided insight into seasonal and daily activity periods, individual movement, home range size, habitat use, life history traits, growth and longevity, mortality, and food habits. Such basic population ecology information was easily and economically gathered by Service staff. It contributed to the overall knowledge of Gila Monster population ecology.*

INTRODUCTION

Gila Monsters (*Heloderma suspectum*; Helodermatidae) are one of the most iconic creatures of the American Southwest and adjacent Mexico. They are characterized by their relatively large body size; small eyes covered by moveable eyelids; beadlike osteoderms on the tops of their head, limbs, body, and tail; venom glands in their lower jaw; long, recurved teeth (some being grooved to help deliver venom); thick, forked tongues; and a substantial, sausage-shaped tail used to store fat reserves (Ernst and Ernst 2011, Lowe et al. 1986).

While immediately recognizable as a species, the color pattern of Gila Monsters varies from population to population, is subject to ontogenetic change (Bogert and Martin del Campo 1956), and is described as having irregular, reticulated patches of black blotches on a rose, orange, or yellow background (Beck 2005).

The geographic range of Gila Monsters includes portions of Sonora, Chihuahua, and Sinaloa in the Republic of Mexico, and portions of Arizona, New Mexico, California, Nevada, and Utah in the United States (Beck 2005). Within their habitats, Gila Monsters are highly sedentary for most of the year, spending >92% of the annual cycle at rest in their shelters (Beck 2005). Gila Monsters appear to be rather uncommon throughout their range. Determining their exact population status is complicated by the fact that they spend most of their lives underground and very little of their time actively moving through their preferred upland habitats (Lowe et al. 1986). The species' secretive behavior through most of the year is also responsible for our relatively limited knowledge of their natural history and conservation status.

Here, I describe the results of long-term opportunistic monitoring conducted by the U.S. Fish and Wildlife Service in Cochise County, Arizona. The data from this monitoring have been efficiently gathered during other work. It sheds new light on several aspects of Gila Monster natural history.

Description of Monitoring Site: The Cochise County, Arizona monitoring site, centered around San Bernardino National Wildlife Refuge (SBNWR) and Leslie Canyon National Wildlife Refuge (LCNWR), is characterized by Chihuahuan desert-scrub, influenced by limestone and volcanic soils, relatively high elevations, cold winters, and hot summers. Refuge elevations range from about 1,134-1,195 m (3,719-3,919 ft) on SBNWR to about 1,402-1,722 m (4,600-5,650 ft) on LCNWR. Mean maximum temperatures in this area ranged from about 13-38 ° C (55-100.5 ° F), mean minimum temperatures ranged from -4.8-21 ° C (23.3-68.9 ° F), and temperature extremes ranged from -18-43 ° C (0-109 ° F) (http://www.rcc-acis.org/) during the time of this monitoring effort.

Annual precipitation, measured at three separate rain gauges located on the two refuges, is bimodal. Mid to late summer thunderstorms comprise the majority of the annual rainfall, which ranged from 15.11 cm (5.95 in) during 2003 to 57.94 cm (22.81 in) during 2014 and averaged 31.67 cm (12.47 in) during the 18-year monitoring effort.

Vegetation: Characteristic plants include velvet mesquite (*Prosopis velutina*), whitethorn acacia (*Acacia constricta*), creosote bush (*Larrea tridentata*), littleleaf sumac (*Rhus microphylla*), sandpaper bush (*Mortonia scabrella*), prickly pear cactus (*Opuntia engelmannii*) and (*O. santa-rita*), banana yucca (*Yucca baccata*), soaptree yucca (*Yucca elata*), sotol (*Dasilyrion wheeleri*), ocotillo (*Fouquieria splendens*), and multiple annual and perennial grass species. Narrow riparian corridors containing Fremont cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii*), velvet ash (*Fraxinus velutina*), netleaf hackberry (*Celtis reticulata*), and other species, are more widely spaced across the landscape.

METHODS

Gila Monsters within the general landscape surrounding SBNWR and LCNWR were opportunistically monitored by U.S. Fish and Wildlife Service (Service) personnel between 2000-2017. When we encountered an individual Gila Monster, we captured and temporarily removed it from the environment; measured the length, weighed, sexed (when possible; see discussion below), photographed, PIT-tagged it to provide positive individual identification, and then released it at the original capture site. PIT-tags were injected subcutaneously on the underside of the abdomen with no problems involving tag retention or injury to the lizards. Sexing was accomplished following Beck (2005), Lowe et al. (1986), and Seward (2000), which indicate males generally have larger, wider heads and a more squared body shape, while females generally had narrower heads and a more pear-shaped body. Smaller individuals are not able to be accurately sexed.

This monitoring was accomplished under the conditions prescribed in an annual Arizona Game and Fish Department Scientific Collecting License. Coordinates for capture sites were recorded with GPS devices when available, or using mapping software when necessary, and mapped. Such basic population ecology information was easily and economically gathered by Service staff working at the refuges, and the data adds to the wealth of information already documented for this lizard and can ultimately help wildlife managers make more informed decisions regarding this species.

RESULTS

Refuge staff and volunteers captured and processed 222 different Gila Monsters (313 captures, including 91 total recaptures) between 2000-2017. This includes 26 individuals that were collected as road kills, which were processed and included in this database before they were donated to museums or university collections. Information gained from this long-term monitoring effort has provided data regarding seasonal and daily activity periods, home range/movement, habitat use, life history traits, growth and longevity, mortality, and limited food habits.

Many of the Gila Monsters in our monitoring area typically have more dark than light color patterns (are darker) than those found in other areas of Arizona, perhaps conforming to the principle of Gloger's rule (Bogert and Martin del Campo, 1956), or perhaps providing a greater degree of favorable cryptic coloration in areas dominated by the dark volcanic rock within this landscape. Dark adults have also been discovered in black basaltic lava flows in Southwest Utah (Beck 1985).

Activity Periods - Gila Monsters become active when they search for food, water, mates, or shelters, are very familiar with the terrain that they inhabit, and exhibit fidelity to familiar sites (Beck 2005). We observed active individuals from March through December, with two peaks of activity (Figure 1). The earliest lizards were observed at the entrances of their shelters in rocky areas on March 20 and March 23. The shelters (n=2) located during this effort were shallow burrows under rock roofs; one facing east and the other facing west.

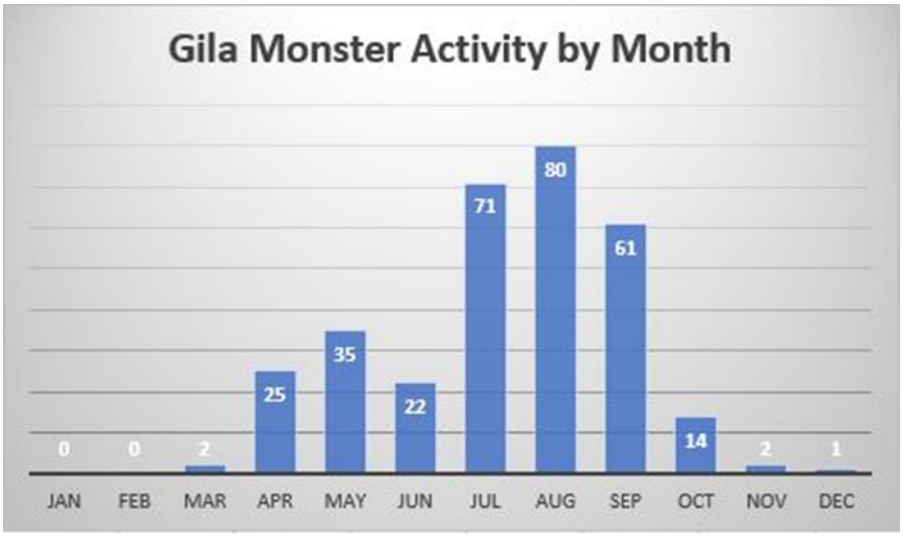

Figure 1. Gila Monsters in southeastern Cochise County, Arizona, have two activity peaks during the year, with the larger peak associated with the summer rainy season. The bars show the number of lizards per month (n=313), including both living and dead individuals.

Gila Monsters were periodically observed thermoregulating at these shelter entrances during March, and their activity away from these burrows generally began during April, with an activity pulse (26% of captures) during spring (April-June). Maximum activity (68% of captures) occurred during the summer rainy season (July – September), when lizards take advantage of opportunities for rehydration and foraging. Most lizard activity tapered off quickly in October with the onset of cooler temperatures.

Our data depicts Gila Monster activity between 6:28 AM and 8:15 PM local time, with most activity (~68%) occurring in the morning between 7 AM - Noon, some activity (~10%) occurring during the middle of the day, and another smaller pulse of activity (~23%) occurring in the afternoon between 4-8 PM (Figure 2). Gila Monsters are likely more tolerant of cold temperatures than of heat, which allows them to use resources during times when other options for maintaining higher activity temperatures are not available (Beck 2005). Nocturnal activity by Gila Monsters was likely underestimated by our efforts because Service staff were generally present on the landscape between 5 AM – 5 PM, and were largely absent outside of that time. However, some staff did spend evening hours conducting inventory and monitoring work, and Gila Monsters were rarely observed during those periods. The higher elevation and overall cooler temperatures of the monitoring site likely influence daily activity periods.

We captured 15 young (<165mm SVL; <67g Mass) Gila Monsters during this effort, but so far none have been recaptured to help determine growth rate or survivorship. This is not completely surprising because the species' conservative energy-use strategy permits them to subsist for long time periods with limited activity, and because smaller Gila Monsters are more secretive than adults and may show greater nocturnal activity (Beck 2005). We captured 60% (n=9) of the young reptiles between 7:20 AM – 11:50 AM, and 40% (n=6) between 4:30 PM – 7:35 PM. While juveniles may utilize warm summer nights for foraging in the area, we have not observed this pattern. However, it would be inaccurate to assume that all Gila Monster age classes have an equal probability of being encountered.

Movement - Home range (HR) is an area within an organism's habitat through which it moves to fulfill its resource needs, which may include foraging, rehydration, reproduction, and other needs (Beck 2005). Recapturing the same Gila Monster over time allowed limited determination of apparent HR use by an individual. We calculated HR sizes by constructing the smallest convex polygon that encompassed all of the

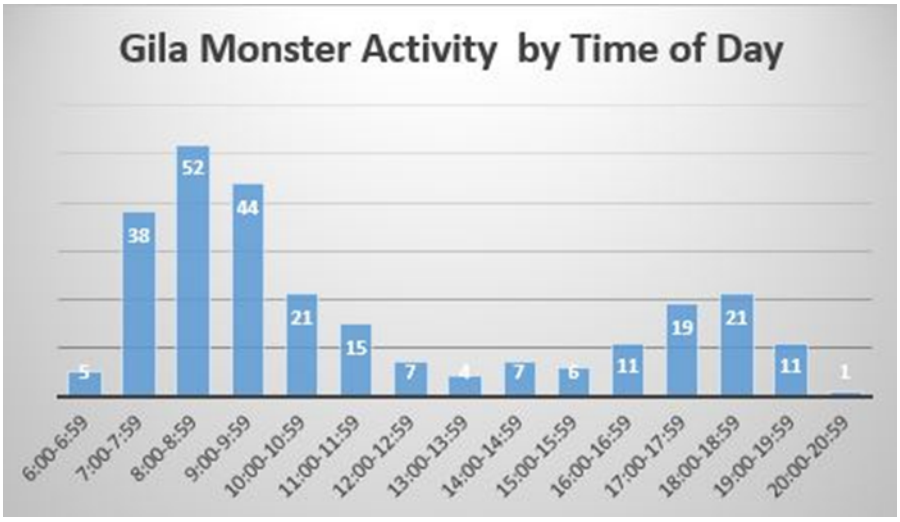

Figure 2. Gila Monsters in southeastern Cochise County, Arizona, have two daily activity peaks, with most activity in the morning hours. The bars show the number of live captures (n=262) over a 24-hour period. Note that personnel tended to be in the field more in the morning than in the evening, which may have affected the distribution of documented captures.

observed locations (Jennrich and Turner 1969). The accuracy of HR calculations is based on having an adequate number of accumulated relocation points (minimum of three), and this was limited by our opportunistic monitoring, but does not influence an animal's movement in the way that tracking a radio-tagged individual may impact an animal's behavior (Millspaugh et al. 2012). The maximum distance between capture points of individual lizards (n=55) during this monitoring effort ranged from 11-3,842 m (37-12,606 ft), and a mean of 563 m (1,847-ft), with nearly half (47%) of the lizards exceeding 402 m (1,320 ft) between maximum capture points. The size of the HR of Gila Monsters (n=18) in this effort varied from 0.03-37.7 ha (0.07-93.2 a), and a mean gross HR of 6 ha (14.85 a). This compares with the HR size ranging from about 6-147 ha (14.8-363.2 a) determined for Gila Monsters by Beck (2005), a mean gross HR of 48.1 ha (116.4 a) for adults and 13.4 ha (33.1 a) for subadults at a site in Arizona (Gallardo et al. 2002), and 6-68 ha (14.8-168.0 a) at another site in Arizona (Sullivan et al. 2004). I anticipate that our estimates of Gila Monster HR in southeastern Cochise County will increase as the number of recaptures continues to grow.

Habitat Use - Habitat use by Gila Monsters in Arizona has been described as desert-scrub, semi-desert grassland, and sometimes woodland areas (Beck 2005). Our monitoring area, characterized by extensive elevation complexity and topographical relief, and composed of small canyons, foothills, and rocky slopes, provides different directional aspects, rock outcroppings, drainages, and flatlands. Elevation range of the Gila Monsters captured during this effort ranged from 1,138 m (3,732 ft) to 1,490 m (4,888 ft), and the average elevation where Gila Monsters were captured (n=313) was 1,278 m (4,193 ft).

Gila Monsters were not found across the landscape in equal numbers, rather their occurrence often existed as "clusters" within the more limited microenvironments that may be necessary to allow the animal to avoid its limits of physiological tolerance (Beck 2005). For example, within their habitats, Gila Monsters spend the vast majority of their time within shelters, taking advantage of the cooler, more humid microclimates located underground (Beck and Jennings 2003). Most of our captures occurred on or immediately adjacent to rugged, rocky areas with substantial vegetative cover, especially velvet mesquite. We occasionally (n=5) found individual Gila Monsters in grassland valley bottoms or at other locations that were far from rocky habitats or other captures. These "wanderers" may represent pioneering individuals or lizards utilizing microenvironments that are not completely recognized or understood. Thus, while Service

personnel spent considerable time in a variety of habitats across the monitoring area, Gila Monsters appeared to select rocky habitat over flat and grassland habitats. Within even the areas with the highest capture rates, population densities of the species appear to be low.

Life history - In nature, mating by Gila Monsters occurs during April – June (Beck 2005), which was supported when Gila Monsters captured during our effort mated on May 7, 2007. Captive Gila Monsters lay eggs within 5-8 weeks following copulation (Eidenmuller and Reisinger 2011, Shaw 1968). Free ranging Gila Monsters lay 2-13 eggs (mean 5.7) during the summer rainy season (Ernst and Ernst 2011, Goldberg and Lowe 1997), which appears crucial for establishing the necessary moisture conditions required for successful hatching (Beck 2005, Goldberg and Lowe 1997, Seward 2000). This was supported during our monitoring by a female laying a clutch of 13 eggs on August 12, 2012. Eggs hatch about 120-152 days later (Eidenmuller and Reisinger 2011), and hatchlings overwinter in their underground nest before emerging during the following spring/summer (Ernst and Ernst 2011, Roger A. Repp, personal communication, Tucson, AZ, May 2018).

Hatchling sized Gila Monsters have been variously described as ranging from 110-141 mm (4.33-5.55 in) SVL, ranging from 150-186 mm (5.9-7.32 in) TL, and having a body mass ranging from 23.1-44 g (0.81-1.55 oz) (Beck 2005, Eidenmuller and Reisinger 2011, Lowe et al. 1986, Shaw 1968). Five presumed hatchlings captured during our monitoring efforts ranged from 115-142 mm (4.53-5.59 in) SVL, ranged from 175-203 mm (6.89-7.99 in) TL, and ranged in weight from 23.5-47.1 g (0.83-1.66 oz). Hatchlings have been observed in nature between April – August (Beck 2005), and this was supported by hatchlings (n=5) captured during our monitoring effort between June 23 – July 25.

Growth and Longevity – Gila Monsters have reached over 30 years of age in captivity, and frequently exceed 20 years in nature (Beck 2005). Growth rates are variable among individuals and size classes, with Gila Monsters taking 10.1-12.8 years to reach 325 mm (12.80 in) SVL, and taking at least 17.6 years to reach over 360 mm (14.17 in) SVL (Beck 2005). Based on this information, I estimate that 65 (29%) of the 222 Gila Monsters encountered during our monitoring effort were at least 10.1-12.8 years old, including five (2%) that were at least 17.6 years old when they were originally captured. Subsequent recaptures of some of those lizards documented two individual females reaching between at least 18.3-21 years old when they were last recaptured, and one female that was between 19.8-22.5 years old when last recaptured.

During our monitoring efforts in Cochise County, the Gila Monsters having the greatest length included a female captured in July 2012 measuring 404 mm (15.9 in) SVL and 445 mm (17.5 in) TL, and a male captured in August 2009 measuring 369 mm (14.5 in) SVL and 531 mm (20.9 in) TL. The Gila Monster having the shortest length was an individual captured in June 2013 measuring 115 mm (4.5 in) SVL and 175 mm (6.9 in) TL. The Gila Monsters having the greatest mass included a female captured in May 2008 that weighed 1,100 g (38.8 oz) and a male captured in May 2007 that weighed 1,085 g (38.3 oz). The Gila Monster having the smallest mass was the individual captured in June 2013 that weighed 23.5 g (0.83 oz). These values are all consistent with size information reported by other authors (Beck 2005, Goldberg and Lowe 1997).

Recaptured lizards demonstrated considerable variation in their weights between captures that were not correlated with significant changes in their length, ranging from 295 g (10.4 oz) gains to 585 g (20.6 oz) losses. In some cases, these changes reflected their reproductive condition (e.g., gravidness), but more often they likely represented gains and losses in association with annual and seasonal changes in food and water availability. *Heloderma* have relatively high rates of evaporative water loss when compared with other lizards (DeNardo et al. 2004, Lowe et al. 1986), which would affect body mass. These fluctuations in their body conditions likely mirror changing ecological conditions such as drought, precipitation, food availability, population dynamics of prey species, and other conditions upon which they depend for their survival.

Mortality - Vulnerability to predation was not adequately assessed by our monitoring. During our efforts, four Gila Monsters were captured that were missing various portions of their tails from prior injuries, several lizards were missing toes, and others exhibited scars on their body or face. While a ringtail cat (*Bassariscus astutus*) was documented by remote trail camera photos as showing an interest in a Gila Monster (Figure 3),

Figure 3. Remote trail camera photos documented this ringtail cat (Bassariscus astutus) showing an interest in a Gila Monster at Leslie Canyon National Wildlife Refuge in southeastern Cochise County, Arizona, but the outcome of the interaction is unknown.

no actual predation was identified. The only Gila Monster fatalities documented during our effort - 26 individuals were collected as road kills - resulted from vehicles.

Food habits – Gila Monster food habits were not studied as part of this monitoring effort. However, a 61 g (2.2 oz) recently consumed baby cottontail rabbit (*Sylvilagus audubonii*) was regurgitated by a captured 351 mm (13.8 in) SVL, 885 g (31.2 oz) female lizard on June 30, 2009.

SUMMARY

Data collected during this long-term monitoring effort are generally consistent with studies of Gila Monsters in other locations, with some important differences. These differences include daily and seasonal activity periods, which are likely influenced by the higher elevation and overall cooler temperatures of the monitoring area compared to other locations and may reflect the lizard's adaptation to meeting optimal thermoregulation requirements. Additionally, home range sizes are generally smaller than those determined by other researchers. This may reflect an abundance of resources within the area we monitored, or a potential sampling bias.

Our data add to the overall knowledge of Gila Monster population ecology, and may inform management decisions. Consider two examples. First, knowing that activity is highest in mid-spring and during the summer rainy season, local managers can focus potential Gila Monster habitat disturbance, e.g., with heavy equipment, during those times because individuals are most likely to be able to disburse and avoid mortality. Second, the measurement and mark-recapture data provide an important baseline against which future measurements may be compared. If future data indicate a systematic decline in body size or condition, or if recaptures suddenly begin to decline with similar effort in the field, managers may develop a structured research program to identify the causes of the changes. In brief, while the data do not provide answers to every question, they provide key insights that can advance Gila Monster conservation.

There are advantages and disadvantages to long-term monitoring work being accomplished opportunistically by staff or "citizen scientists." Perhaps the greatest advantage is that long-term monitoring of a fixed area can be accomplished cost effectively; it can be done opportunistically while employees are engaged in their other duties. Importantly, participants build comradery that promotes teamwork, and participation builds interest in principles of conservation ecology, population dynamics, behavioral patterns, and other ecological values. There are also limitations to opportunistic monitoring compared to structured, intensive monitoring by more qualified researchers. These include employee turnover and participants having differing levels of interest and expertise, which requires continual training, oversight, and error checking. There is also a potential bias relating to any monitoring occurring only during established employee working hours. Accounting for these benefits and costs over the 18 years of the Gila Monster monitoring effort, I believe the benefits have far outweighed any costs as we have learned more about this animal and taught many others a greater appreciation of it.

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Session Abstracts and Papers / *Resúmenes y Articulos*

Session 34: No Topic or Session

Session 35: Current Research on Herpetofauna of the Sonoran Desert and Sky Islands, Part #4

Santa Rita Mountains landscape
(Photo courtesy of the USDA Forest Service, Coronado National Forest)

Abstracts and Papers
Bradley
Brocka
Christiansen
Droat

Locating suitable habitat for the Tucson Shovel-nosed Snake in the Sonoran Desert

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The Tucson Shovel-nosed snake (*Chionactis annulata klauberi*) is a small colubrid adapted to the sandy loams of the Sonoran Desert region of central and western Arizona that has experienced habitat loss due to agricultural conversion and urban development. The snake is a redefined subspecies of the Colorado Desert shovel-nosed snake based on a recent genetic study. Using data from this study we constructed a species distribution model to map the remaining suitable habitat and found that 45% of historic habitat has been converted into urban development, roads, agriculture, quarries, mines, or invasive grasses. Of the remaining 612,313 ha, nearly 77% is privately owned, state trust land, or tribally owned with no mandate for protection. These findings are in contrast with the U.S. Fish and Wildlife Service's model that estimated nearly three times as much remaining suitable habitat for the subspecies.

Localización del hábitat adecuado para la serpiente Tucson con nariz de pala en el desierto de Sonora

La serpiente con nariz de pala de Tucson (Chionactis annulata klauberi) es un pequeño colúbrido adaptado a las franjas arenosas de la región del Desierto de Sonora en el centro y oeste de Arizona que ha experimentado la pérdida de hábitat debido a la conversión agrícola y el desarrollo urbano. La serpiente es una subespecie redefinida de la serpiente de nariz de pala del Desierto de Colorado basada en un reciente estudio genético. Usando datos de este estudio, construimos un modelo de distribución de especies para mapear el hábitat adecuado restante y descubrimos que el 45% del hábitat histórico se ha convertido en desarrollo urbano, caminos, agricultura, canteras, minas o pastos invasores. De las 612,313 hectáreas restantes, casi el 77% son de propiedad privada, tierras de fideicomisos estatales o tribales, sin ningún mandato de protección. Estos hallazgos contrastan con el modelo del Servicio de Pesca y Vida Silvestre de los EE. UU., que estima casi tres veces el hábitat adecuado restante para la subespecie.

Note: Full Paper Follows

DEFINING SUITABLE HABITAT AND CONSERVATION STATUS FOR THE TUCSON SHOVEL-NOSED SNAKE (*CHIONACTIS ANNULATA KLAUBERI*) IN THE SONORAN DESERT

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***Abstract**--The Tucson shovel-nosed snake (Chionactis annulata klauberi) is a small specialized colubrid associated with sandy loams of the elevated portions of the Lower Colorado River Valley Sonoran Desert in central Arizona. This taxon is a recently redefined subspecies based on genetic data, and may be extirpated in the Tucson region, including the type locality. A recent (USFWS 2014) decision against protecting it was based in part on an expansive definition of its geographic range and a habitat model. Here, we redefine the subspecies distribution by uniting published results of mitochondrial and nuclear DNA. We then present a new ecologically based model of its original and current habitat using the machine learning algorithm Random Forests. The new model accurately matches known and estimated presence-absence data for this taxon, and is consistent with morphometrics and, largely, with color pattern variation. It estimates 60% less available habitat than the USFWS model. We estimate that 39% of the 1,255,946 ha (3,103,505 ac) of original habitat has been converted to urban developments, roads, agriculture, or otherwise altered non-habitat. Of the remaining 770,971 ha (1,905,108 ac), 60% is susceptible to habitat conversion in the region, with only 10.9% of habitat having current legal protection. Ongoing and projected urbanization and energy development in its flatland desert habitat present a bleak future for this subspecies.*

INTRODUCTION

In recent decades, genetic data have greatly increased our understanding of the history and processes shaping populations, gene pools, and landscape relationships of species (Avise 2000). This revolution has reshaped concepts of speciation, species boundaries, subspecies, and appropriate targets of conservation and management (Avise and Ayala 2017). Earlier consensus regarding the "biological species concept" and subspecies have largely been supplanted by evolutionary and genealogical species concepts. Here taxa are considered species if they are on distinct evolutionary trajectories and have anciently differentiated genetically (De Quiroz 2007). Subspecies have become controversial, with some elevated to full species rank while others have been dismissed or remain in taxonomic limbo. However, adaptive subspecific differentiation may play a critical role in speciation (Gavrilets 2014), and subspecies may merit protected conservation status (Phillimore and Owens 2006).

Shovel-nosed snakes (genus *Chionactis*) present complexities with regard to identifying species, lineages, and significant conservation entities. Four taxa are currently recognized: the relatively divergent Sonoran shovel-nosed snake (*C. palarostris*) and three taxa in the geographically variable *C. occipitalis* complex (Wood et al. 2014). These include the Mojave shovel-nosed snake (*C. occipitalis*) and two subspecies of the Sonoran Desert shovel-nosed snake (*C. annulata*): the Colorado Desert shovel-nosed snake (*C. a. annulata*) and the Tucson shovel-nosed snake (*C. a. klauberi*). The *C. occipitalis* complex displays complicated geographic patterns of genetic differentiation (Wood et al. 2014) making definition of taxon boundaries (Wood et al. 2014; USFWS 2014) and conservation status challenging.

In the *C. occipitalis* complex, the head is morphologically specialized for burrowing in the sandy soils they inhabit (Ernst and Ernst 2003), more so than in the sister taxon *C. palarostris*. The body is slim and thus apparently adapted for rapid locomotion (Cundall 1987) compared to the stouter build of the closely related banded sand snake (*Chilomeniscus cinctus*), which is similarly specialized for burrowing (Ernst and Ernst 2003). Further, *Chionactis* in the Sonoran Desert have bold red and black crossbands over a cream or yellowish ground color, marking them as mimics of venomous coralsnakes, including the sympatric Sonoran coralsnake (*Micruroides euryxanthus*).

In 2004, *C. a. klauberi* was petitioned for listing as Threatened or Endangered under the US Endangered Species Act (ESA). This petition was based on its habitat specialization in desert flats subject to agricultural conversion and urban sprawl in central Arizona, and its apparent disappearance from the Tucson region (Center for Biological Diversity

2004), which includes the type locality (Stickel 1941). The subspecies was defined based on the strong infusion of black pigment on the red crossbands, which may enhance both coralsnake mimicry (Mahrdt *et al*. 2001) and background matching (via flicker-fusion: Titcomb et al. 2014). Its geographic range and the presence of intergrades with *C. a. annulata* were described by Klauber (1951) and Cross (1979). On the basis of morphological, mitochondrial and nuclear gene analyses, Wood et al. (2008, 2014) supported continued recognition of *C. a. annulata* and *C. a. klauberi* as a subspecies with "fuzzy" boundaries due to evidence of asymmetric gene flow between the recovered genetic entities that were largely consistent with the earlier concepts of the morphologically described subspecies (Stickel 1941; Klauber 1951; Mardt et al. 2001; Stebbins 2003). However, Wood et al. (2014) did not define distributional limits for *C. a. klauberi*. In rejecting *C. a. klauber*i for ESA protection the U.S. Fish and Wildlife Service (USFWS; 2014) adopted an expansive definition of the subspecies that included all geographic regions within *C. annulata* with any genetic connection to *C. a. annulata*. Herein we define operational boundaries consistent with the complex genetic variation known in *C. annulata* for analysis of the conservation status of *C. a. klauberi*. We then model the ecological distribution and habitat extent of *C. a. klauberi* and re-evaluate the geographic extent of threats to its habitat and its vulnerability to extinction.

METHODS

Occurrence records: *L*ocation data were coordinates for tissue sample records in Wood et al. (2014, Table 1). Delineating the geographic distribution of *C. a. klauberi* presented challenges associated with divergent geographic gradients in mtDNA and nuclear microsatellite data (Wood et al. 2008, 2014). We resolved this problem by using the intersection of the mitochondrial and nuclear DNA datasets from Wood et al. (2014), using individuals from microsatellite cluster C (red circles and half circles in Figure 1a, Wood et al. 2014) that were also contained in mtDNA clade C. This resulted in 44 locality points from which we added verified museum and published locality records that were within the previously delineated range of *C. a. klauberi* (Mahrdt et al. 2001) but not sampled by Wood et al. (2014). This included records from Santa Cruz Flats, Pinal County, and Avra Valley near Tucson, Pima County (including the type locality) that could be mapped with a precision of 0.161 km or better. We placed a grid of 1 km square cells over the points and randomly selected one occurrence per cell to remove repetitive records that likely reflect sampling bias and to reduce autocorrelation. The resulting dataset represented 53 C.a. klauberi "presence" records (Figure 1b) that were used as model inputs.

Absence records: We constructed model inputs of "absence" records based on paved road segments (the only way this subspecies was effectively sampled) that have been intensively searched without yielding records of *C. a. klauberi*. Points were placed along the paved road transects at 10 km intervals, excluding all areas within 10 km of a record of a *C. a. klauberi* record. Road transects are often in areas of low slope gradient, so we placed additional absence records on popular mountain ranges near Phoenix where there are no records of *Chionactis.* We placed an additional eleven absence records in western Arizona at localities representing microsatellite clusters A or B (Wood et al. 2014). The absence dataset thus included 74 locality records (Figure 1) yielding a balanced presence/absence dataset for use in our model.

Environmental Predictors: We assembled 38 explanatory (*x*) variables that literature (Klauber 1951, Cross 1979, Stebbins 2003, Ernst and Ernst 2003) and our field experience suggested as potentially important to the species (Table 1), with particular attention to soils. We extracted percent sand, silt, clay, rock fragments, and available water storage from the USDA's STATSGO2 database for Arizona (STATSGO 2016). We did not use the finer scale SSURGO database because it has significant data gaps and discontinuities within our study area. Soil map units were converted into a 90 m resolution grid for use in our model that appropriately represented the resolution of the original vector data. All subsequent raster datasets mentioned herein were resampled to match this 90 m resolution using bilinear interpolation for continuous data or majority filter for discrete data.

We represented vegetation with the Biophysical Settings, Vegetation Cover, and Existing Vegetation Type (EVT) datasets from LANDFIRE (LANDFIRE 2014). The Biophysical Settings maps depict the vegetation likely present before

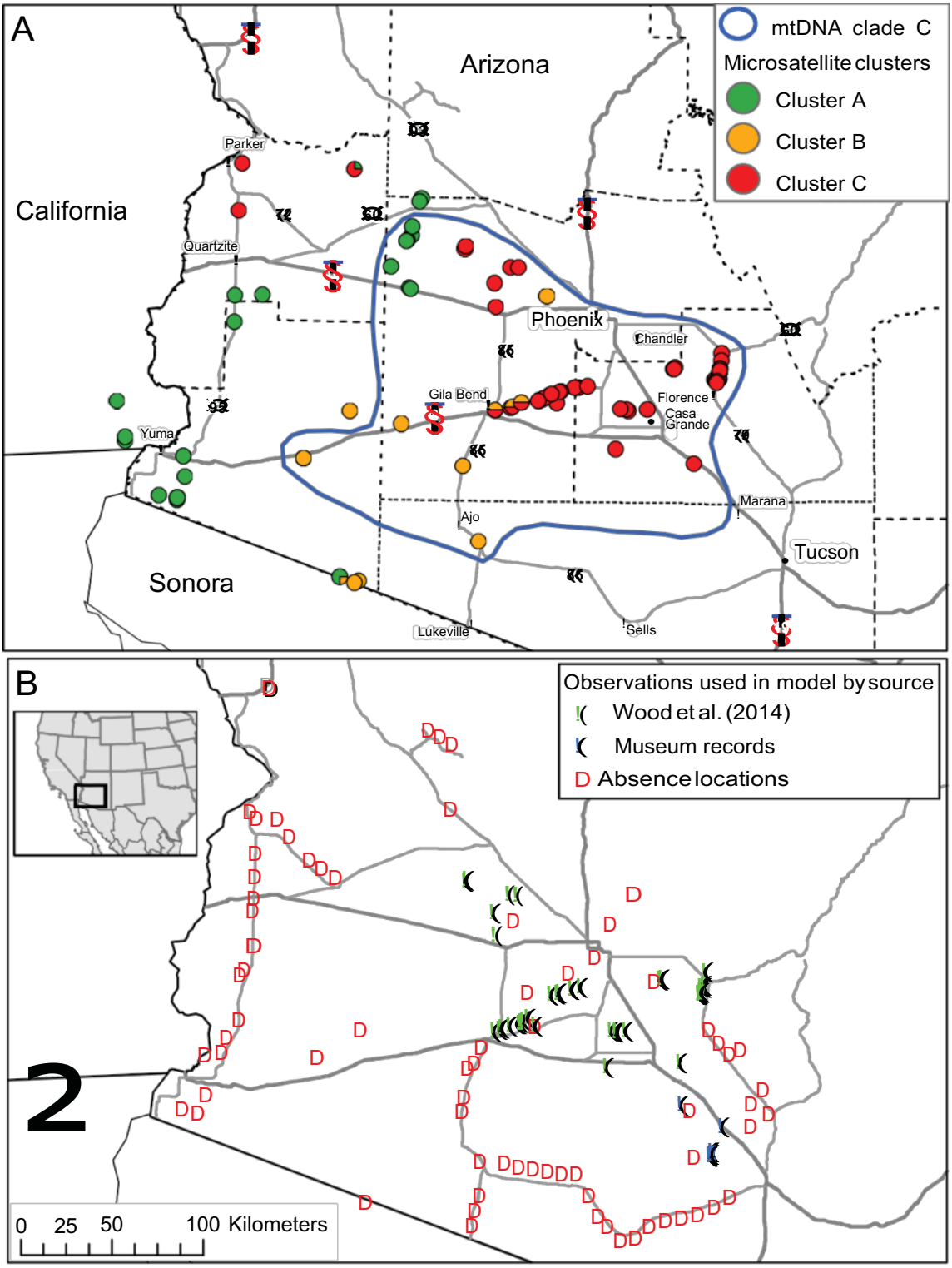

Figure 1--A) Microsatellite clusters and mtDNA clade C from Fig. 5 in Wood et al. (2014). The cluster C locations (red circles and half circles) within the mtDNA clade C are the basis for delineating *C. a. klauberi*'s distribution. B) Observations and assigned absence locations used in the species distribution model

Euro-American settlement and was used in our model because many observation records pre-date valley conversion to non-habitat. The Vegetation Cover dataset was modified to indicate the percent shrub cover. The EVT maps were used

Table 1— Explanatory variables evaluated for inclusion in the species distribution model for *C. a. klauberi*. Final variables used in the model are in bold. Variable importance rankings can be seen in Figure 5.

Variable	Description	Variable	Description
ELEV	**Elevation in meters**	bio_1	Annual mean temperature
Slope	**Slope (%)**	bio_2	Mean diurnal range
Slope2dir	Second derivative of slope	bio_3	Isothermality
HSP	Hierarchical slope position	bio_4	Temperature Seasonality
CTI	Compound topographic index	bio_5	Max Temperature of Warmest Month
Sand	Sand by weight (%)	bio_6	Minimum temperature of coldest month
Silt	Silt by weight (%)	bio_7	Temperature Annual Range
Clay	Clay by weight (%)	**bio_8**	Mean Temperature of Wettest Quarter
Frags	Rock fragments by weight (%)	bio_9	Mean Temperature of Driest Quarter
H2OStorage	Available water storage	bio_10	Mean Temperature of Warmest Quarter
BPS	Biophysical settings	bio_11	Mean Temperature of Coldest Quarter
PctShrubLFire	Shrub cover (%)	**bio_12**	**Annual precipitation**
LS8_B1	Landsat 8 band 1	**bio_13**	**Precipitation of wettest month**
LS8_B2	Landsat 8 band 2	bio_14	Precipitation of Driest Month
LS8_B3	Landsat 8 band 3	bio_15	Precipitation Seasonality
LS8_B4	Landsat 8 band 4	bio_16	Precipitation of Wettest Quarter
LS8_B5	Landsat 8 band 5	**bio_17**	**Precipitation of Driest Quarter**
LS8_B6	Landsat 8 band 6	bio_18	Precipitation of Warmest Quarter
LS8_B7	Landsat 8 band 7	bio_19	Precipitation of Coldest Quarter

to classify areas that have been converted to non-habitat such as agriculture, roads, urban and semi-urban development, quarries/mines, or otherwise altered habitat. To supplement our landcover datasets we acquired the most recent late spring, cloud-free Landsat 8 imagery, from 5/3/2017 to 5/21/2017. Land ownership data were obtained from the Arizona State Land Department to determine how much current habitat is vulnerable to future conversion.

Elevation, slope, and the topographic indices of hierarchical slope position, the second derivative of slope, and compound topographic index were derived from a 30 m digital elevation model. Bioclimatic variables, based on average monthly temperature and precipitation data of conditions between 1970 and 2000, were downloaded from WorldClim (Fick and Hijmans, 2017) at the 30 arc-second (~ 1km) resolution. These 19 variables are often used in species distribution modeling and represent annual means and ranges in temperature and precipitation as well as limiting environmental factors such as temperature of the coldest and warmest months.

Random Forest Model--We modeled resource selection using the data-mining algorithm Random Forests (RF) (Breiman 2001) in R (R Core Team 2013). RF is gaining prominence in ecology because of its ability to work with spatially autocorrelated data and requires no assumption of variable distributions (Cutler et al. 2007, Evans et al. 2011). We tested and removed any our 38 initial variables that were multi-collinear using the R package "rfUtilities" (threshold = 0.05; Evans and Murphy 2017). From the remaining explanatory variables, we selected the most parsimonious model that maximized the amount of explained variation while minimizing model error and the number of explanatory variables, resulting in six variables in the final model.

The RF algorithm samples approximately 66% of the data to build regression trees, and the remaining withheld data are a validation sample to assess error. We used the validation sample to determine the amount of variance explained and variable importance. The algorithm also produces individual variable importance measures by calculating differences in prediction mean square error before and after randomly permuting each dependent variable's values. Variable importance is a measure of how much each variable contributes to the model's overall predicative accuracy. Unlike linear models, RF does not produce regression coefficients to examine how a change in a predictor variable affects the response variable. The analogy to this in RF is the partial dependence plot which is a graphical depiction of how the probability of occurrence will change with a single predictor while averaging out the effects of the other predictors (Cutler et al. 2007).

The model predicted probabilities of habitat suitability on a raster map where each 90 x 90 m cell was assigned a probability ranging from 0 to 1, with higher values corresponding to higher habitat suitability. To differentiate between habitat and non-habitat we used a threshold value of equal sensitivity and specificity (the probability at which the false positive rate and the true negative rate are equal) based on Liu et al. (2005). The thresholding resulted in patches of habitat and non-habitat. We retained habitat patches that overlapped our occurrence records and considered this historic (original) habitat. We removed from historic habitat those areas that were converted to agriculture, urbanized, etc., to map the remaining available habitat.

Using land ownership, we determined how much remaining habitat is susceptible to habitat conversion: private, state trust, BLM lands outside of national monuments, tribal, and 'other' lands. National parks, national monuments, military, and city, county, and state parks were considered legally protected from habitat conversion.

RESULTS

Predicted probabilities for habitat suitability are shown in Figure 2. The model was well supported with low (8.59 %) error (Table 2). The observed versus expected accuracy of our model was 0.825 (Kappa statistic), which is considered "almost perfect agreement" (Landis and Koch 1977), and the AUC value of 0.976 also indicates a very good model fit.

The threshold value of 0.52 produced a nearly contiguous habitat patch that incorporated 52 of the 53 observation records. We determined that, historically, the snake's distribution included 1,255,946 ha (3,103,505 ac) of suitable habitat, of which 38.6% has been converted into non-habitat types (Table 3, Figure 3). Of the remaining 770,971 ha (1,905,108 ac), only 10.9% (84,041 ha, 207,669 ac) is afforded legal protection from habitat conversion (Table 4).

The variable importance plot (Figure 5) indicates that elevation was the most important variable in explaining the variation in the data, followed by three climate variables and a topographic variable: annual precipitation, precipitation of the driest quarter, precipitation of the wettest month and percent slope. All of the climate variables are linked to elevation, to some degree, but also to spatial variation of the summer monsoon rainfall pattern.

Table 2—Model error, sensitivity, specificity, Kappa, ROC area under curve (AUC), significance (P), and the threshold value of equal sensitivity and specificity (Threshold).

Model error (%)	Sensitivity	Specificity	Kappa	AUC	Threshold
8.590	0.926	0.905	0.825	0.976	0.52

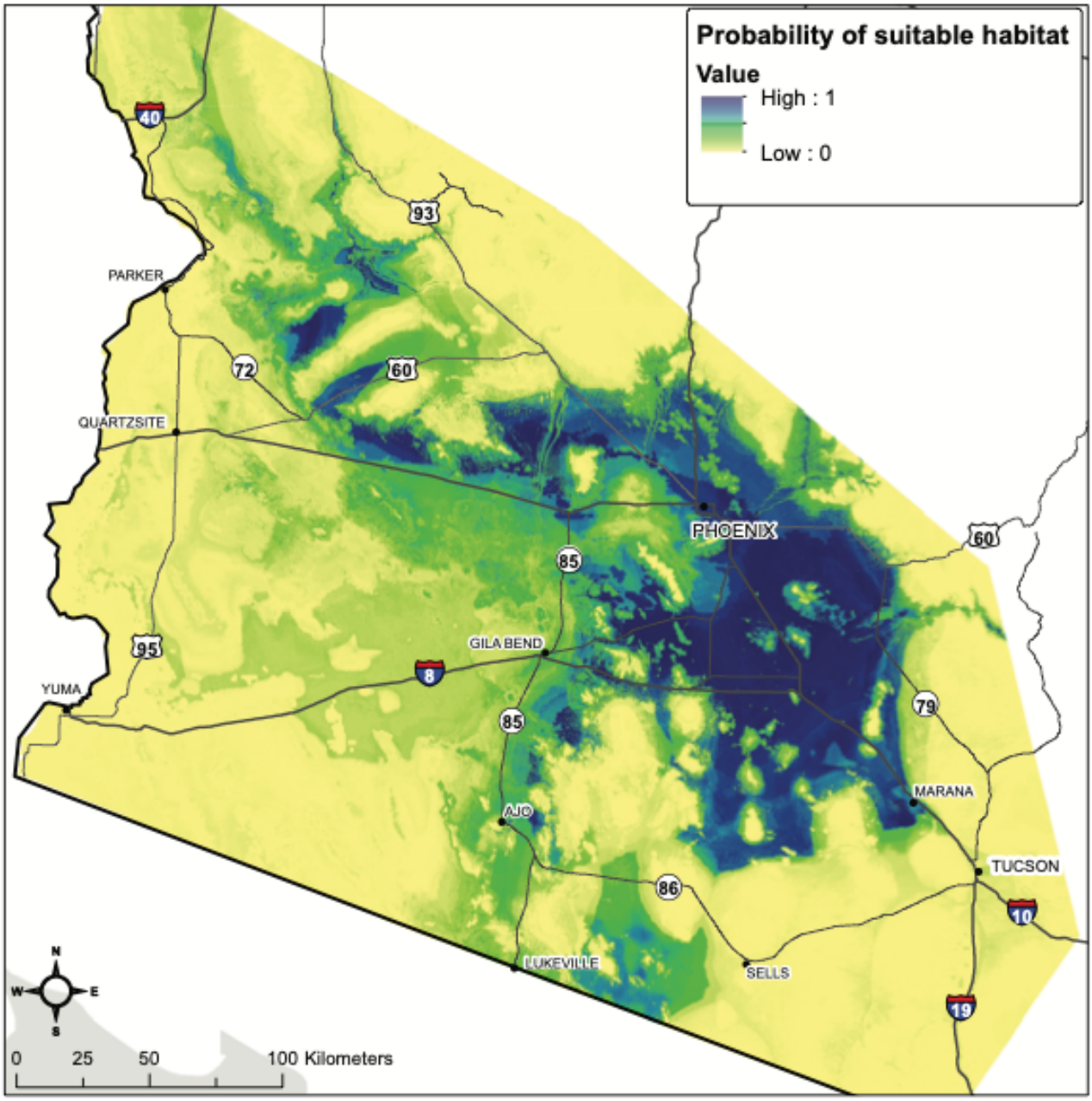

Figure 2--Estimated habitat suitability for the Tucson shovel-nosed snake in Arizona.

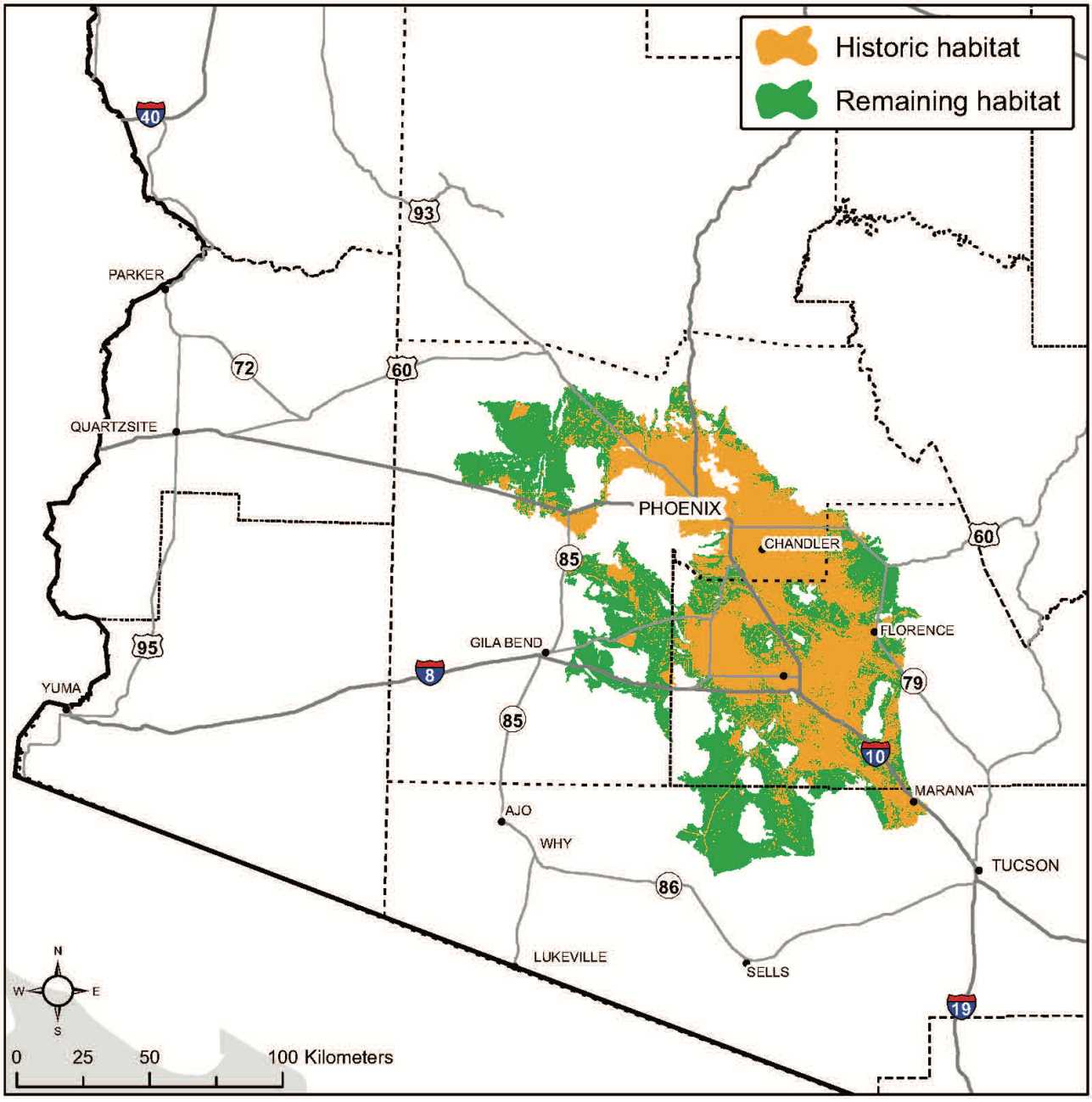

Figure 3--Currently suitable habitat and historic habitat that has been converted to urban development, roads, and agriculture within the distribution of *C. a. klauberi.*

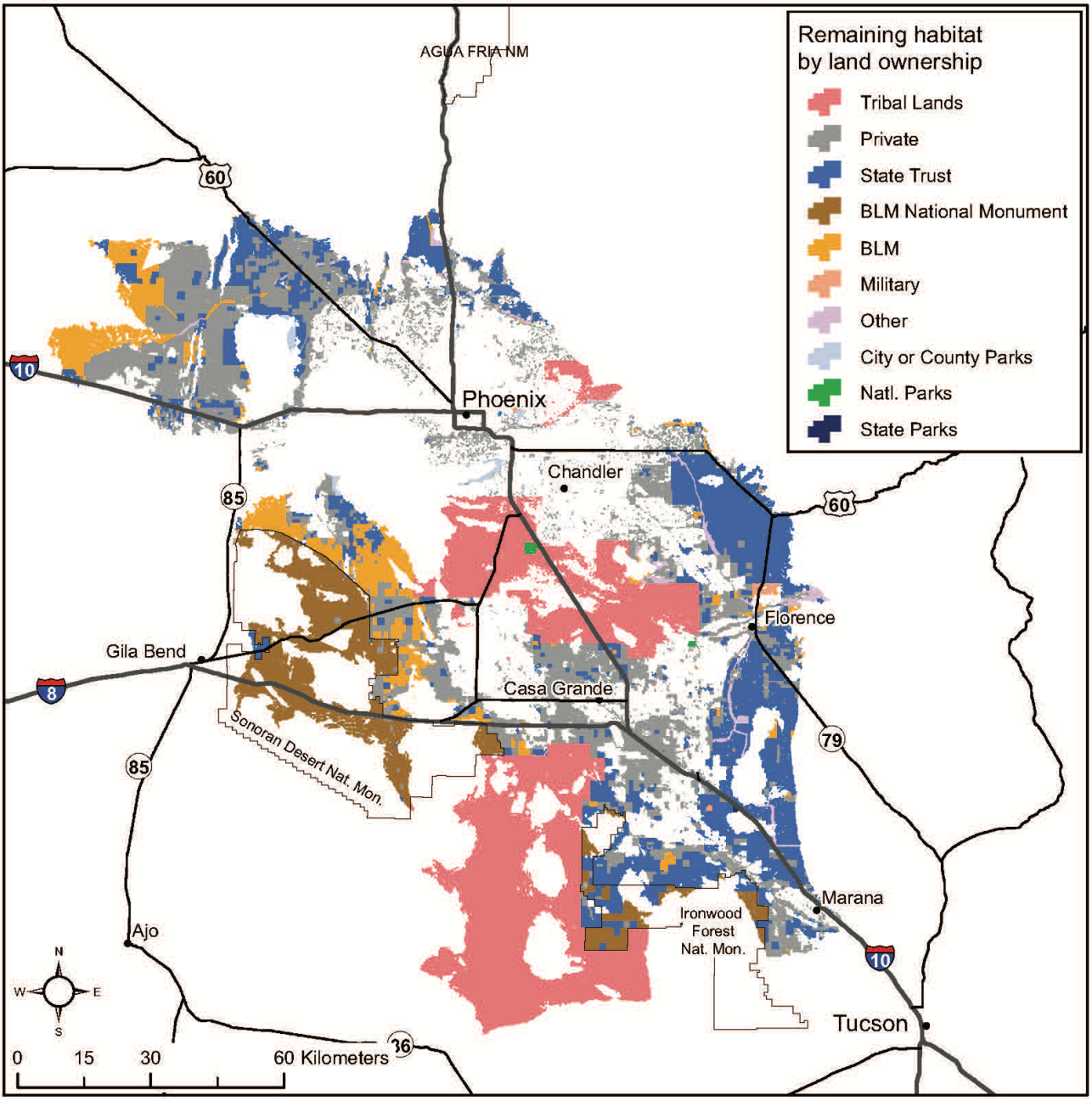

Figure 4--Land ownership of the currently suitable habitat of C. a. klauberi.

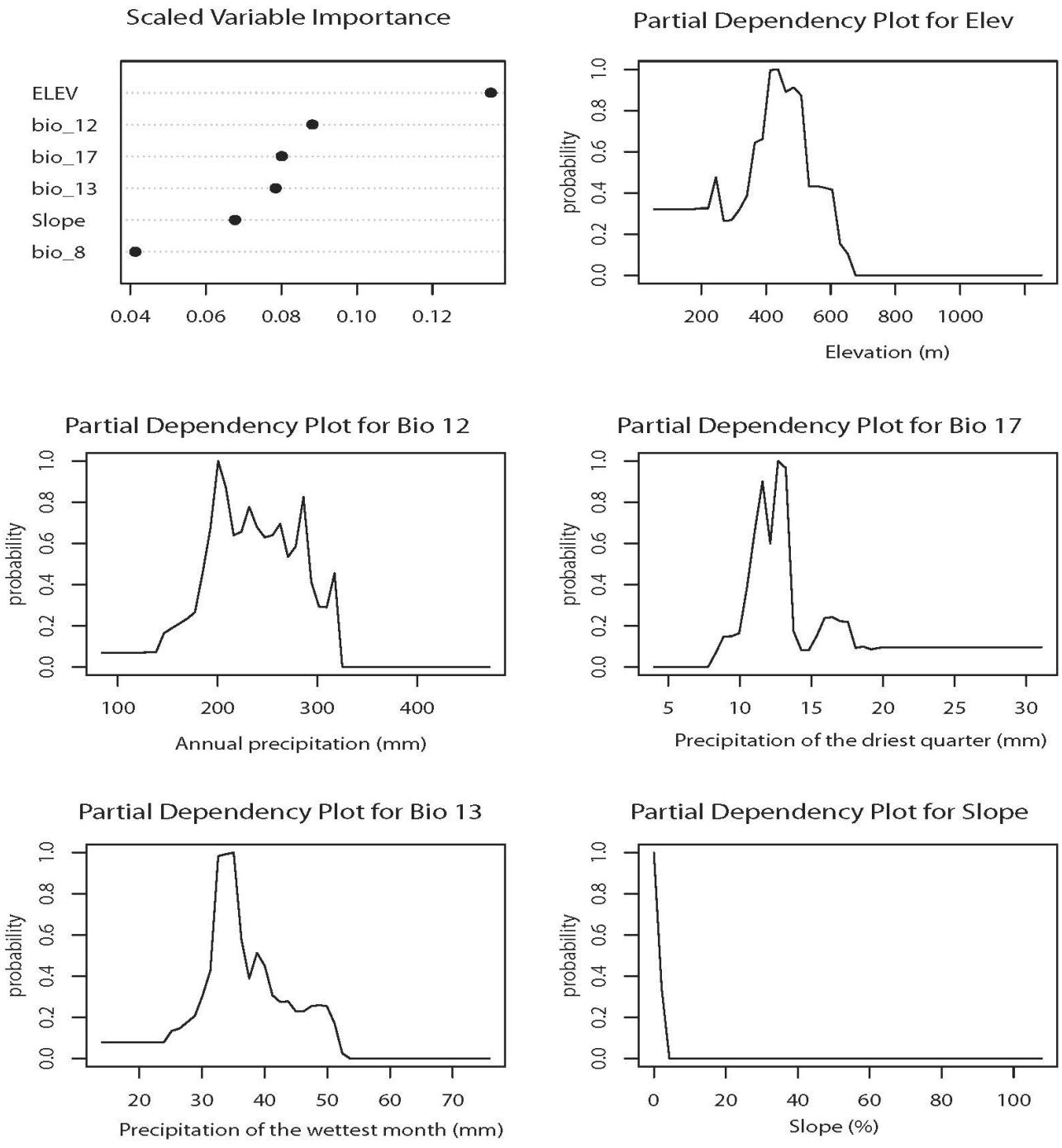

Figure 5--Variable importance plot and partial dependence plots of the top 5 independent variables in the species distribution model for C. a. klauberi: elevation (ELEV), annual precipitation (bio_12), precipitation of the driest quarter (bio_17), precipitation of wettest month (bio_13), and slope.

Table 3— Historic versus remaining habitat of *C. a. klauberi* by land ownership and protection class. Private, state trust, BLM lands outside national monuments, tribal, and 'other' lands are considered inadequately protected.

Category	Hectares	Acres		% of historic
Historic habitat	1,255,946	3,103,505		
Converted habitat	484,975	1,198,397		38.6
Remaining habitat	770,971	1,905,108		61.4
Remaining habitat by ownership	**Hectares**	**Acres**	**% of current**	**% of historic**
Tribal lands	222,407	549,580	28.8	17.7
Private	219,592	542,622	28.5	17.5
State Trust	185,081	457,345	24.0	14.7
BLM (national monuments)	75,036	185,418	9.7	6.0
BLM (other)	57,345	141,703	7.4	4.6
Military	6,617	16,352	0.9	0.5
Other	2,505	6,189	0.3	0.2
City or County Parks	1,563	3,863	0.2	0.1
National Parks	672	1,661	0.1	0.1
State Parks	152	375	0.0	0.0
Remaining habitat by protection class	**Hectares**	**Acres**	**% of current**	**% of historic**
Inadequately protected	686,930	1,697,438	89.1	54.7
Protected	84,041	207,669	10.9	6.7

DISCUSSION

The GIS-based habitat model used by USFWS (2014) in rejecting legal protection status for *C. a. klauberi* yielded an estimated area of suitable habitat 2.4 times greater (1,835,591 vs 770,971 ha) than what we estimated. The USFWS (2014) did not assess model sensitivity or specificity to report how well the model performed but we identified several reasons for the overestimation of habitat. First, the model included areas up to the 1500 m elevation which is over twice the maximum elevation for any *C. annulata* record (735 m) we can find in Arizona. Our analysis indicated an approximate elevational range of 350–625 m for *C. a. klauberi* (Figure 6). The elevation discrepancy may explain why well-sampled regions where the subspecies is unrecorded were included in the USFWS model, e.g., the region between Florence and Tucson along U.S. Highway 79 that supports strongly arborescent Arizona Upland Sonoran Desertscrub rich in saguaro cactus, and semi-desert grassland. Second, the USFWS (2014) model relied entirely on two variables, land cover and elevation, to predict *C. a. klauberi* habitat. We found elevation to be the most important habitat predictor while land cover was supplanted by climate variables and ultimately dropped from our model (Table 1). Third, the USFWS (2014) model included areas with limited nuclear and mtDNA representation associated with *C. a. klauberi* (Clade E, see Fig. 6), whereas we used a preponderance of genetic evidence approach to delineate the geographic distribution.

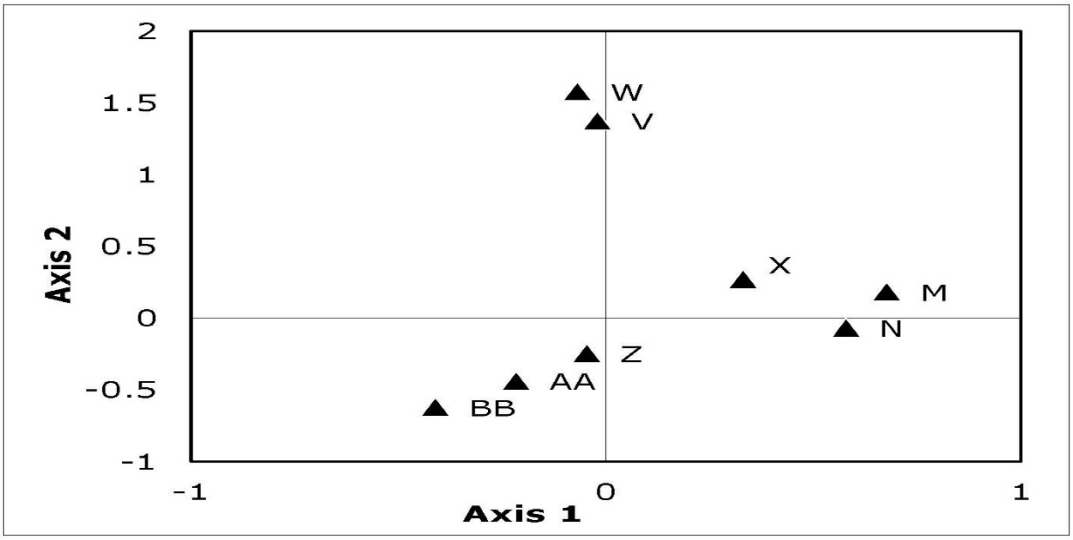

Figure 6--Locations of morphologicaly defined populations of C. annulata in Arizona designated by Cross (1979) and corresponding nonmetric mulitdeminsional scailing (NMS) ordination based on 14 morphological variables from Wood et al. (2008) (inset, modified with permission). USFWS (2014) range boundary shown in blue outline with mtDNA clade E specimens from Wood et al. (2014) shown as yellow dots.

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Figure 6 shows the results of Wood et al.'s (2008) nonmetric multidimensional scaling (NMS) ordination based on 14 morphological variables collected from Cross (1979), with population labeling added (D. Wood, pers. comm. 2018). Population M, included in the USFWS (2014) model, is morphometrically divergent from the *C. a. klauberi* populations located at AA and BB based on the NMS analysis (Figure 3 inset). Our genetics-based range interpretation also includes nearly all observation records classified using color pattern as either *C. a. klauberi* or intergrades with *C. a. annulata* (Cross 1979; Klauber 1951; Mahrdt et al. 2001) and excludes geographic populations that are markedly dissimilar to *C. a klauberi* on the basis of morphological characters (D. Wood, pers. comm. 2018). The new model we present is thus consistent with morphometric as well as genetic data and better represents the color pattern characteristic upon which the subspecies was originally based. Therefore, Figure 3 represents an improved estimate of the geographic extent of *Chionactis annulata klauberi*.

On this basis we found that 60.3% of remaining habitat (not already rendered unsuitable by agricultural conversion and urbanization) is vulnerable to loss from urbanization and other habitat uses, such as conversion to solar energy production facilities, in the coming five or so decades (or less). This dire scenario occurs as a result of the low slope values of occupied habitat, which is restricted to valley flats and lower bajadas with relatively simple perennial vegetation. These environments currently receive little protection, are rapidly being urbanized throughout central and southern Arizona, and are the typical siting for solar energy fields. Further, the lands we considered to have some reasonable chance of supporting natural environments in perpetuity may not actually do so. Both tribal and military lands could be used for energy production or other purposes destructive to natural environments. Recently, even national monument status may no longer be viewed as inviolate (Center for Biological Diversity 2017).

Explanatory bio-climatic variables estimating habitat availability for *C. a. klauberi* highlight its association with elevated portions of the highly arid Lower Colorado River Valley subdivision of the Sonoran Desert. These environments are higher in elevation, less arid, less sparsely vegetated, and less sand-dominated than those largely occupied by *C. a. annulata*. The weak predictive power of soil attributes in our model is likely due to the coarse scale of the STATSGO2 data. An earlier model for the Avra Valley population (Town of Marana 2004), for which the SSURGO soils data were usable, showed a strong association with loam- and sand-dominated soils. Thus, soil characteristics are likely critical for shovel-nosed snake conservation.

Despite extensive surveys from 1987-2017 (USFWS 2014; P. Rosen, unpublished), *C. a. klauberi* has not been found in formerly occupied, seemingly suitable habitat in the Avra Valley region, suggesting a range contraction of ca. 35 km since ca. 1979, facts dismissed by USFWS (2014). Urbanization in the Phoenix-Casa-Grande-Tucson-Florence corridor, comprising the genetic core of *C. a klauberi* and much of rest of the geographic distribution, is rapidly urbanizing (McClure et al. 2017) with no current prospect for substantial protection of valley habitats of *C. a. klauberi*. Although the relationship of recent regional climate change to range contraction of *C. a. klauberi* is unclear, climate acclimation via upward elevation range shifts would likely be blocked by anthropogenic land cover changes. *Chionactis annulata klauberi* may be significantly more threatened than foreseen by USFWS (2014), under both current and projected future climate and landscape regimes. As such, protection and restoration of sandy, saguaro-free, valley floor and lower bajada habitat in the northeastern Sonoran Desert of central Arizona may deserve higher priority than it is currently afforded.

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Taking the field: Terrestrial ecology of the endangered Sonoran Tiger Salamander

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Knowledge of ecological and behavioral processes are essential for the conservation of species at risk of extinction. Approximately one third of all amphibian species are threatened or endangered, and those with limited distribution or population size are particularly vulnerable. To develop effective conservation strategies for at-risk amphibians, managers need to understand their ecological requirements. The Sonoran tiger salamander (STS; *Ambystoma mavortium stebbinsi*) is a federally endangered subspecies found only in the San Rafael Valley of southeastern Arizona and northern Sonora, Mexico. The STS was listed as endangered in 1997 due to highly restricted distribution, dependence on human-constructed environments, invasive species, genetic swamping by non-native salamanders, and disease. Cattle tanks created by ranchers to hold water have replaced natural springs. They are now primary breeding sites for STS. The terrestrial life stage is the only means of responding to pond drying or die-offs and thus is critical to the maintenance of metapopulation dynamics. However, the ecology of metamorphosed salamanders outside of breeding tanks is virtually unknown. We are using radio-telemetry to assess STS terrestrial movement patterns, habitat preferences, and life history traits. Spatial information is important for wildlife managers to develop effective management strategies to conserve the Sonoran tiger salamander and other isolated amphibians.

Tomando el campo: Ecología terrestre de la salamandra tigre de Sonora en peligro de extinción

El conocimiento de los procesos ecológicos y de comportamiento es esencial para la conservación de las especies en peligro de extinción. Aproximadamente un tercio de todas las especies de anfibios están amenazadas o en peligro de extinción, y aquellas con distribución o tamaño de población limitada son particularmente vulnerables. Para desarrollar estrategias efectivas de conservación para anfibios en riesgo, los gerentes deben comprender sus requisitos ecológicos. La salamandra tigre de Sonora (STS; Ambystoma mavortium stebbinsi) es una subespecie en peligro federal que solo se encuentra en el valle de San Rafael, en el sureste de Arizona y el norte de Sonora, México. La STS se incluyó en la lista de especies en peligro de extinción en 1997 debido a la distribución altamente restringida, la dependencia de los entornos construidos por humanos, las especies invasoras, el hundimiento genético por salamandras no nativas y la enfermedad. Los tanques de ganado creados por los ganaderos para retener el agua han reemplazado a los manantiales naturales, y ahora son los criaderos principales de la STS. La etapa de la vida terrestre es el único medio para responder al secado o extinción de estanques y, por lo tanto, es fundamental para el mantenimiento de la dinámica de la metapoblación. Sin embargo, la ecología de las salamandras metamorfoseadas fuera de los tanques de cría es prácticamente desconocida. Estamos utilizando la radiotelemetría para evaluar los patrones de movimiento terrestre de la STS, las preferencias de hábitat y los rasgos del ciclo de vida. La información espacial es importante para que los administradores de vida silvestre desarrollen estrategias efectivas de manejo para conservar la salamandra tigre de Sonora y otros anfibios aislados.

NOTE: A manuscript was not submitted to accompany this presentation.

The use and efficacy of passive infrared (PIR) camera traps to monitor herpetofauna of Tonto National Monument

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The use of passive infrared (PIR) triggered wildlife cameras have been widely used for the monitoring of many types of mammal, bird, and fish species. The use of this technology for monitoring herpetofauna, however, is relatively nascent. Our pilot study aims to determine if PIR camera traps are an effective way to collect data for occupancy modeling of herpetofauna taxa at Tonto National Monument. Traditional herpetofauna monitoring techniques, while useful, are time intensive, costly, and can present dangers to the target species. The use of PIR technology can mitigate these detriments, while still providing continuous monitoring capabilities. The ease of setup and recovery, and a shallow operational learning curve makes PIR camera traps an attractive method for use by citizen scientist projects. While additional design and testing is needed, preliminary results indicate that the use of PIR camera trap arrays can be advantageous for the herpetofauna monitoring community, especially in conjuction with citizen science projects.

El uso y la eficacia de las trampas de cámara infrarroja pasiva (PIR) para monitorear la herpetofauna del Monumento Nacional Tonto

El uso de cámaras de vida silvestre desencadenadas por infrarrojos pasivos (PIR) se ha utilizado ampliamente para el monitoreo de muchos tipos de mamíferos, aves y especies de peces. El uso de esta tecnología para controlar la herpetofauna, sin embargo, es relativamente incipiente. Nuestro estudio piloto tiene como objetivo determinar si las trampas de la cámara PIR son una forma efectiva de recopilar datos para modelar la ocupación de los taxa de herpetofauna en el Monumento Nacional Tonto. Las técnicas tradicionales de monitoreo de herpetofauna, si bien son útiles, requieren mucho tiempo, son costosas y pueden presentar peligros para la especie objetivo. El uso de la tecnología PIR puede mitigar estos inconvenientes, al tiempo que proporciona capacidades de monitoreo continuo. La facilidad de configuración y recuperación, y una curva de aprendizaje operativa poco profunda hace que las cámaras trampa PIR sean un método atractivo para el uso de proyectos de científicos ciudadanos. Si bien se necesitan diseños y pruebas adicionales, los resultados preliminares indican que el uso de matrices trampa de cámara PIR puede ser ventajoso para la comunidad de monitoreo de herpetofauna, especialmente en conjunto con proyectos de ciencia ciudadana.

NOTE: A manuscript was not submitted to accompany this presentation.

Kingsnakes (*Lampropeltis spp.)* in southern Arizona: Distribution and hybridization

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Three forms of the Common Kingsnake complex (*Lampropeltis getula* s.l.) converge and overlap in southern Arizona and the surrounding region. These forms have variously been treated as full species or subspecies: the California Kingsnake, the Desert Kingsnake, and the Western Black Kingsnake. Hybridization/introgression of the different forms produces distinctive, recognizable pattern types in both captive crosses and in the wild. In the southern Arizona area, these hybrid pattern types extend from the area of the southern border of Arizona and New Mexico, west to near Sells, Pima County,

Arizona, north to the area of Tucson and northern Graham County, Arizona, and south to the Arizona-Mexico border. Desert Kingsnake influence enters the area from the east, and Western Black Kingsnake influence encroaches from the south. We will present observations from captive crosses of the three parent forms and discuss patterns and trends in the distribution of the three forms, and of hybrids among them.

Kingsnakes (Lampropeltis spp.) En el sur de Arizona: distribución e hibridación

Tres formas del complejo Common Kingsnake (Lampropeltis getula s.l.) convergen y se superponen en el sur de Arizona y la región circundante. Estas formas se han tratado varias veces como especies completas o subespecies: California Kingsnake, Desert Kingsnake y Western Black Kingsnake. La hibridación / introgresión de las diferentes formas produce tipos de patrones distintivos y reconocibles en cruzas cautivas y en la naturaleza. En el área del sur de Arizona, estos tipos de patrones híbridos se extienden desde el área del borde sur de Arizona y Nuevo México, al oeste hasta cerca de Sells, Condado de Pima, Arizona, al norte del área de Tucson y al norte del Condado de Graham, Arizona y al sur la frontera Arizona-México. La influencia de Desert Kingsnake ingresa al área desde el este, y la influencia de Western Black Kingsnake invade desde el sur. Presentaremos observaciones de cruzamientos cautivos de las tres formas parentales, y discutiremos patrones y tendencias en la distribución de las tres formas, y de híbridos entre ellas.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 36: Current Research on Herpetofauna of the Sonoran Desert and Sky Islands, Part #5

Tucumacori Highlands landscape, Coronado National Forest, Arizona
(Photo courtesy of the USDA Forest Service, Coronado National Forest)

Abstracts and Papers
Swann
Villa

Citizen science program for Gila Monsters at Saguaro National Park

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Gila monsters (Heloderma suspectum) have a fascinating allure to visitors in the Sonoran Desert. The University of Arizona, Saguaro National Park, and other partners have taken advantage of this interest during the past 6 years with a Citizen Science project that encourages park visitors to safely photograph Gila monsters and share their photos for their scientific value. Because Gila monster skin color patterns are relatively fixed in adults, we can use these photos to identify individuals and track them over long time periods. To date we have processed over 500 photos and have multiple photos of approximately 150 individuals, with a few individuals photographed on 7-10 occasions. We will present some of the results of these studies, describe the citizen science activities and other Gila monster datasets, and discuss potential future directions and applications of this project.

Programa de Ciencia Ciudadana para los Monstruos de Gila en el Parque Nacional Saguaro

Los monstruos de Gila (Heloderma suspectum) tienen un encanto fascinante para los visitantes en el desierto de Sonora. La Universidad de Arizona, el Parque Nacional Saguaro y otros socios han aprovechado este interés durante los últimos 6 años con un proyecto de Ciencia Ciudadana que alienta a los visitantes del parque a fotografiar de manera segura los monstruos de Gila y compartir sus fotos por su valor científico. Debido a que los patrones de color de la piel del monstruo de Gila están relativamente fijos en los adultos, podemos usar estas fotos para identificar a los animales y rastrearles durante largos períodos de tiempo. Hasta la fecha, hemos procesado más de 500 fotos y tenemos varias fotos de aproximadamente 150 personas, con algunos individuos fotografiados en 7-10 ocasiones. Presentaremos algunos de los resultados de estos estudios, describiremos las actividades de ciencia ciudadana y otros conjuntos de datos de monstruos de Gila, y discutiremos posibles direcciones futuras y aplicaciones de este proyecto.

NOTE: A manuscript was not submitted to accompany this presentation.

When Kware'epa tricked Yuku: Ethnoherpetology and conservation of the Sonoran Desert Toad (*Inclius alvarius*)

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Recent media attention in the last seven years has led to renewed popularity of the psychedelic properties of Sonoran Desert Toad (*Incilius alvarius* syn*. Bufo alvarius*). The powerful hallucinogen 5-meo-DMT was discovered in the skin of this toad 1967 and likely as a result became popular in 1984 with the circulation of a pamphlet and subsequent establishment of a church. *Incilus alvarius* is the only animal known to produce 5-meo-DMT. A brief natural history, misconceptions, ethnology, and comments on the unique threats and conservation challenges facing *I. alvarius* is presented.

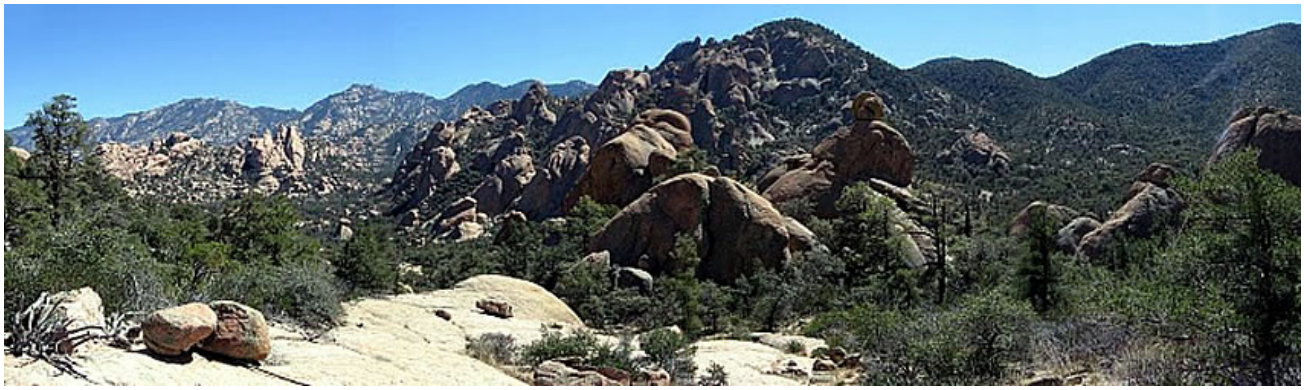
Cuando Kware'epa engañó a Yuku: etnoherpetología y conservación del sapo del desierto de Sonora (Inclius alvarius)

La atención reciente de los medios en los últimos siete años ha llevado a una renovada popularidad de las propiedades psicodélicas del Sapo del Desierto de Sonora (Incilius alvarius syn. Bufo alvarius). El poderoso alucinógeno 5-meo-DMT fue descubierto en la piel de este sapo de 1967 y, como resultado, se popularizó en 1984 con la circulación de un panfleto y el posterior establecimiento de una iglesia. Incilus alvarius es el único animal conocido que produce 5-meo-DMT. Se presenta una breve historia natural, conceptos erróneos, etnología y comentarios sobre las amenazas únicas y los desafíos de conservación que enfrenta I. alvarius.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 43: Mammals, Part #1



Santa Teresa Mountain landscape (Photo courtesy of the USDA Forest Service Coronado National Forest)

Abstracts and Papers
Cirett-Galan
Coronel
Gomez-Ramirez
Radke
Silva-Kurumiya
Traphagen
Van Devender

Conservation status of the American Beaver in the Bavispe River, Sonora, Mexico

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The American Beaver (*Castor canadensis*) is a key species the riparian ecosystems of North America. Despite its function, beaver populations have been decimated due to changes in the landscape and habitat fragmentation, including the riparian areas of northeastern Sonora. In this context, we conducted a diagnosis of the beaver population in the Bavispe River. We applied questionnaires to determine the perception of the beaver by users of the Bavispe River the municipalities of Huachinera, Bacerac, Bavispe, Agua Prieta, Nacozari de García and Fronteras. All respondents (n = 16) reported seeing a beaver recently. The community seems to know the beaver and relates it to their habits, although the presence of the river otter (*Lontra longicaudis*) could generate confusion. We also navigated the Bavispe River by kayak and surveyed for beavers from October 30 to November 30, 2016, covering 148 km. No beavers were seen, although we found 152 evidences of presence (tracks, burrows, trunks and recently gnawed branches) from Cóbora to the northern edge of the La Angostura dam basin. These tracks constitute an index of abundance that could be the basis for a more consistent monitoring effort for the species in Bavispe. It is necessary to implement control and management measures for the eradication of Tamarix to avoid severe damage to the beaver's habitat as well as direct education and dissemination efforts to make the beaver and otter known in the community, and their role in the ecosystem.

Estado de conservación del Castor Americano en el Río Bavispe, Sonora, México

El Castor americano (Castor canadensis) es una especie clave de los ecosistemas ribereños de América del Norte. A pesar de su función, las poblaciones de castores han sido diezmadas debido a los cambios en el paisaje y la fragmentación del hábitat, incluidas las áreas ribereñas del noreste de Sonora. En este contexto, llevamos a cabo un diagnóstico de la población de castores del río Bavispe. Aplicamos cuestionarios para determinar la percepción del castor por los usuarios del río Bavispe, los municipios de Huachinera, Bacerac, Bavispe, Agua Prieta, Nacozari de García y Fronteras. Todos los encuestados (n = 16) informaron haber visto un castor recientemente. La comunidad parece conocer el castor y lo relaciona con sus hábitos, aunque la presencia de la nutria de río (Lontra longicaudis) podría generar confusión. También navegamos por el río Bavispe en kayak y examinamos castores desde el 30 de octubre hasta el 30 de noviembre de 2016, cubriendo 148 km. No se vieron castores, aunque encontramos 152 evidencias de presencia (huellas, madrigueras, troncos y ramas recientemente roídas) desde Cóbora hasta el borde norte de la cuenca de la presa La Angostura. Estas pistas constituyen un índice de abundancia que podría ser la base de un esfuerzo de monitoreo más consistente para la especie en Bavispe. Es necesario implementar medidas de control y manejo para la erradicación de Tamarix para evitar daños severos al hábitat de los castores, así como también esfuerzos directos de educación y diseminación para que el castor y la nutria sean conocidos en la comunidad y su papel en el ecosistema.

NOTE: A manuscript was not submitted to accompany this presentation.

Current status of the last Prairie Dog colony in Sonora

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The black-tailed prairie dog (*Cynomys ludovicianus*) is a key species in its habitat as it interacts directly and indirectly with the flora and fauna that surrounds it, influencing plant succession, hydrology and the nutrient cycle. To obtain information on the conservation status of the last prairie dog colony in the San Pedro River Basin, censuses were conducted to calculate its population density by means of two sampling methods: linear transect of 1 km during 2014 and quadrants during 2015. The highest density obtained was during the month of June 2015, with a total of 9.72 individuals ha^{-1}. In order to strengthen the state of health of prairie dogs, they were supplemented with food pellets for small rodents during nine events in the period 2014-2015, supplementation proved to be a good strategy, since it was possible to appreciate a good state of health and body of individuals. To ensure the presence of the population of the black-tailed prairie dogs within the San Pedro River basin, it is necessary to ensure the conservation and creation of new colonies. It is necessary to strengthen the actions of participation and collaboration with the owner of the land to ensure the 52 ha where they are and to continue with the monitoring activities and with this help the permanence of the last colony of prairie dogs in Sonora.

Estado Actual de la Última Colonia de Perrito de la Pradera en Sonora

El perrito de la pradera de cola negra (Cynomys ludovicianus) es una especie de clave en su hábitat que interactúa de manera directa e indirectamente con la flora y la fauna que rodea la vegetación en la sucesión vegetal, la hidrología y el ciclo de nutrientes. Para obtener información sobre el estado de conservación de la última colonia de perrito de la pradera en la Cuenca del Río San Pedro se hizo censos para calcular su densidad poblacional por medio de dos métodos de muestreo: transecto lineal de 1 km durante 2014 y por cuadrantes durante 2015. La densidad más alta alcanzó durante el mes de junio de 2015, con un total de 9.72 individuales ha^{-1}. Con la finalidad de fortalecer el estado de salud de los perritos de la pradera, se suplementaron una base de alimento en pellets para pequeños roedores durante nueve períodos en el período 2014-2015, la suplementación demostró ser una buena estrategia, ya que se pudo apreciar un buen estado de salud y corporal de los individuos. Para asegurar la presencia de la población de los ríos de la pradera de cola negra dentro de la cuenca del Río San Pedro, es necesario asegurar la conservación y creación de nuevas colonias. Se requiere fortalecer las acciones de participación y colaboración con el dueño de la tierra para asegurar las 52 ha, donde se encuentran y se puede continuar con las actividades de monitoreo y con esto ayudar a la permanencia de la última colonia de perritos de la pradera en Sonora.

NOTE: A manuscript was not submitted to accompany this presentation.

First estimations of survival and density for the northernmost ocelot population

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The Northern Jaguar Reserve near Sahuaripa, Sonora, is also a refuge for a portion of the northernmost ocelot population. Nowadays, there are several efforts to generate knowledge and understand more about this population that reaches into southern Arizona through the Sky Islands. From January 2010 to July 2012, we continuously surveyed a 350 km² area using remote cameras as part of a general wildlife monitoring effort focused on jaguars. We estimated ocelot survival, abundance, and density by analyzing remote camera data and mark-recapture statistic models. We obtained 381 ocelot photographs corresponding to 33 individuals (8 females, 16 males, and 9 unidentified sex). Our results show that an average apparent survival was 0.65 for females and 0.63 for males; abundance estimates ranged from 2.02 ± 0.13 to 7.06 ± 0.24 ocelots. Ocelot density was 0.63 ± 0.06 females per 100 km² and 0.95 ± 0.08 males per 100 km². These density estimations are among the lowest values reported for the species across its distribution, principally in those areas where habitat loss and fragmentation are the main causes of ocelot populations decimating. However, we consider that our

results must be associated with natural processes rather than human-caused disturbance, without dismissing an additive factor by the latter.

Primeras estimaciones de supervivencia y densidad para la población de ocelotes más norteña

La Reserva Jaguar Norte, cerca de Sahuaripa, Sonora, es también un refugio para una porción de la población de ocelote más norteña. Hoy en día, hay varios esfuerzos para generar conocimiento y comprender más acerca de esta población que llega al sur de Arizona a través de las Islas Serranas. Desde enero de 2010 hasta julio de 2012, inspeccionamos continuamente un área de 350 km² utilizando cámaras remotas como parte de un esfuerzo general de monitoreo de vida silvestre centrado en los jaguares. Estimamos la supervivencia, abundancia y densidad del ocelote mediante el análisis de datos de cámaras remotas y modelos estadísticos de marcado y recaptura. Obtuvimos 381 fotografías de ocelote correspondientes a 33 individuos (8 mujeres, 16 hombres y 9 relaciones sexuales no identificadas). Nuestros resultados muestran que una supervivencia aparente promedio fue de 0.65 para las mujeres y 0.63 para los hombres; las estimaciones de abundancia variaron de 2.02 ± 0.13 a 7.06 ± 0.24 ocelots. La densidad del Ocelote fue de 0.63 ± 0.06 mujeres por cada 100 km² y 0.95 ± 0.08 hombres por cada 100 km². Estas estimaciones de densidad se encuentran entre los valores más bajos reportados para la especie a través de su distribución, principalmente en aquellas áreas donde la pérdida de hábitat y la fragmentación son las principales causas del diezmo de las poblaciones de ocelote. Sin embargo, consideramos que nuestros resultados deben estar asociados con procesos naturales en lugar de perturbaciones causadas por el ser humano, sin descartar un factor aditivo por este último.

NOTE: A manuscript was not submitted to accompany this presentation.

Effects of Beaver (*Castor canadensis*) Herbivory and Wildfire on Foliage Density and Woody Debris, San Pedro Riparian National Conservation Area, Arizona

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Beaver (*Castor canadensis*) were reintroduced beginning in 1999 on the San Pedro Riparian National Conservation Area. Herbivory is the most obvious effect from beaver, but little research exists of herbivory effects after reintroduction. Fire processes may also have substantial effects to vegetation, and both beaver and fire are important ecological components for comparing effects and subsequent management decisions. The objective of this research, conducted during 2008 and 2009, was to determine any effects to foliage density caused by beaver herbivory and wildfire as compared to control sites. There were significant differences in foliage density between control, beaver, and wildfire sites, with lower foliage density and at greater above-ground heights associated with wildfire sites. Although near the significance level, there were no interactions between control, beaver, or wildfire sites for changes in foliage density at different heights. Mean Fremont cottonwood, Goodding's willow, and seep willow foliage density was significantly different between control, beaver, and fire sites. Fremont cottonwood had significantly higher foliage density at control sites than at fire sites, but not between control and beaver sites or between beaver and fire sites. Goodding's willow density was significantly higher at control and beaver sites than fire sites, with no significant difference between control and beaver sites. Seep willow foliage density was significantly higher at control and beaver sites compared to fire sites, but not significantly different between control and beaver sites. Mean downed and dead wood cover was not significantly different between control, beaver, and fire-influenced sites, between beaver and control sites, between control and fire sites, or between beaver and fire sites. Management applications include more strategic wildfire planning and preparedness. This can be achieved

through integrated tamarisk control in the riparian area and using prescribed fire in upland habitats in order to reduce fire size and severities that threaten the riparian gallery forest and their ecosystem services.

Effects of Beaver (*Castor canadensis*) Herbivory and Wildfire on Foliage Density and Woody Debris, San Pedro Riparian National Conservation Area, Arizona

El castor (Castor canadensis) se reintrodujo a partir de 1999 en el Área de Conservación Nacional Riparia de San Pedro. La herbivoría es el efecto más obvio del castor, pero existen pocas investigaciones sobre los efectos de la herbivoría después de la reintroducción. Los procesos de fuego también pueden tener efectos sustanciales en la vegetación, y tanto el castor como el fuego son componentes ecológicos importantes para comparar efectos y decisiones de manejo posteriores. El objetivo de esta investigación, realizada durante 2008 y 2009, fue determinar cualquier efecto en la densidad del follaje causado por la herbivoría de los castores y los incendios forestales en comparación con los sitios de control. Hubo diferencias significativas en la densidad del follaje entre los sitios de control, castores e incendios forestales, con menor densidad de follaje y a mayores alturas sobre el suelo asociadas con los sitios de incendios forestales. Aunque cerca del nivel de significancia, no hubo interacciones entre los sitios de control, castores o incendios forestales para cambios en la densidad del follaje a diferentes alturas. La densidad media del follaje del álamo de Fremont, el sauce de Goodding y el sauce de filtración fue significativamente diferente entre los sitios de control, castor y fuego. El álamo de Fremont tenía una densidad de follaje significativamente mayor en los sitios de control que en los sitios de incendio, pero no entre los sitios de control y los castores o entre los castores y los sitios de fuego. La densidad de sauces de Goodding fue significativamente más alta en los sitios de control y castor que en los sitios de incendio, sin diferencias significativas entre los sitios de control y de castor. La densidad del follaje de los sauces fue significativamente mayor en los sitios de control y castor en comparación con los sitios de incendio, pero no significativamente diferente entre los sitios de control y castor. La cobertura media de madera caída y muerta no fue significativamente diferente entre los sitios de control, castores e influenciados por fuego, entre castores y sitios de control, entre control y sitios de incendio, o entre castores y sitios de incendio. Las aplicaciones de gestión incluyen planificación y preparación más estratégicas contra incendios forestales. Esto se puede lograr mediante el control integrado de tamariscos en el área ribereña y el uso de incendios prescritos en hábitats de tierras altas para reducir el tamaño y la gravedad de los incendios que amenazan el bosque de galería ribereño y sus servicios de ecosistema.

NOTE: The paper was not presented but a manuscript was submitted. ***The full paper follows.***

Effects of Beaver (*Castor canadensis*) Herbivory and Wildfire on Foliage Density and Woody Debris, San Pedro Riparian National Conservation Area, Arizona

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***Abstract**--Beaver (Castor canadensis) were reintroduced beginning in 1999 on the San Pedro Riparian National Conservation Area. Herbivory is the most obvious effect from beaver, but little research exists of herbivory effects after reintroduction. Fire processes may also have substantial effects to vegetation, and both beaver and fire are important ecological components for comparing effects and subsequent management decisions. The objective of this research, conducted during 2008 and 2009, was to determine any effects to foliage density caused by beaver herbivory and wildfire as compared to control sites. There were significant differences in foliage density between control, beaver, and wildfire sites, with lower foliage density and at greater above-ground heights associated with wildfire sites. Although near the significance level, there were no interactions between control, beaver, or wildfire sites for changes in foliage density at different heights. Mean Fremont cottonwood, Goodding's willow, and seep willow foliage density was significantly different between control, beaver, and fire sites. Fremont cottonwood had significantly higher foliage density at control sites than at fire sites, but not between control and beaver sites or between beaver and fire sites. Goodding's willow density was significantly higher at control and beaver sites than fire sites, with no significant difference between control and beaver sites. Seep willow foliage density was significantly higher at control and beaver sites compared to fire sites, but not significantly different between control and beaver sites. Mean downed and dead wood cover was not significantly different between control, beaver, and fire-influenced sites, between beaver and control sites, between control and fire sites, or between beaver and fire sites. Management applications include more strategic wildfire planning and preparedness. This can be achieved through integrated tamarisk control in the riparian area and using prescribed fire in upland habitats in order to reduce fire size and severities that threaten the riparian gallery forest and their ecosystem services.*

INTRODUCTION

After extirpation by fur trappers by 1894 (Bailey 1971), beaver (*Castor canadensis*) were reintroduced on the San Pedro Riparian National Conservation Area (SPRNCA) during 1999, 2000, and 2002 in a coordinated effort between the Bureau of Land Management (BLM) and Arizona Game and Fish Department. Based on an average of 5.2 beaver per colony (Collen and Gibson 2001), and about 20 colonies with 33 dams, the estimated beaver population on the SPRNCA was 100 by 2008.

In other areas, beaver herbivory has shown to be an important component in shaping vegetation communities, including tree density and basal area (Johnston and Naiman 1990), and herbaceous species richness (Wright et al. 2002). The effects of beaver and avian community structure have been studied on the San Pedro River (Johnson and van Riper 2014), but the effect of beaver herbivory to vegetation has not been previously studied on the SPRNCA. Effects to vegetation are important because of the occurrence of federally listed species on the SPRNCA that may nest in riparian vegetation, including southwestern willow flycatcher (*Empidonax traillii extimus*) and yellow-billed cuckoo (*Coccyzus americanus*). These riparian wetland ecosystems are also important habitat corridors for numerous wildlife species including other neotropical birds (Knopf et al. 1988).

Similar to beaver herbivory, fire may also have discernable effects to relative cover (Busch 1995) and structure (Bendix and Cowell 2010) of riparian vegetation. Because both beaver herbivory and fire may have significant impacts to riparian vegetation, it is important to document the effects of both processes compared to control areas, especially where beaver reintroduction has occurred. Foliage density is a clearly observable and quantifiable object affected by beaver herbivory and fire. Thus, the purpose of this research was to quantify the effects to foliage density caused by beaver herbivory or wildfire compared to control sites.

STUDY AREA

The SPRNCA, located in southeastern Arizona approximately 85 km (53 mi) southeast of Tucson, was established in 1988 with Public Law 100-696. This Congressional designation established the conservation area shall be managed "in a manner that conserves, protects, and enhances the riparian area…" by the BLM. The riparian area is the "river of green," largely surrounded by Chihuahuan desert scrub, and contains 85 km (51 mi) of the San Pedro River immediately north of Sonora, Mexico. The river flows from its headwaters in Mexico north approximately 208 km (130 mi) to join the Gila River. Fremont cottonwood (*Populus fremontii*)/Goodding's willow (*Salix gooddingii*) gallery forest occurs over the river's length from the International Boundary to approximately the historic ghost town of Contention about 64 km (40 river miles) north of Mexico. Thereafter, the cottonwood/willow gallery forest continues, but the river is invaded by increasing amounts of non-native tamarisk (*Tamarix ramosissima*) to the SPRNCA's northern boundary near St. David, Arizona.

METHODS

Foliage density data was collected during 2008 to 2009 during summer months when plant species were completely leafed. Areas influenced by beaver herbivory were located using UTM coordinates of 2008 active dams, and only included those sites with active and pre-existing beaver herbivory where beavers were known to have occupied for the longest time period since reintroduction. Data collected at control, beaver, and wildfire sites included identification of species (Fremont cottonwood, Goodding's willow, or seep willow – *Baccharis salicifolia*). Control sites were randomly chosen in the same river reach as beaver sites in order to limit variability with geomorphology, water regime, and vegetation differences. Wildfire sites were chosen using known wildfires that occurred in the riparian area on the SPRNCA.

Foliage density was estimated at 0 – 100% (in 5% segments) using a 1-m (3.3 ft) square density board (see Sanders and Flett 1989). A total of 40 plots (20 each on both the west and east side of the river) at each site were read at each of 0 to 1 (0 to 3.3 ft), 1 to 2 (3.3 to 6.6 ft), and 2 to 3 (6.6 to 9.8 ft) m heights at 5 m (16.4 ft) intervals. At beaver-influenced sites, 20 plots were read on the west side of the river, and 20 plots were read on the east side of the river, with the reader beginning at the dam. All plots were read by one observer. The species comprising the majority of the foliage in front of the board was the species recorded, and species recorded included Fremont cottonwood, Goodding's willow, and seep willow. Down and dead wood density was recorded using the same method.

The significance threshold for all analyses was 0.05. The *a priori* design to test for differences in percent foliage density was a parametric three-factor analysis of variance (ANOVA) using influence (control, beaver, and wildfire as three levels), species (Fremont cottonwood, Goodding's willow, seep willow, and wood as four levels, and 0 to 1, 1 to 2, and 2 to 3 m (0 to 3.3, 3.3 to 6.6, and 6.6 to 9.8 ft) heights as three levels. After data collection, normality for $n \geq 20$ was tested using the D'Agostino-Pearson K^2 test for normality (Zar 1999). Foliage density data sets were significantly different from normal; therefore, data lumping was utilized to increase the power of analyses when no significant differences were found within a factor. Species were lumped, and percent foliage density was analyzed using a two-factor ANOVA with treatment and height as the factors.

Assumptions for a parametric ANOVA were not met if a significant difference from normality existed for each data set. Significant differences in normality were exhibited with Fremont cottonwood, seep willow, and wood densities, but not for Goodding's willow. Other data sets that were not normal included the difference in foliage density between Fremont cottonwood, seep willow, and woody debris. In this case, a nonparametric Kruskal-Wallis ANOVA was used with tied ranks to assess significance, and any significant difference between groups was determined using nonparametric Mann-Whitney pairwise comparisons. Foliage density for Goodding's willow was analyzed using a one-way ANOVA with treatment (control, beaver, or wildfire-influenced) as the factor, and pairwise comparisons after ANOVA were analyzed using the Tukey test (Zar 1999).

RESULTS

There was a significant difference in foliage density (with all species lumped) between control, beaver, and wildfire sites (Figure 1; two-way ANOVA, $F=6.938$, $df=\infty$, $P=0.001$). Pairwise comparison indicated significant differences in foliage density between wildfire and control sites (Tukey test, $q=5.135$, $df=\infty$, $P=0.001$) and between wildfire and beaver sites (Tukey test, $q=4.676$, $df=\infty$, $P=0.003$), but not between control and beaver sites (Tukey test, $q=0.566$, $df=\infty$, $P=0.915$). Lower foliage density was detected at wildfire sites.

Significant differences existed in foliage density at different heights (Figure 1; two-way ANOVA, $F=7.544$, $df=\infty$, $P=0.001$). There was no significant interaction between control, beaver, or wildfire sites and changes in foliage density at different foliage heights (Figure 1; two-way ANOVA, $F= 0.192$, $df = \infty$, $P=0.05$). Significant differences in foliage density were found between control, beaver, and wildfire between 1 to 2 and 2 to 3 m (3.3 to 6.6 and 6.6 to 9.8 ft) heights (Tukey test, $q=3.693$, $df=\infty$, $P=0.025$; Figure 1), and between 0 to 1 and 2 to 3 m (0 to 3.3 and 6.6 to 9.8 ft) heights (Tukey test, $q= 5.374$, $df=\infty$, $P=0$; Figure 1). No significant difference existed between 0 to 1 and 1 to 2 m (0 to 3.3 and 3.3 to 6.6 ft) heights (Tukey test, $q=1.732$, $df=\infty$, $P=0.439$; Figure 1). Lower foliage density was directed at increased height. Significant differences were found with five comparisons between foliage density by influence and height, with lower foliage density directed at wildfire sites and increased height (least significant Tukey test, $q=4.392$, $df=\infty$, $P=0.05$). No significant difference existed between all other comparisons (most significant Tukey test, $q=3.646$, $df=\infty$, $P=0.197$).

Mean Fremont cottonwood cover was significantly different between control, beaver, and wildfire sites (Figure 2; Kruskall-Wallis test, $F=14.027$, $df=\infty$, $P<0.001$), with significantly higher foliage density at control sites than at wildfire sites (Mann-Whitney pairwise comparison, $P=0.018$). Mean foliage density of Fremont cottonwood was not significantly different between control and beaver sites (Mann-Whitney pairwise comparison, $P=0.138$) or between beaver and wildfire sites (Mann-Whitney pairwise comparison, $P=0.243$).

Goodding's willow mean foliage density cover was significantly different between control, beaver, and wildfire sites (Figure 3; one-way ANOVA, $F=9.927$, $df=121$, $P=0$), with higher foliage density at control sites (Tukey test, $q=5.783$, $df=121$, $P=0$) and at beaver sites (Tukey test, $q=5.682$, $df=121$, $P=0$) than at wildfire sites. Mean foliage density of Goodding's willow was not significantly different between control and beaver sites (Tukey test, $q=0.646$, $df=121$, $P=0.891$).

Mean seep willow cover was significantly different between control, beaver, and wildfire sites (Figure 4; Kruskall-Wallis test, $F=4.185$, $df=\infty$, $0.02<P<0.05$), with significantly higher foliage density at control sites (Mann-Whitney pairwise comparison, $P=0.004$) and beaver sites (Mann-Whitney pairwise comparison, $P=0.02$) than at wildfire sites. Mean foliage density of seep willow was not significantly different between control and beaver sites (Mann-Whitney pairwise comparison, $P=0.71$).

Woody debris cover was not significantly different between control, beaver, and wildfire sites (Figure 5; Kruskall-Wallis test, $F=1.079$, $df=75$, $P>0.50$), with no significant difference between beaver and control sites (Mann-Whitney pairwise comparison, $P=0.15$.), between control and wildfire sites (Mann-Whitney pairwise comparison, $P=0.90$), or between beaver and wildfire sites (Mann-Whitney pairwise comparison, $P=0.29$).

DISCUSSION

There was no significant difference in foliage density between control and beaver sites, but a significant difference existed between control and wildfire sites, and between beaver and wildfire sites. Lower foliage density was associated with wildfire sites rather than control or beaver sites. Effects from beaver sites spanned a maximum of 10 years. Conversely, wildfire sites spanned a range of 10 to 19 years since the wildfire occurred.

The significantly higher Fremont cottonwood foliage density at control and beaver sites compared to wildfire sites, suggests the ecological adaptation of Fremont cottonwood to beaver herbivory by vegetative resprouting and their lack of adaptation to fire, suggested by high mortality and much lower resprouting rates (Finch et al. 1995, Bateman et al.

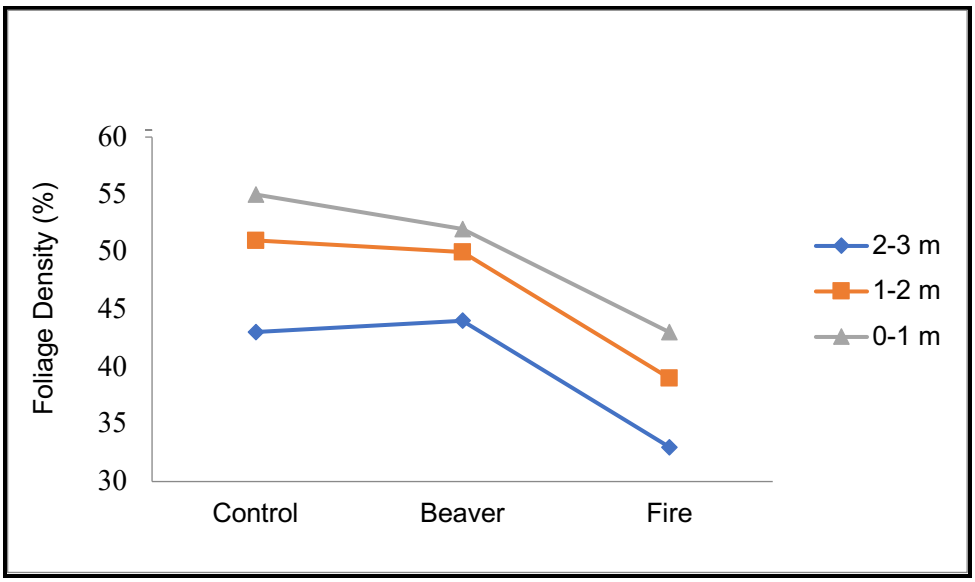

Figure 1. Mean foliage density (percent) at 0 to 1, 1 to 2, and 2 to 3 m (0 to 3.3, 3.3 to 6.6, and 6.6 to 9.8 ft) heights between control, beaver, and wildfire sites, San Pedro Riparian National Conservation Area, 2008 to 2009.

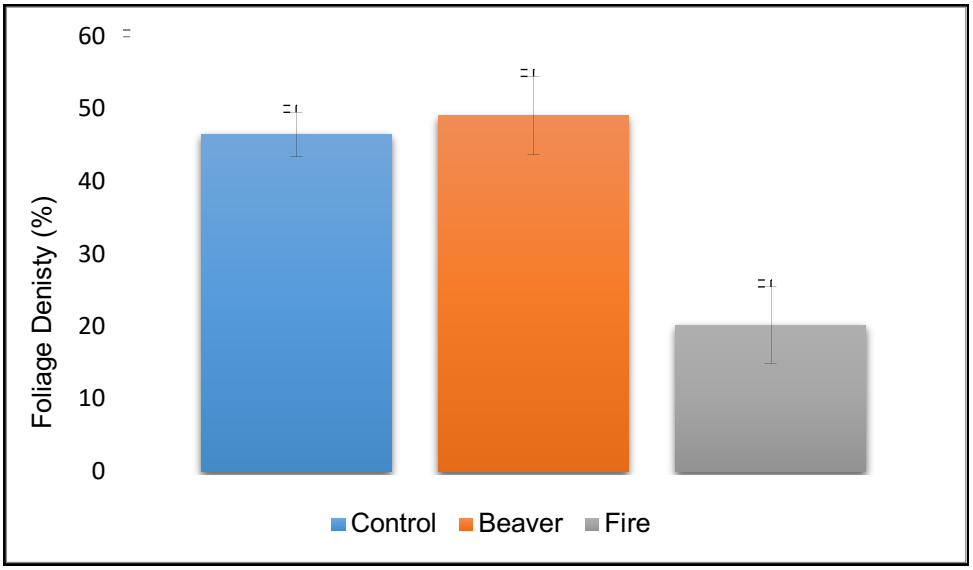

Figure 2. Mean (± standard error) foliage density of Fremont cottonwood at 0 to 3 m (0 to 9.8 ft) height between control, beaver, and wildfire sites, San Pedro Riparian National Conservation Area, 2008 to 2009.

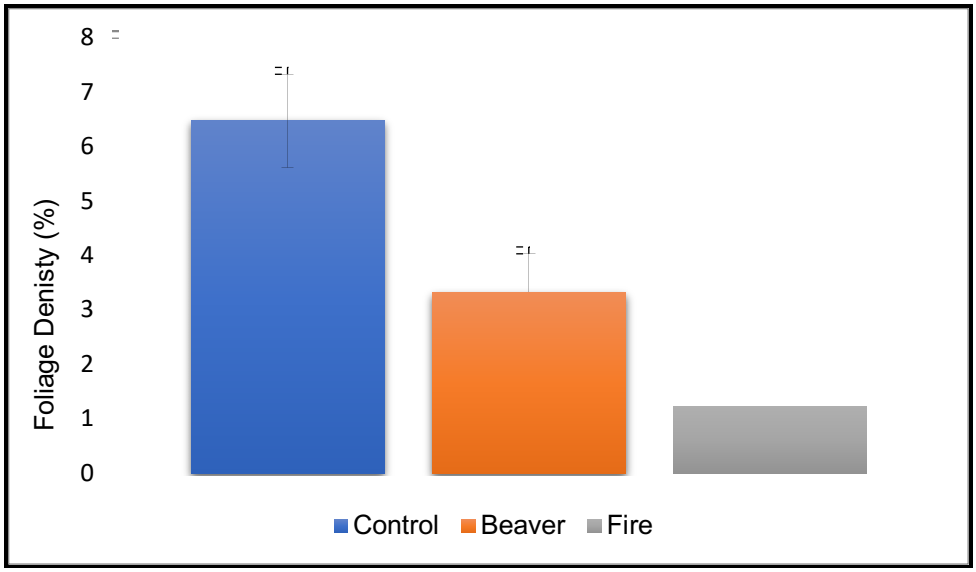

Figure 3. Mean (± standard error) foliage density of Goodding's willow at 0 to 3 (0 to 9.8 ft) height between control, beaver, and wildfire sites, San Pedro Riparian National Conservation Area, 2008 to 2009.

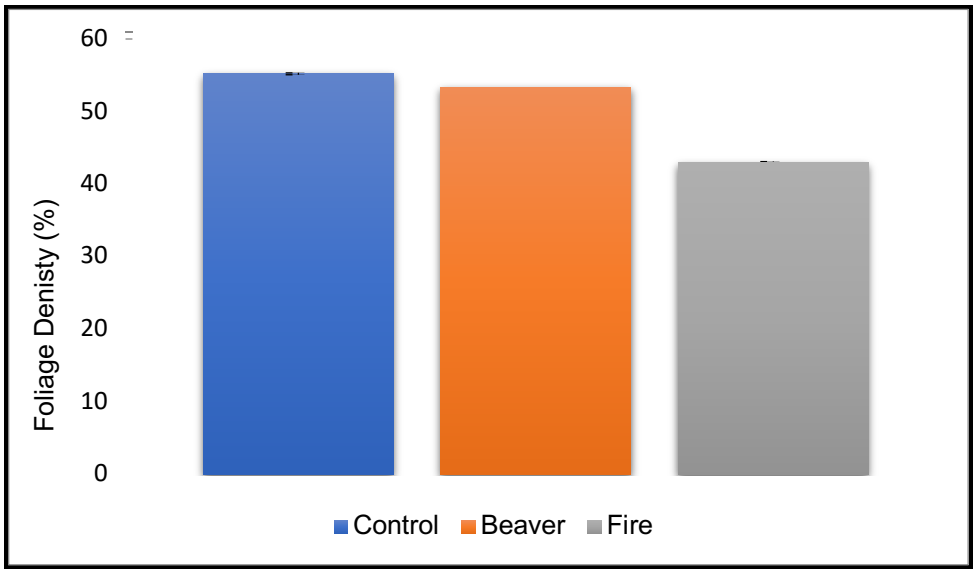

Figure 4. Mean (± standard error) foliage density of seep willow at 0 to 3 m (0 to 9.8 ft) height between control, beaver, and wildfire sites, San Pedro Riparian National Conservation Area, 2008 to 2009.

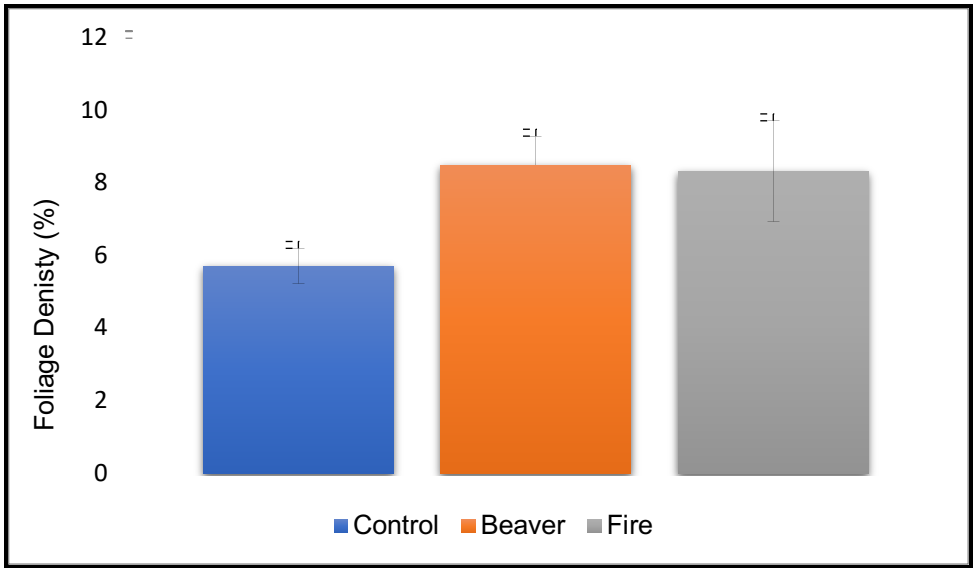

Figure 5. Mean (± standard error) density of downed and dead wood at 0 to 3 m (0 to 9.8 ft) height between control, beaver, and wildfire sites, San Pedro Riparian National Conservation Area, 2008 to 2009.

2013). High-severity wildfire commonly kills cottonwood roots, as evidenced by the amount of large tree-fall consisting of branches and trunks of killed cottonwoods with no resprouts in the wildfire areas. Cottonwoods may resprout from the base (McGinley and Whitham 1985) and resprouting cottonwood occurs at beaver sites on SPRNCA. Thus, past wildfire on the SPRNCA currently has more effect on cottonwood foliage density than beaver herbivory even given the longer time span since wildfire occurred.

Similarly, there was a significantly higher foliage density of Goodding's willow at control and beaver sites compared to wildfire sites, but not a significant difference between control and beaver sites. Mean Goodding's willow foliage density (approximately 50%) was higher than Fremont cottonwood (approximately 3%) at beaver influenced sites and higher (approximately 20%) than cottonwood (approximately 1%) at wildfire sites, indicating the superior ability of willow to resprout after beaver herbivory and wildfire. Old wildfire scars in the riparian area are still apparent on SPRNCA. The scars show qualitatively that Goodding's willow has regrown after the wildfire and much of the Fremont cottonwood has been removed.

Foliage density over all species between control, beaver, and wildfire sites was similar between 0 to 1 and 1 to 2 m (0 to 3.3 and 3.3 to 6.6 ft) in height, but density decreased significantly between 1 to 2 and 2 to 3 m (3.3 to 6.6 and 6.6 to 9.8 ft), and between 0 to 1 and 2 to 3 m (0 to 3.3 and 6.6 to 9.8 ft) in height. The interaction between density and height among control, beaver, and wildfire was also near the significance level. Seep willow also had significantly higher mean foliage density at control and beaver sites compared to wildfire sites, but not a significant difference between control and beaver sites. This may be attributed to thick stands of seep willow, reaching approximately 3 m (9.8 ft) in height at a maximum with stems no more than approximately 3.5 cm (1.4 in) in diameter, over much of the San Pedro River's edge. In contrast to Goodding's willow and especially Fremont cottonwood, seep willow readily resprouts after removal by beaver or wildfire. These willows may quickly regain prior height and density in the matter of a few years. Thus, seep willow may account for the likeness in foliage density between control, wildfire, and beaver sites at 0 to 1 m (0 to 3.3 ft) height.

Similarly, significant differences in foliage density between control, beaver, and wildfire sites between the 1 to 2 and 2 to 3 m (3.3 to 6.6 and 6.6 to 9.8 ft) height may also be due to life history traits of vegetation species. Both Fremont cottonwood and Goodding's willow grow to maximum heights taller than seep willow, with Goodding's willow and Fremont cottonwood attaining approximately 20 m and 30 m (66 to 98 ft) in height, respectively. As discussed previously,

cottonwood does not resprout after high-severity wildfire on the SPRNCA, although Goodding's willow readily resprouts after wildfire, but takes longer to reach its maximum height than seep willow. Thus, results indicate that the significant decrease in foliage density between 1 to 2 m and 2 to 3 m (3.3 to 6.6 and 6.6 to 9.8 ft) may be from wildfire that removes Goodding's willow and Fremont cottonwood, at least for longer time periods than beaver herbivory and longer times than seep willow from wildfire.

Large woody debris cover was not significantly different between control, beaver, and wildfire sites. The San Pedro River reaches flood events of several thousand cubic feet per second approximately every second or third year, with these flushing flows capable of moving woody debris throughout the main stem of the river. These flood events may redistribute woody debris so that any differences between control, beaver, and wildfire sites are negated.

Large woody debris is used by BLM as an indicator of riparian health during Proper Functioning Condition assessment (PFC; USDI Bureau of Land Management 1998). Indicator 13 of this assessment investigates whether floodplain and channel characteristics, such as rocks, overflow channels, coarse and/or large woody debris, are adequate to dissipate energy from flood flows. Wildfire may remove woody debris, while beaver may increase the amount of downed trees, at least locally and temporarily. Therefore, it is important that recruitment of younger tree stands from scouring natural flood regimes and redistribution of woody debris remain important ecohydrological processes of the San Pedro River.

These results indicate that Fremont cottonwood, Goodding's willow, or seep willow do not recover similarly following beaver herbivory or wildfire events, even though each species is capable of resprouting under suitable environmental conditions. The 2012 National Riparian Service Team (NRST) PFC assessment for the SPRNCA notes that impacts of wildfire on cottonwood galleries was evident, but large-scale destabilization of banks or other adverse effects to the channel were not observed (USDI Bureau of Land Management 2012). Rather, wildfire promoted shrubs and herbaceous plants that also stabilize banks. Nevertheless, recommendations from the NRST included maintenance of the maximum number of cottonwood stands to achieve riparian function and associated resource values, because it is expected that cottonwood on the terraces will decrease in extent as trees become senescent. The risk of increasing wildfire size and severity is great given exotic species' adaption to fire, fuel loading, drought, and climate warming (CITE?). The use of prescribed fire to restore upland grasslands and to create fuel breaks may be challenging given the relatively narrow north-south band of public land on the SPRNCA.

Perhaps these few years since reintroduction were still too early to ascertain quantifiable effects from beaver herbivory to the riparian vegetation parameter addressed during this study. However, beaver effects may become stronger with more time post-reintroduction. For example, cottonwood resprouts from beaver herbivory were relatively infrequent during 2008, with only a few observed, but appeared more frequent and with increased height during later years. Resprouts from beaver herbivory and/or seedling recruitment in beaver sites after flood events may eventually change foliage density between control and beaver sites in the future. Other future changes may include expanded wetlands created by beaver habitats, which also reduce wildfire risk in these areas due to increased water, relative humidity, and fuel moisture. Beaver induced/enhanced wetlands may also increase natural detritivore and microbial activity that feed on woody debris, further improving the condition of floodplain soil.

MANAGEMENT IMPLICATIONS

Research was conducted only a few short years after beaver reintroduction. Effects to ecohydrological components after beaver reintroduction are little-known. Beaver reintroduction assessments, including impacts to vegetation, other wildlife, and hydrology, should continue on SPRNCA.

Better wildfire planning and preparedness should be more fully integrated into land management planning to reduce the size and severity of future fire events, and their impacts to riparian and wetland habitats (Smith et al. 2009). Wildfire planning should include the following concepts.

Tamarisk did not occur within the sites used for this study, beaver herbivory to tamarisk was observed on SPRNCA on only one small plant, and tamarisk is not known to be a species favored by beaver. Because longer-term browsing by

beaver may cause vegetation to be replaced by shrubs of non-preferred species (Donkor and Fryxell 2000), foliage density of tamarisk may change over time given beaver herbivory to preferred species. Tamarisk is highly adapted to wildfire, outcompeting native plants after wildfire. With potential effects of beaver herbivory and wildfire to native species, and tamarisk's superior adaptation to fire, tamarisk control should continue on the SPRNCA to manage for a possible community shift away from native species.

Prescribed fire on SPRNCA should be conducted in grassland and upland habitats in order to reduce fuel loading, create natural fuel breaks, and thereby protect the cottonwood/willow gallery forest from high-severity wildfire. Even so, prescribed fire would not likely prevent all wildfires from entering the riparian gallery and a mosaic of habitat would be expected following wildfire. This mosaic may be important for future cottonwood recruitment.

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Mammals documented in wildlife cameras in the highlands of Sonora, Mexico

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The mammal fauna of the mountains of eastern and central Sonora was studied using wildlife cameras. In 2011, 2014, and 2015. Cameras were placed at 118 sites in the municipalities of Cumpas, Huásabas, Moctezuma, Nácori Chico, and Villa Hidalgo in the Madrean Archipelago, and Yécora in the Sierra Madre Occidental. The camera traps were installed according to the methodology of Díaz-Pulido (2017) and checked monthly. The vegetation sampled at the monitoring sites included foothills thornscrub, oak woodland, and pine-oak and pine forests. The images documented five orders, 17 families, and 25 species of mammals. Three species are protected in NOM-059-SEMARNAT-2010 (the Mexican endangered species law): *Leopardus pardalis, Sciurus arizonensis,* and *Ursus americanus*. The most common species recorded were *Urocyon cineroargenteus, Nasua narica, Odocoileus virginianus, Pecari tajacu, Canis latrans, Lynx rufus, Spermophilus variegatus,* and *Didelphis marsupialis*.

Mamíferos documentados en cámaras de vida silvestre en las tierras altas de Sonora, México

La fauna de mamíferos de las montañas del este y centro de Sonora se estudió utilizando cámaras de vida silvestre en 2011, 2014 y 2015. Se colocaron cámaras en 118 sitios en los municipios de Cumpas, Huásabas, Moctezuma, Nácori Chico y Villa Hidalgo en el archipiélago de Madrense, y Yécora en la Sierra Madre Occidental. Las cámaras trampa se instalaron de acuerdo con la metodología de Díaz-Pulido (2017) y se verificaron mensualmente. La vegetación muestreada en los sitios de monitoreo incluyó estribaciones de espinas, bosques de robles y bosques de pinos y robles. Las imágenes documentaron cinco órdenes, 17 familias y 25 especies de mamíferos. Tres especies están protegidas en NOM-059-SEMARNAT-2010 (la ley mexicana de especies en peligro de extinción): Leopardus pardalis, Sciurus arizonensis y Ursus americanus. Las especies más comunes registradas fueron Urocyon cineroargenteus, Nasua narica, Odocoileus virginianus, Pecari tajacu, Canis latrans, Lynx rufus, Spermophilus variegatus y Didelphis marsupialis.

NOTE: A manuscript was not submitted to accompany this presentation.

Habitat connectivity for the White-Sided Jackrabbit (*Lepus callotis gaillardi*) between the United States and Mexico: the border divides a species

MYLES TRAPHAGEN

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First described by Edgar Mearns near Border Monument 65 in New Mexico during the International Boundary Commission survey in 1895, the white-sided jackrabbit (*Lepus callotis gaillardia*) is a nocturnal hare that inhabits the Madrean Plains Grassland valleys and foothills of the eastern Sierra Madre, ranging from just north of the Rio Nazas in Durango, Mexico and reaching its northern limit in Hidalgo County, New Mexico where there exists a single population of about 65 animals. Formerly, the species enjoyed an unbroken corridor between the U.S. and Mexico, but since the 1990s a population decline has occurred, and the US population is separated from its nearest cousins in Mexico by about 100 km. To assess connectivity, a least cost path model was developed utilizing points from historic survey locations of

jackrabbits, along with Landsat imagery from 1984 to 2014 that quantified land cover change. In the 30-year period since 1984, a 300% increase in woody shrub cover has resulted in a shrub-dominated savannah that is poor habitat for *Lepus callotis*. In 2011 spotlight surveys were repeated on transects regularly surveyed since 1976 by the New Mexico Department of Game & Fish. Transects that experienced a reduction in hare density from 0.03 ha^{-1} to 0.01 ha^{-1} recorded 18 times more Border Patrol vehicles versus private vehicles. Roadkill was documented on these transects. Transects that were free of Border Patrol experienced no change in density. However, the conspicuous decline in areas where Border Patrol vehicles were observed to cause roadkill, suggests that securing the homeland may come at a significant cost to biodiversity. This places the continued survival of the white-sided jackrabbit in doubt.

Conectividad del hábitat para la liebre de cara blanca (Lepus callotis gaillardi) entre los Estados Unidos y México: la frontera divide una especie

Descrita por primera vez por Edgar Mearns cerca de Border Monument 65 en Nuevo México durante la encuesta de la Comisión Internacional de Fronteras en 1895, la liebre de cara blanca (Lepus callotis gaillardia) es una liebre nocturna que habita en los valles de las praderas Madrenses y en las estribaciones de la Sierra Madre oriental. que van desde justo al norte del río Nazas en Durango, México y que alcanzan su límite norte en el condado de Hidalgo, Nuevo México, donde existe una sola población de alrededor de 65 animales. Anteriormente, la especie disfrutaba de un corredor ininterrumpido entre los Estados Unidos y México, pero desde la década de 1990 se ha producido un declive poblacional y la población de los Estados Unidos está separada de sus primos más cercanos en México en unos 100 km. Para evaluar la conectividad, se desarrolló un modelo de ruta de costo mínimo utilizando puntos de lugares de estudio históricos de liebres, junto con imágenes Landsat de 1984 a 2014 que cuantificaron el cambio de cobertura de la tierra. En el período de 30 años desde 1984, un aumento del 300% en la cobertura de arbustos leñosos ha resultado en pastizal dominado por arbustos que es hábitat deficiente para Lepus callotis. En 2011, se repitieron las encuestas de mira en transectos regularmente inspeccionados desde 1976 por el Departament of Game and Fish de Nuevo México. Los transectos que experimentaron una reducción en la densidad de liebre de 0.03 / hectareas a 0.01 / hectareas registraron 18 veces más vehículos de la Patrulla Fronteriza que vehículos privados. Se documentaron atropellos en estos transectos. Los transectos libres de la Patrulla Fronteriza no experimentaron cambios en la densidad. Sin embargo, la notable disminución en las áreas donde se observó que los vehículos de la Patrulla Fronteriza causaron accidentes, sugiere que asegurar la patria puede tener un costo significativo para la biodiversidad. Esto pone en duda la supervivencia continua de la liebre de lados blancos.

NOTE: A manuscript was not submitted to accompany this presentation.

Mammals of the Lower Río Bavispe Valley, Sonora, Mexico

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Project WILDCAT is predator conservation project south of Granados in the Río Bavispe Valley, Municipios de Granados and Divisaderos, Sonora, Mexico. In November 2015, wildlife cameras were placed at 14 sites on six ranches. Cameras were check at two-month intervals for a year, and again beginning in April 2017 until the present. Several cameras were moved nearby due to flooding. The vegetation is foothills thornscrub dominated in some areas by *Acacia cochliacantha, Aloysia gratissima, Coursetia glandulosa, Dodonaea viscosa, Fraxinus gooddingii, Haematoxylum brasiletto, Mimosa distachya,* and *Prosopis velutina*. Riparian vegetation dominated by A*cacia occidentalis, Baccharis salicifolia, Hymenoclea monogyra, Populus fremontii,* and *Salix gooddingii* occurs along the Río Bavispe, Arroyo Bacadéhuachi, and larger arroyos. Twenty species of mammals were photographed by the cameras. The most common species are white-tailed deer (*Odocoileus virginianus*), grey fox (*Urocyon cineoreoargenteus*), coatimundi (*Nasua narica*), rock squirrel

(*Spermophilus variegatus*), and skunks (three species). Native cats included mountain lion (*Puma concolor*, common), ocelot (*Leopardus pardalis*, common), bobcat (*Lynx rufus*, uncommon), and jaguar (*Panthera onca*, uncommon). Images of a female jaguar and her cub on Rancho Barragan southwest of Granados in January 2016 are an important breeding record. Ocelots were seen at 16 camera sites - most of them on multiple dates. Grey foxes were documented eating a newborn javelina (*Pecari tajacu*) and an adult green ratsnake (*Senticolis triaspis*). A mountain lion ate a Yaqui slider (*Trachemys yaquia*). Racoons (*Procyon lotor*) and badgers (*Taxidea taxus*) are rare in the area.

Mamíferos del Bajo Río Bavispe Valley, Sonora, México

El proyecto WILDCAT es un proyecto de conservación de depredadores al sur de Granados en el Valle del Río Bavispe, Municipios de Granados y Divisaderos, Sonora, México. En noviembre de 2015, se colocaron cámaras de vida silvestre en 14 sitios en seis ranchos. Las cámaras se controlaron en intervalos de dos meses durante un año, y de nuevo a partir de abril de 2017 hasta el presente. Varias cámaras se movieron cerca debido a las inundaciones. La vegetación es el arbusto espinoso dominado en algunas áreas por Acacia cochliacantha, Aloysia gratissima, Coursetia glandulosa, Dodonaea viscosa, Fraxinus gooddingii, Haematoxylum brasiletto, Mimosa distachya y Prosopis velutina. La vegetación ribereña dominada por Acacia occidentalis, Baccharis salicifolia, Hymenoclea monogyra, Populus fremontii y Salix gooddingii ocurre a lo largo del Río Bavispe, Arroyo Bacadéhuachi y arroyos más grandes. Veinte especies de mamíferos fueron fotografiadas por las cámaras. Las especies más comunes son el ciervo de cola blanca (Odocoileus virginianus), el zorro gris (Urocyon cineoreoargenteus), el coatimundi (Nasua narica), la ardilla de roca (Spermophilus variegatus) y zorrillos (tres especies). Los gatos nativos incluyeron el puma (Puma concolor, común), el ocelote (Leopardus pardalis, común), el gato montés (Lynx rufus, poco común) y el jaguar (Panthera onca, poco común). Las imágenes de un jaguar hembra y su cachorro en Rancho Barragán, al suroeste de Granados en enero de 2016, son un importante registro de reproducción. Los ocelotes se vieron en 16 sitios de cámara, la mayoría de ellos en múltiples fechas. Los zorros grises fueron documentados comiendo una javelina recién nacida (Pecari tajacu) y una rata verde adulta (Senticolis triaspis). Un león de montaña se comió un deslizador yaqui (Trachemys yaquia). Los mapaches (Procyon lotor) y los tejones (Taxidea taxus) son raros en el área.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 44: Mammals, Session #2

Whetstone Mountains landscape, Coronado National Forest, Arizona
(Photo courtesy of the USDA Forest Service)

Abstracts and Papers
Alcalá #1
Alcalá #2
Alcalá #3
Blanco
Christianson
Marin
Van Devender

Abundance of Wild Felines in the Sierra de Álamos Flora and Fauna Protection Area-Cuchujaqui River, Álamos, Sonora

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Wild cats play important roles in the dynamics of the tropical forests where they live through the predation processes they exert on their prey. The populations of these carnivorous mammals have decreased throughout their range, due to conflicts with the human use landuse, destruction and fragmentation of their habitat. In order to know the abundance of the wild cats of the APFF-SARC, a monitoring study was carried out with 105 trap-chambers during two sampling periods (August-October and October-December 2016) in two sites of the reserve. The duration of the sampling was 120 days, obtaining an effort of 3,474 camera days for the two periods. Sixteen species of mammals were recorded, among which the jaguar (Panthera onca), the puma (Puma concolor), lynx (Lynx rufus) and the ocelot (Leopardus pardalis) stand out. The jaguar was photo-captured 13 times and in five stations within the reserve. Five individuals were identified, of which three were males and two were indeterminate sex. Regarding the indices of abundance (reg./100 days-cameras) the felines with the highest value were the puma with 1.08 and the ocelot with 1.88 for the first and second period respectively. As regards the density of the jaguar, it was estimated 1.43 (± 0.60) individuals / 100 km^2. The photographic trapping was an efficient tool to estimate the abundance and density of the wild cats in the area, besides it allowed to determine the presence and relative abundance of other species of mammals.

Abundancia de Felinos Silvestres en el Área de Protección de Flora y Fauna Sierra de Álamos-Rio Cuchujaqui, Álamos, Sonora

Los felinos silvestres a través de los procesos de depredación que ejercen sobre sus presas juegan papeles importantes en la dinámica de los bosques tropicales donde habitan. Las poblaciones de estos mamíferos carnívoros han disminuido en toda su área de distribución, debido a conflictos con el uso de suelo del ser humano, por la destrucción y fragmentación su hábitat. Con la finalidad de conocer la abundancia de los felinos silvestres del APFF-SARC, se realizó un monitoreo con 105 cámaras-trampa durante dos periodos de muestreo (agosto-octubre y octubre-diciembre del 2016) en dos sitios de la reserva. La duración del muestreo fue de 120 días, obteniéndose un esfuerzo de 3,474 días-cámaras para los dos periodos. Se registraron 16 especies de mamíferos, entre las que destacan el jaguar (Panthera onca), el puma (Puma concolor), lince (Lynx rufus) y el ocelote (Leopardus pardalis). El jaguar fue foto-capturado en 13 ocasiones y en cinco estaciones dentro de la reserva. Se identificaron cinco individuos, de los cuales tres eran machos y dos sexo indeterminado. En cuanto a los índices de abundancia (reg./100 días-cámaras) los felinos con el valor más alto fueron el puma con 1.08 y el ocelote con 1.88 para el primer y segundo periodo respectivamente. En lo que respecta a la densidad del jaguar se estimó 1.43 (±0.60) individuales/100 km^2. El trampeo–fotográfico fue una herramienta eficiente para estimar la abundancia y densidad de los felinos silvestres en el área, además permitió determinar la presencia y abundancia relativa de otras especies de mamíferos.

Note: Full Paper Follows

Abundance of Wild Felids in the Area of Protection of Flora and Fauna Sierra de Álamos-Rio Cuchujaqui, Álamos, Sonora

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Naturalia Comité para la Conservación de Especies Silvestres A.C.

Abstract-- *Wild felids play an important role in the dynamics of the tropical forests where they live, through the processes of depredation they exert on their prey. The populations of these carnivorous mammals have decreased throughout their range, due to conflicts with humans, habitat destruction and fragmentation. In order to know the abundance of wild cats in the Area of Protection of Flora and Fauna Sierra de Álamos-Cuchujaqui, a monitoring was carried out with the 105 trap cameras during two sampling periods (August-September and October-December of 2016) in two sites in the protected area. The duration of the sampling was 120 days, obtaining an effort of 3,474 camera days for the two periods. Sixteen species of mammals were recorded, among which highlights the jaguar (Panthera onca), the puma (Puma concolor), the bobcat (Lynx rufus) and the ocelot (Leopardus pardalis). The jaguar was photographed 13 times and in five stations within the area. Five individuals were identified, of which three were males and two were not able to determine their sex. The highest indices of abundance were for the puma (1.08) in the first period and for the ocelot (1.88) in the second period. A density of 1.43 (± 0.60) ind / 100 km^2 of jaguar was estimated. The photographic trapping was an efficient tool to estimate the abundance and density of wild cats in the area and allowed to determine the presence and relative abundance of other mammal species.*

Keywords: Panthera onca, Leopardus pardalis, photo-trapping, Leopardus weidii.

INTRODUCTION

The Area of Protection of Flora and Fauna Sierra de Álamos- Rio Cuchujaqui (APFF-SARC) is distinguished by its high diversity and biological richness. Around 1,100 species of higher plants that representing 67 percent of the families recognized for Sonora, and more than 500 species of vertebrates, among which 351 of birds, 101 of mammals (including the jaguar), 72 of reptiles, 20 amphibians and 14 fish species confluence the area (SEMARNAT-CONANP 2015, Zarate 2012). This biological richness is the reason due some scientists consider this reserve as "the treasure of the Western Sierra Madre" (SEMARNAT-CONANP 2015).

The biodiversity conservation needs as well as the ecological and evolutionary processes in the region of the APFF-SARC are very important because of their geographical location and representativeness at the country level. Therefore, it is essential to design and execute appropriate strategies and management plans that ensure the maximum productive efficiency of agricultural and forestry systems in a manner compatible with the conservation of biological diversity and ecological continuity of the water-soil-vegetation-wildlife system (Zarate 2012).

To establish conservation plans for wild felids such as the jaguar (*Panthera onca*), puma (*Puma concolor*), ocelot (*Leopardus pardalis*), tigrillo (*Leopardus weidii*) and bobcat (*Lynx rufus*) in the APFF-SARC, it is necessary to generate information on the conservation status of their populations, their prey and the quality of the habitat where they are found (Aranda 2012; Krebs 1999; Garshelis 2000). Due to the above, this study has the purpose of knowing the state of the populations of felines and their prey by means of the photo-trapping method.

METHODS

Study area

The APFF Sierra de Álamos and Rio- Cuchujaqui is located in the south of the state of Sonora and has a variety of physiographic conditions (Figure 1), and soil conformation that together with climatic and edaphic conditions define a variety of plant associations that correspond mainly:

Deciduous forest 64%, plant community from 4 to 15 m high where more than 75% of the species lose leaves during the dry season.

Oak forest 19%, located in temperate climates and at altitudes greater than 800 m.

Modified vegetation for agricultural, livestock and forestry use 10%. The activity that makes use of forest and livestock resources, can be permanent or temporary.

Pine forest 7%, located in the highest parts of the reserve and represented by several species of the *Pinus* genus (SEMARNAT-CONANP 2015).

Estimation of wild felines populations

We used the photo-trapping based on capture-recapture model method to estimate the density of jaguars with the closed population model (Karanth and Nichols, 1998; Silver et al., 2004). Two sampling periods were carried out between the months of August-September and October-December 2016, in the first period 26 stations were installed (21 paired), while in the second were 29 stations of which 24 were paired, for both periods the stations were placed for a spatial design and temporarily closed. Each sampling season was based on different sites: the first included the area known as the Cuchujaqui River, and the second sampling was at the site called Sierra de Álamos (Figure 2). Each station was separated approximately 1 to 3 km.

Each sampling season comprised a period of 60 days, which is similar to the previous methods used for felines (Karanth and Nichols, 1998, Trolle and Kéry, 2003, Silver et al., 2004, Maffei et al., 2005; Di Bitteti et al., 2006; Dillon and Kelly, 2007). Each period was considered as a sampling event and a closed population was assumed (Trollé et al., 2007). The cameras were placed following the methodology of Karanth and Nichols (1998) and Chávez et al. (2013), in sites with potential for the crossing of these felines such as trails, streams, roads and canyons (Aranda 2012). The cameras were installed at an approximate height of 50 cm from the ground, attached to tree trunks or stakes. The circuit of the cameras was programmed to remain active for 24 hours, to take pictures every 15 seconds, the cameras used were the models Moultrie M-880, Cuddeback Ambush and Attack. The cameras were revised at the end of each sampling period.

Through the photographic record, the jaguar individuals were identified by the unique rosette pattern, where each specimen was assigned a name and a unique code. Subsequently, a capture history was drawn up for each photographed jaguar individual, generating a matrix of presence (1) - absence (0) according to the sampling days (Trolle and Kery 2003).

To obtain the number of jaguars that exist in the sampled area, the MARK program was used in its CAPTURE module, which distinguishes between different capture scenarios and gives a selection of the best model that explains the probability of capture as well as an estimate of the population size (White et al. 1982; White 2008). To estimate the population density, the value of the abundance of jaguars estimated by the CAPTURE program was divided between the Effective Surveyed Area.

The density was defined as: Density (D): estimated jaguar abundance (N) / effective surveyed area. The effective surveyed area (ESA) was calculated by the method described by Karanth and Nichols (1998) and Silver et al. (2004), which consists of adding an area around the perimeter formed by the trap cameras and thus delimiting a "buffer area" from which the animals were captured. The area of influence was estimated based on the average size of the household area that has been recorded for the species (100 km^2, USFWS 2012).

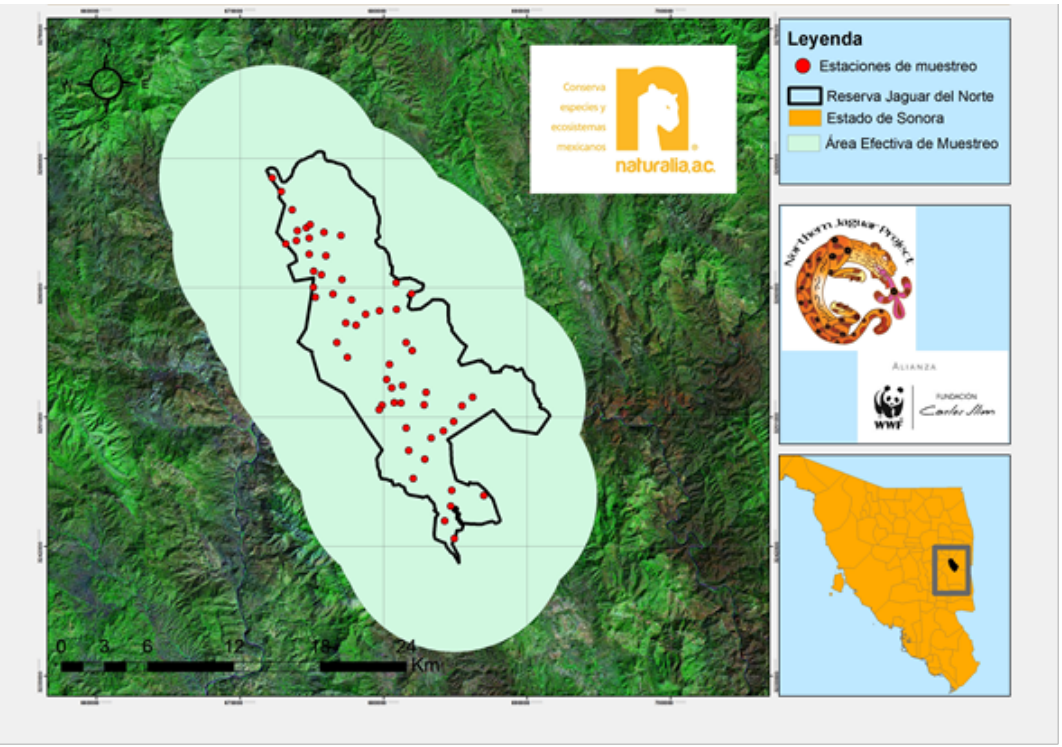

Figure 1. Location of the APFF Sierra de Alamos and Cuchujaqui River Sonora, Mexico.

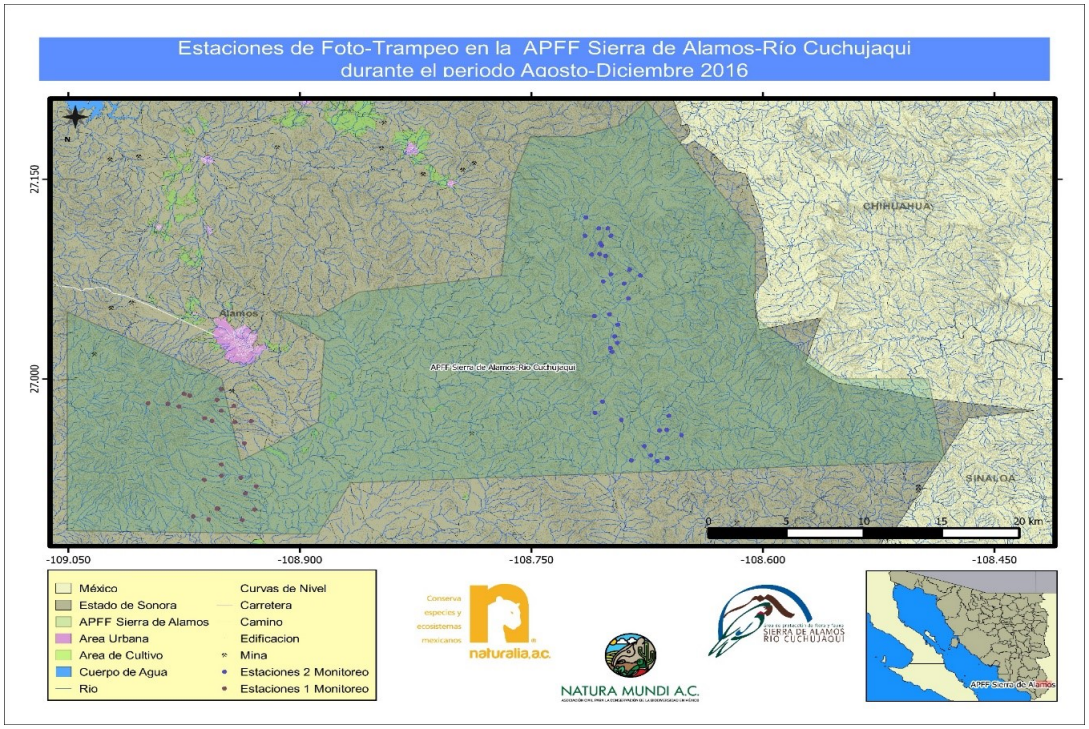

Figure 2. Camera-trap stations for monitoring jaguar (Panthera onca) in APFF Sierra de Álamos- Rio Cuchujaqui in August-December 2016.

To obtain the relative abundance index (IAR) of the ocelots, the formula suggested by Maffei et al. (2002) IAR = (C / EM) x 100 days / trap. Where: C is the captures or independent events photographed; EM is the total sampling effort (number of trap cameras multiplied by the sampling days) and 100 days / trap (capture frequency standardizing to 100 days / trap). To avoid over-estimations, only those records that were independent with a 24-hour gap between each event were considered in the analyzes. An independent record was considered as: 1) consecutive photographic records where it was not possible to identify the jaguar as a distinct individual, 2) consecutive photographic records of completely identifiable different individuals, and 3) photographic records with several individuals considering each individual as an event.

RESULTS

Sampling was realized during 120 days in the two periods: August-September and October-December 2016, where a total sampling effort of 3,474 camera-days was obtained in both periods. As for the fauna, it was possible to register the five species of felines present in the reserve (jaguar, puma, lynx, ocelot, and tigrillo), as well as their main prey (white-tailed deer, collared peccary, wild turkey, and jackrabbit antelope; Table 1).

Regarding the jaguar records, 13 photo-captures were obtained, three corresponded to the first monitoring site (Sierra de Alamos) and ten to the second (Cuchujaqui River). With respect to the indices of relative abundance, a total sampling effort of 3,474 camera days was obtained. The most abundant feline species for both periods were puma and ocelot (Figure 3).

In order to estimate the density, five jaguar individuals were identified. Two individuals were photo-captured at the Sierra de Alamos site, and three at the Cuchujaqui River. Regarding the results obtained from the MARK Program for the first site, an abundance of two jaguar individuals was obtained, and the Capture selection algorithm indicated that the most suitable model was M (b), which is applied when the animals have different reactions to capture, that is, when the probability of capture differs between previously captured individuals and non-captured individuals, due to the response behavior they exhibit. In the case of the second site, an abundance of five individuals was obtained, the model that fitted the data the most was the M (h), which incorporates the individual heterogeneity, that is, a single probability of capture for each individual as a consequence of the accessibility that these have to the traps by the activity, the social dominance or the differences in age or sex. The estimated capture probability (*P*) varied from 0.01 to 0.03. The calculation of the effective sampling area was based on a buffer area of 4.96 km (which was estimated based on the home range of 100 km^2), which resulted in an ESM of 267 km^2 and 349 km^2 for the first and second sites respectively (Table 2).

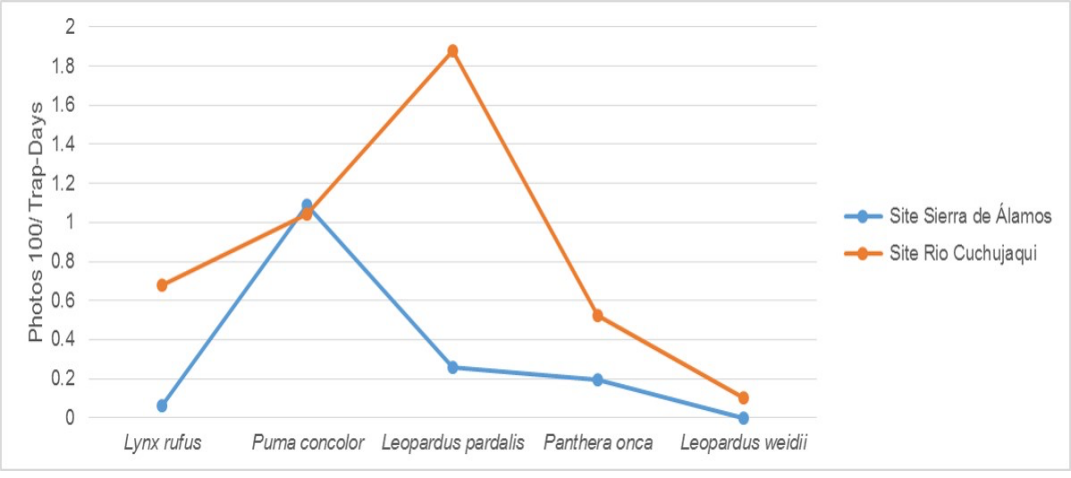

Figure 3. Index of relative abundance estimate by photo-trapping in the APFF Sierra de Alamos Rio Cuchujaqui, Sonora (August-December 2016). IAR (Photos/100 Camera-Days).

Table 1. Species of vertebrates with interest for the conservation of the jaguar (*Panthera onca*) recorded in the APFF Sierra de Álamos-Río Cuchujaqui. List based on the taxonomic order of the species from the guide of mammals of Reid, (2006), Aranda (2012) and of the birds of the American Union of Ornithologists (1998).

ORDER, Family, genus and specie	Common name	Direct sighting	Indirect sign	Photo-capture
CARNIVORA				
Canidae				
Canis latrans Say, 1823	Coyote	X	X	X
Urocyon cinereoargenteus(Schreber, 1775)	zorra gris		X	X
Felidae				
Puma concolor (Linnaeus, 1771)	Puma		X	X
Panthera onca (Linnaeus, 1758)	Jaguar			X
Leopardus pardalis (Linnaeus, 1758)	Ocelote			X
Leopardus weidii (Schinz, 1821)	Tigrillo			X
Lynx rufus (Eschreber, 1777)	Gato montés			X
Procyonidae				
Bassariscus astutus (Lichtenstein, 1830)	Cacomixtle norteño			X
Procyon lotor (Linnaeus, 1758)	Mapache			X
Nasua narica (Linnaeus, 1766)	Cholugo	X		X
Mephitidae				
Mephithis mephithis (Schreber, 1776)	Zorrillo rayado			X
Conepatus leuconotus (Lichtenstein, 1832)	Zorrillo real			X
Spilogale gracilis (Merriam, 1890)	Zorrillo manchado			X
ARTIODACTYLA				
Tayassuidae				
Pecari tajacu (Linnaeus, 1758)	pecarí de collar	X		X
Cervidae				
*Odocoileus virginianus Z*immermann,1780	Venado cola blanca	X	X	X
LAGOMORPHA				
Leporidae				
Lepus alleni (Mearns, 1890)	Liebre	X	X	X
GALLIFORMES				
Phasianidae				
Meleagris gallopavo (Linnaeus, 1758)	Guajolote	X		X
Psittacidae				
Ara militaris (Linnaeus, 1766)	Guacamaya verde	X		

Table 2. Abundance and density (Ind / 100 km^2) of jaguar (*Panthera onca*) estimates from closed-capture method in the APFF Sierra de Álamos-Río Cuchujaqui during the period August-December 2016.

Site	August-December 2016				
	Abundance	**S.E.**	**ESM** (km^2)	**Density**	**S.E.**
Sierra de Álamos (Aug-Sep 2016)	2	0.73	267	0.74	0.27
Rio Cuchujaqui (Oct-Dec 2016)	5	2.12	349	1.43	0.60

DISCUSSION

In the APFF Sierra de Alamos Rio Cuchujaqui the densities obtained for the jaguar by means of photographic trapping were able to estimate 0.74-1.4 ind / 100 km^2, which is similar to that obtained in other regions of Sonora, as is the case of the Reserve Jaguar del Norte where jaguar density values varies from 0.78 - 1.5 ind / 100 km^2 (Amador et al. 2015), as well as in the municipality of Nacori Chico where they have obtained densities of 1.0 ind / 100km^2 (Rosas-Rosas and Bender 2012). In contrast, with the density obtained for the same area in 2013, which was 2.15 ind / km^2 (Gutiérrez et al. 2013). The difference in densities may be due to jaguar hunting that occurred in the area in retaliation for the depredation of cattle in recent years 2015-2016 (Amador et al. 2017). This density is low compared to those reported in other reserves of the country with low forest ecosystems such as: Chamela-Cuixmala Jalisco (2 ind / km^2, Nuñez, et al. 2011), Reserva de la Biosfera Maya, Guatemala (2 ind / km^2; Novack et al. 2005) and in the Calakmul Biosphere Reserve (3-7 ind / 100km^2; Chávez 2006). It is important to mention that during the surveyed period extraordinary environmental and climatic events (flooding of rivers and streams) that prevented five camera-trap stations from working correctly during all the time, which caused the loss of stations with high photographic potential catches of wild cats. In this region where the vegetation is a mixture of dry deciduous forest, xerophilous scrub and oak-pine forests, the density of jaguars is low due they require larger territories to satisfy their needs for shelter and food (Urness 1981). Also, illegal hunting and killing of specimens due to reprisals against cattle depredation caused by jaguars and other carnivores, may cause the populations of these felines to be scattered and present low numbers (Rosas-Rosas et al., 2008).

SUMMARY

The estimated jaguar densities in this region of northwest Mexico are among the lowest for the country. The survival of the jaguar and other felines in the APFF-SARC will depend on whether the extensions of the tropical forest remain unchanged from land use and that the cases of hunting of felines and other species are punished in an exemplary manner as the law indicates. Meanwhile, it is important to continue with the studies and monitoring of wild cats and work with producers to develop strategies for sustainable livestock management that will reduce the damage caused by the depredation of large carnivores.

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Abundancia de Felinos Silvestres en el Área de Protección de Flora y Fauna Sierra de Álamos-Rio Cuchujaqui, Álamos, Sonora

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Resumen--*Los felinos silvestres juegan un papel importante en la dinámica de los bosques tropicales donde habitan, a través de los procesos de depredación que ejercen sobre sus presas. Las poblaciones de estos mamíferos carnívoros han disminuido a lo largo de su área de distribución, debido a conflictos con el humano, la destrucción y fragmentación del hábitat. Con la finalidad de conocer la abundancia de los felinos silvestres del Área de Protección de Flora y Fauna Sierra de Álamos-Río Cuchujaqui, se realizó un monitoreo con el 105 cámaras-trampa durante dos periodos de muestreo (agosto-septiembre y octubre-diciembre del 2016) en dos sitios en el área protegida. La duración del muestreo fue de 120 días, obteniéndose un esfuerzo de 3,474 días-cámaras para los dos periodos. Se registraron 16 especies de mamíferos, entre las que destacan el jaguar (Panthera onca), el puma (Puma concolor), el lince (Lynx rufus) y el ocelote (Leopardus pardalis). El jaguar fue fotografiado en 13 ocasiones y en cinco estaciones dentro del área. Se identificaron cinco individuos, de los cuales tres eran machos y dos no se logró determinar su sexo. Los índices de abundancia más altos fueron para el puma (1.08) en el primer periodo y para el ocelote (1.88) en el segundo periodo. Se estimó una densidad de 1.43 (±0.60) ind/100 km^2 de jaguar. El trampeo–fotográfico fue una herramienta eficiente para estimar la abundancia y densidad de los felinos silvestres en el área, y permitió determinar la presencia y abundancia relativa de otras especies de mamíferos.*

Palabras clave: *Panthera onca, Leopardus pardalis*, foto-trampeo, *Leopardus weidii*.

INTRODUCCIÓN

El Área de Protección de Flora y Fauna Sierra de Álamos-Río Cuchujaqui (APFF-SARC) se distingue por presentar alta diversidad y riqueza biológica. Se han registrado alrededor de 1,100 especies de plantas superiores que representan el 67 por ciento de las familias reconocidas para Sonora, más de 500 especies de vertebrados, entre los que destacan 351 de aves, 101 de mamíferos (entre ellos el jaguar), 72 de reptiles, 20 de anfibios y 14 especies de peces (SEMARNAT-CONANP 2015; Zarate 2012). Esta riqueza biológica es la razón por la que algunos científicos consideran a esta reserva como "el tesoro de la Sierra Madre Occidental" (SEMARNAT-CONANP 2015).

Las necesidades de conservación de la biodiversidad al igual que de los procesos ecológicos y evolutivos en la región de la APFF-SARC son muy importantes por su ubicación geografica y representatividad a nivel de país. Por ello, es imprescindible diseñar y ejecutar apropiadamente estrategias y planes de manejo que aseguren la máxima eficiencia productiva de los sistemas agropecuarios y forestales en forma compatible con la conservación de la diversidad biológica y continuidad ecológica del sistema agua-suelo-vegetación-fauna silvestre (Zarate 2012).

Para establecer planes de conservación de los felinos silvestres como el jaguar (*Panthera onca*), puma (*Puma concolor*), ocelote (*Leopardus pardalis*), tigrillo (*Leopardus weidii*) y gato montes (*Lynx rufus*) en la APFF-SARC, es necesario generar información sobre el estado de conservación de sus poblaciones, sus presas y la calidad del hábitat donde se encuentran (Aranda 2012; Krebs 1999; Garshelis 2000). Debido a lo anterior, este estudio tiene el propósito de conocer el estado de las poblaciones de felinos y sus presas mediante el método de foto-trampeo.

MÉTODOS

Área de estudio

La APFF Sierra de Álamos y Río Cuchujaqui se encuentra localizada al sur del estado de Sonora y presenta una variedad de condiciones fisiográficas (Figura 1), y de conformación de suelos que aunado a las condiciones climáticas y edáficas define una variedad de asociaciones vegetales que corresponden principalmente:

Selva baja caducifolia 64%, comunidad vegetal de 4 a 15 m de altura en donde más del 75 % de las especies pierden las hojas durante la época de secas.

Bosque de encino 19%, localizados en climas templados y en altitudes mayores a los 800 m.

Vegetación modificada por uso agrícola, pecuario y forestal 10%. Actividad que hace uso de los recursos forestales y ganaderos, puede ser permanente o de temporal.

Bosque de pino 7%, localizado en las partes más elevadas de la reserva y representada por varias especies del genero *Pinus* (SEMARNAT-CONANP 2015).

Estimación de las poblaciones de felinos silvestres

Se utilizó el método captura-recaptura empleando el foto-trampeo para estimar la densidad de jaguares con el modelo de población cerrada (Karanth y Nichols 1998; Silver et al. 2004). Se realizaron dos periodos de muestreo entre los meses de agosto-septiembre y octubre-diciembre del 2016, en el primer periodo se instalaron 26 estaciones (21 pareadas), mientras que en el segundo fueron 29 estaciones de las cuales 24 eran pareadas, para ambos periodos las estaciones estuvieron colocadas para que presentaran diseño espacial y temporalmente cerrrado. Cada temporada de muestreo se úbico en sitios diferentes: el primero abarco el área denominada Rio Cuchujaqui; y el segundo muestreo fue en el sitio llamado Sierra de Álamos (Figura 2). Cada estación estuvo separada aproximadamente de 1 a 3 km.

Cada temporada de muestreo comprendió un periodo de 60 días, el cual es similar a los métodos previos usados para felinos (Di Bitteti et al. 2006; Dillon y Kelly 2007; Karanth y Nichols 1998; Maffei et al. 2005; Trolle y Kéry 2003; Silver et al. 2004). Se consideró a cada periodo como un evento de muestreo y se asumió una población cerrada (Trolle et al. 2007).

Las cámaras se colocaron siguiendo la metodología de Karanth y Nichols (1998) y Chávez et al. (2013), en los sitios con potencial para el cruce de estos felinos como veredas, arroyos, caminos y cañadas (Aranda 2012). Las cámaras se instalaron a una altura aproximada de 50 cm del suelo, sujetadas a trocos de árboles o en estacas. El circuito de las cámaras fue programado para permanecer activo durante las 24 horas, tomar fotografías cada 15 segundos, las cámaras utilizadas fueron de los modelos Moultrie M-880, Cuddeback Ambush y Attak. Las cámaras se revisaron al finalizar cada periodo de muestreo.

Por medio del registro fotográfico, se identificaron los individuos de jaguar por el patrón único de rosetas, donde a cada ejemplar se le asignó un nombre y una clave única. Posteriormente, se elaboró un historial de captura para cada individuo de jaguar fotografiado generando así una base de presencia (1)- ausencia (0) de acuerdo a los días de muestreo (Trolle y Kery 2003).

Para obtener el número de jaguares que existen en el área muestreada se utilizó el programa MARK en su módulo CAPTURE el cual distingue entre distintos escenarios de captura y da una selección del mejor modelo que explica la probabilidad de captura así como un estimado del tamaño poblacional (White et al. 1982; White, 2008). Para estimar la densidad poblacional, se dividió el valor de la abundancia de jaguares estimada por el programa CAPTURE entre el Área

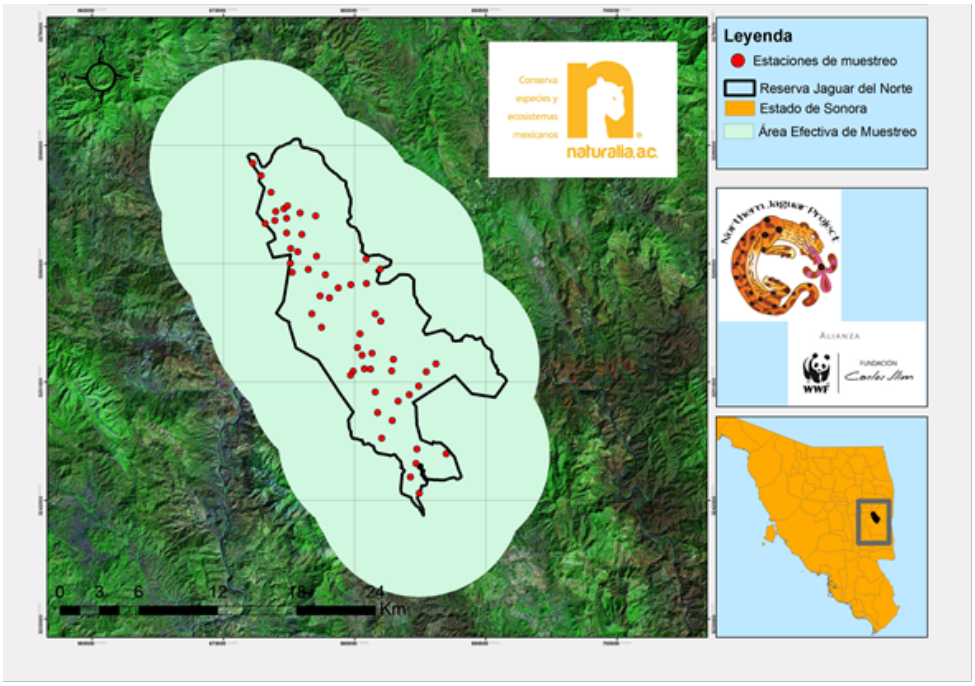

Figura 1. Localización del APFF Sierra de Álamos y Río Cuchujaqui Sonora, México.

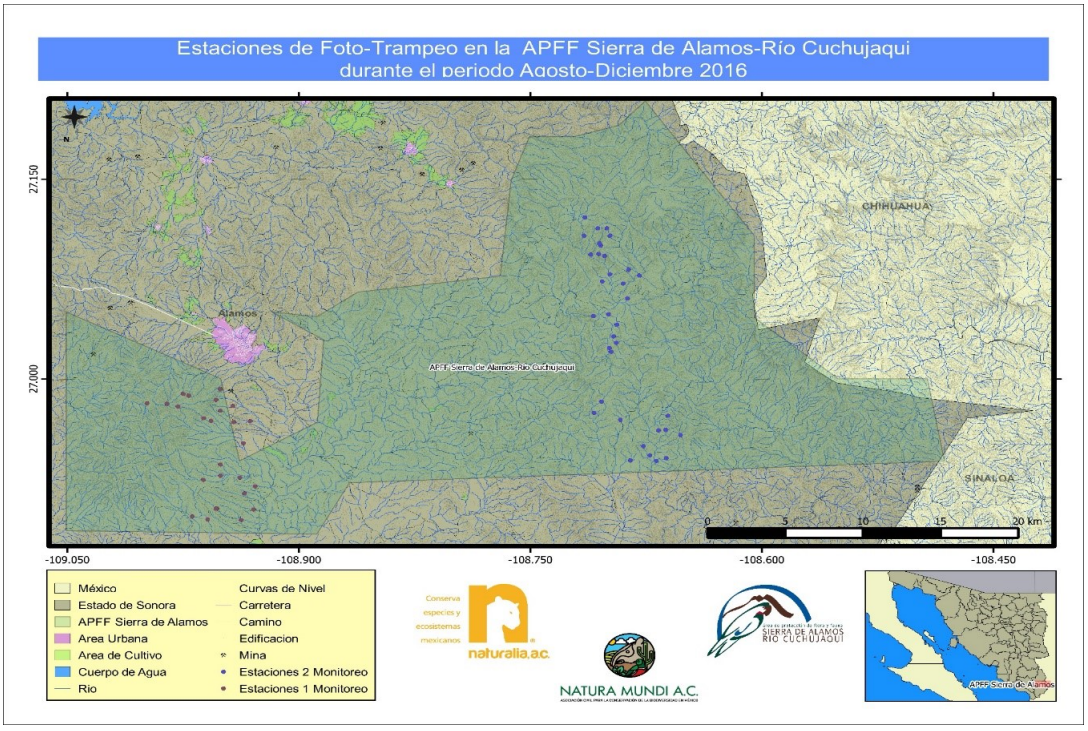

Figura 2. Estaciones cámara-trampa para el monitoreo del jaguar (Panthera onca) en APFF Sierra de Álamos- Río Cuchujaqui en agosto-diciembre de 2016.

Efectiva de Muestreo (AEM). La densidad se definió como: Densidad (D): abundancia de jaguares estimada (N)/ área efectiva muestreada (AEM)

El área efectiva de muestreo (AEM) se calculó mediante el método descrito por Karanth y Nichols (1998) y Silver et al. (2004), que consiste en añadir un área alrededor del perímetro conformado por las cámaras–trampa y así delimitar un "área de influencia" desde la cual los animales fueron capturados. El área de influencia se estimó con base en el tamaño promedio del ámbito hogareño que se ha registrado para la especie (100 km^2; USFWS, 2012).

Para obtener el índice de abundancia relativa (IAR) de los ocelotes, se utilizó la formula sugerida por Maffei *et al.* (2002) IAR = (C/EM) x 100 días / trampa. Dónde: C son las capturas o eventos independientes fotografiados; EM es el esfuerzo de muestreo total (número de cámaras trampa multiplicado por los días de muestreo) y 100 días/trampa (frecuencia de captura estandarizando a 100 días/trampa). Para evitar sobre estimaciones, se consideraron en los análisis sólo aquellos registros que fueran independientes con un lapso de separación de 24 horas entre cada evento. Un registro independiente fue considerado como: 1) registros fotográficos consecutivos en donde no fuera posible identificar al ocelote como un individuo distinto, 2) registros fotográficos consecutivos de individuos diferentes completamente identificables, y 3) registros fotográficos con varios individuos considerando a cada individuo como un evento.

RESULTADOS

Se muestreo durante 120 días en los dos períodos: agosto-septiembre y octubre-diciembre del 2016, donde se obtuvo un esfuerzo total de muestreo de 3,474 días-cámara en ambos periodos. En cuanto a la fauna se logró registrar a las cinco especies de felinos presentes en la reserva (jaguar, puma, lince, ocelote y tigrillo), así como a sus presas principales (venado cola blanca, pecarí de collar, guajolote silvestre y liebre; Tabla 1).

En cuanto a los registros de jaguar se obtuvieron 13 foto-capturas, tres correspondieron al primer sitio de monitoreo (Sierra de Alamos) y diez al segundo (Río Cuchujaqui). Con respecto a los índices de abundancia relativa se obtuvo un esfuerzo de muestreo total de 3,474 días-cámara. Las especies de felinos más abundantes para ambos períodos fueron el puma y el ocelote (Figura 3).

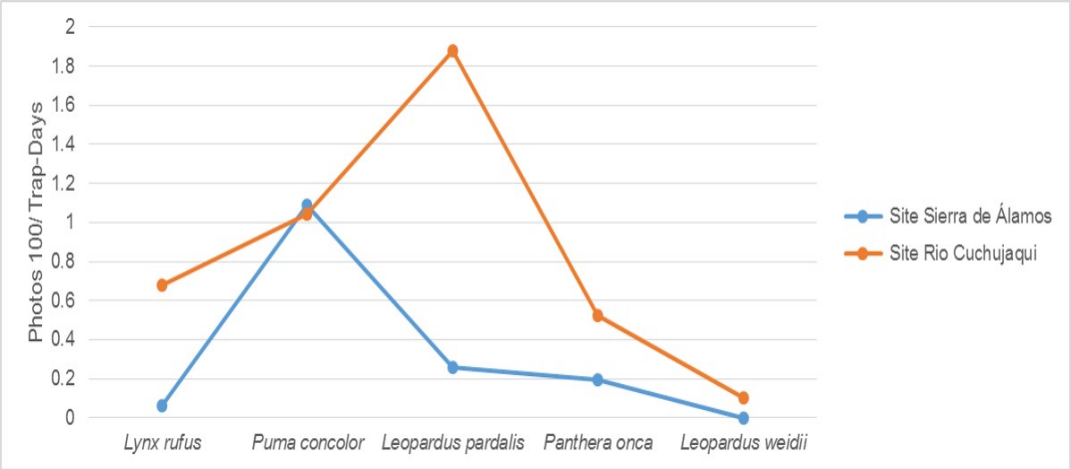

Figura 3. Índice de estimación de abundancia relativa por foto-trampas en la APFF Sierra de Alamos Río Cuchujaqui, Sonora (agosto-diciembre de 2016). IAR (Fotos / 100 días-cámara).

Para la estimación de la densidad se lograron identificar cinco individuos de jaguar. Dos individuos fueron foto-capturados en el sitio Sierra de Alamos, y tres en Río Cuchujaqui. En cuanto a los resultados obtenidos del Programa MARK para el primer sitio se obtuvo una abundancia de dos individuos de jaguar, y el algoritmo de selección de *Capture*

indico que el modelo más adecuado fue M(b), el cual se aplica cuando los animales tienen distintas reacciones a la captura, es decir, cuando la probabilidad de captura difiere entre individuos previamente capturados e individuos no capturados, debido al comportamiento de respuesta que exhiban. En el caso del segundo sitio se obtuvo una abundancia de cinco individuos, el modelo que más se ajustó a los datos fue el M(h), que incorpora la heterogeneidad individual, es decir, una única probabilidad de captura para cada individuo a consecuencia de la accesibilidad que estos tengan a las trampas por la actividad, la dominancia social o las diferencias en edad o el sexo. La probabilidad de captura ($\hat{P}$) estimada vario de 0.01 a 0.03. El cálculo del área efectiva de muestreo se basó en un área de amortiguamiento de 4.96 km (la cual se estimó en base al ámbito hogareño de 100 km^2), que resulto en un AEM de 267 km^2 y 349 km^2 para el primer y segundo sitio respectivamente (Tabla 2).

DISCUSIÓN

En la APFF Sierra de Alamos Rio Cuchujaqui las densidades obtenidas para el jaguar por medio del trampeo fotográfico se logró estimar 0.74-1.4 ind/100 km^2, lo cual es similar a lo obtenido en otras regiones de Sonora, como es el caso de la Reserva Jaguar del Norte donde se han calculado de 0.78 - 1.5 ind/100 km^2 (Amador et al. 2015), así como también en el municipio de Nacori Chico donde han obtenido densidades de1.0 ind/100km^2 (Rosas-Rosas y Bender 2012). En contraste, con la densidad obtenida para la misma zona en el año 2013, que fue de 2.15 ind/ km^2 (Gutiérrez et al. 2013), la diferencia en las densidades, posiblemente se deba a la cacería de jaguares que se presentó en el área en represalia por la depredación de ganado en años recientes 2015-2016 (Amador et al. 2017). Esta densidad es baja en comparación a las reportadas en otras reservas del país con ecosistemas de selva baja como en: Chamela-Cuixmala Jalisco (2 ind/km^2; Nuñez et al. 2011), Reserva de la Biosfera Maya, Guatemala (2 ind/km^2; Novack et al. 2005) y en la Reserva de la Biosfera Calakmul (3-7 ind/100km^2; Chávez 2006). Es importante mencionar que durante el periodo de muestreo se presentaron eventos ambientales y climáticos extraordinarios (desborde de ríos y arroyos) que impidieron que cinco estaciones de foto-trampeo no funcionaran correctamente durante todo el tiempo, lo que ocasiono que se perdieran sitios con potencial alto de foto-capturas de felinos silvestres. No obstante, en esta región donde la vegetación es una mezcla de selvas bajas caducifolias, matorral xerófilo y bosques de encino-pino la densidad de jaguares son bajas debido a que requieren de mayores territorios para satisfacer sus necesidades de refugio y alimentación (Urness, 1981). También, la cacería ilegal y las muertes de ejemplares debido a represalias por las depredaciones de ganado ocasionadas por los jaguares y otros carnívoros, puede estar ocasionado que las poblaciones de estos felinos se encuentren dispersas y en números bajos (Rosas-Rosas et al., 2008). Las densidades de jaguar estimadas en esta región del noroeste de México son de las más bajas para el país La sobrevivencia del jaguar y otros felinos en la APFF-SARC dependerá de que las extensiones del bosque tropical se mantengan sin cambios de uso de suelo y que los casos de cacería de felinos y otras especies sean castigados de manera ejemplar como señala la ley. Mientras tanto es importante continuar con los estudios y monitoreo de felinos silvestres y del trabajo con productores para desarrollar estrategias de manejo ganadero sostenible que lleven a disminuir las afectaciones por depredación de la fauna silvestre.

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Tabla 1. Fauna silvestre de interés para la conservación del jaguar (*Panthera onca*) registrados en la APFF Sierra de Álamos-Río Cuchujaqui. Lista basada en el orden taxonómico de las especies y la guía de mamíferos de Reid (2006) y Aranda (2012) y de las aves de la Unión Americana de Ornitólogos (1998).

ORDER, Family, genus and specie	Common name	Direct sighting	Indirect sign	Photo-capture
CARNIVORA				
Canidae				
Canis latrans Say, 1823	Coyote	X	X	X
Urocyon cinereoargenteus (Schreber, 1775)	zorra gris		X	X
Felidae				
Puma concolor (Linnaeus, 1771)	Puma		X	X
Panthera onca (Linnaeus, 1758)	Jaguar			X
Leopardus pardalis (Linnaeus, 1758)	Ocelote			X
Leopardus weidii (Schinz, 1821)	Tigrillo			X
Lynx rufus (Eschreber, 1777)	Gato montés			X
Procyonidae				
Bassariscus astutus (Lichtenstein, 1830)	Cacomixtle norteño			X
Procyon lotor (Linnaeus, 1758)	Mapache			X
Nasua narica (Linnaeus, 1766)	Cholugo	X		X
Mephitidae				
Mephithis mephithis (Schreber, 1776)	Zorrillo rayado			X
Conepatus leuconotus (Lichtenstein, 1832)	Zorrillo real			X
Spilogale gracilis (Merriam, 1890)	Zorrillo manchado			X
ARTIODACTYLA				
Tayassuidae				
Pecari tajacu (Linnaeus, 1758)	pecarí de collar	X		X
Cervidae				
*Odocoileus virginianus Z*immermann,1780	Venado cola blanca	X	X	X
LAGOMORPHA				
Leporidae				
Lepus alleni (Mearns, 1890)	Liebre	X	X	X
GALLIFORMES				
Phasianidae				
Meleagris gallopavo (Linnaeus, 1758)	Guajolote	X		X
Psittacidae				
Ara militaris (Linnaeus, 1766)	Guacamaya verde	X		

Tabla 2. Abundancia y densidad (Ind/100Km^2) de jaguar (*Panthera onca*) registrados por medio de trampas cámara en la APFF Sierra de Álamos-Río Cuchujaqui durante el período Agosto-Diciembre 2016.

Site	August-December 2016				
	Abundance	**S.E.**	**ESM** (km^2)	**Density**	**S.E.**
Sierra de Álamos (Aug-Sep 2016)	2	0.73	267	0.74	0.27
Rio Cuchujaqui (Oct-Dec 2016)	5	2.12	349	1.43	0.60

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Monitoreo de Jaguar (*Panthera onca*) mediante la técnica de foto-trampeo en la Reserva Jaguar del Norte, Sonora

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***Resumen**--La Reserva Jaguar del Norte (RJN) se creó en 2003 con la finalidad de proteger la población más norteña de jaguar (Panthera onca), y a otras especies igualmente importantes que habitan en el territorio de esa región. Con el propósito de generar información de la población de felinos silvestres: jaguar, puma (Puma concolor), ocelote (Leopardus pardalis), y gato montes (Lynx rufus) se realizaron monitoreos con 92 cámaras-trampa dentro de la RJN. Se obtuvo un esfuerzo de muestreo de 21,170 días-cámaras para los siete periodos en los que se dividió el estudio (enero-diciembre del 2014). Se registraron 14 especies de mamíferos, entre las que destacan además de los felinos, el coyote (Canis latrans) y la zorra gris (Urocyon cinereoargenteus). El jaguar fue foto-capturado en 26 sitios de la reserva. Los índices de abundancia (reg./100 días-cámaras) con valores más altos entre los felinos fueron, lince con 3.15, puma con 1.72, ocelote con 0.76 y jaguar con 0.59. En lo que respecta a la densidad para el jaguar el valor máximo estimado fue 1.03 (±0.54) ind/100 km^2. El trampeo–fotográfico fue una herramienta eficiente para estimar la abundancia y densidad de los felinos silvestres. Para conservar al jaguar en la RJN se debe contemplar el manejo integral de sus poblaciones y del hábitat. Los resultados positivos en el registro de felinos en la RJN continúan demostrando la importancia de esta región en la conservación del jaguar y otras especies claves.*

Palabras clave: *Leopardus pardalis*, *Lynx rufus*, *Puma concolor*, *Panthera onca*.

INTRODUCCIÓN

Actualmente los procesos de deterioro ambiental generados por el incremento de la población humana y sus actividades productivas no sustentables, han provocado reducciones en muchos rangos de distribución de poblaciones de fauna silvestre en el continente americano (Bodmer et al. 2004). Prácticas como la ganadería y la agricultura, que generan cambios en la cobertura forestal y del uso de suelo, se traducen en la fragmentación o pérdida de hábitat y de especies (Jager et al. 2006). Una de las alternativas implementadas en México, como instrumento de conservación biológica es el decreto de áreas naturales protegidas (Bezaury-Creel y Gutiérrez-Carbonell 2009). Sin embargo estas requieren de trabajos de investigación y monitoreo constante para incrementar su funcionalidad y mantener el equilibrio ecológico de los ecosistemas (Simonetti et al. 2002). La Reserva Jaguar del Norte (RJN) es una reserva privada que se creó con la finalidad de proteger la población más norteña de jaguares, así como a las demás especies que habitan en ese territorio. Con el propósito de verificar el estado de la población de jaguares y evaluar el grado de efectividad de la RJN, se realizó el monitoreo con trampas cámara para analizar las fotografias y los datos de campo para comparar los diferentes periodos. Este método fue elegido, debido a que es el más utilizado para estimar abundancia y densidad de jaguares (Chávez et al. 2013; Kelly et al. 2008).

ÁREA DE ESTUDIO

El área de estudio está localizada en la Reserva Jaguar del Norte (RJN), la cual se encuentra al norte del municipio de Sahuaripa, Sonora. La superficie de la reserva es de 24,000 ha (59,305 ac; Figura 1). Topográficamente es una zona muy accidentada, con altitudes que van de 370-1,600 msnm. El clima predominante es semiárido semicálido, con una temperatura media anual de 18º C (-1°C a 47 °C; CONABIO 2004). La vegetación se compone principalmente de matorral xerófilo, donde las especies dominantes son: *Lysiloma watsonii, Prosopis velutina, Vachelia campechiana,* entre otras. Selva baja en algunas cañadas, bosque de encino en alturas de más de 1000 msnm, donde predominan las especies

Quercus arizónica y *Q. emorii* (CONANP 2016). La fauna silvestres registrada incluye 59 especies de mamíferos como son el venado cola blanca (*Odocoileus virginianus*), pecarí de collar (*Pecari tajacu*), el coyote (*Canis latrans*) y la zorra gris

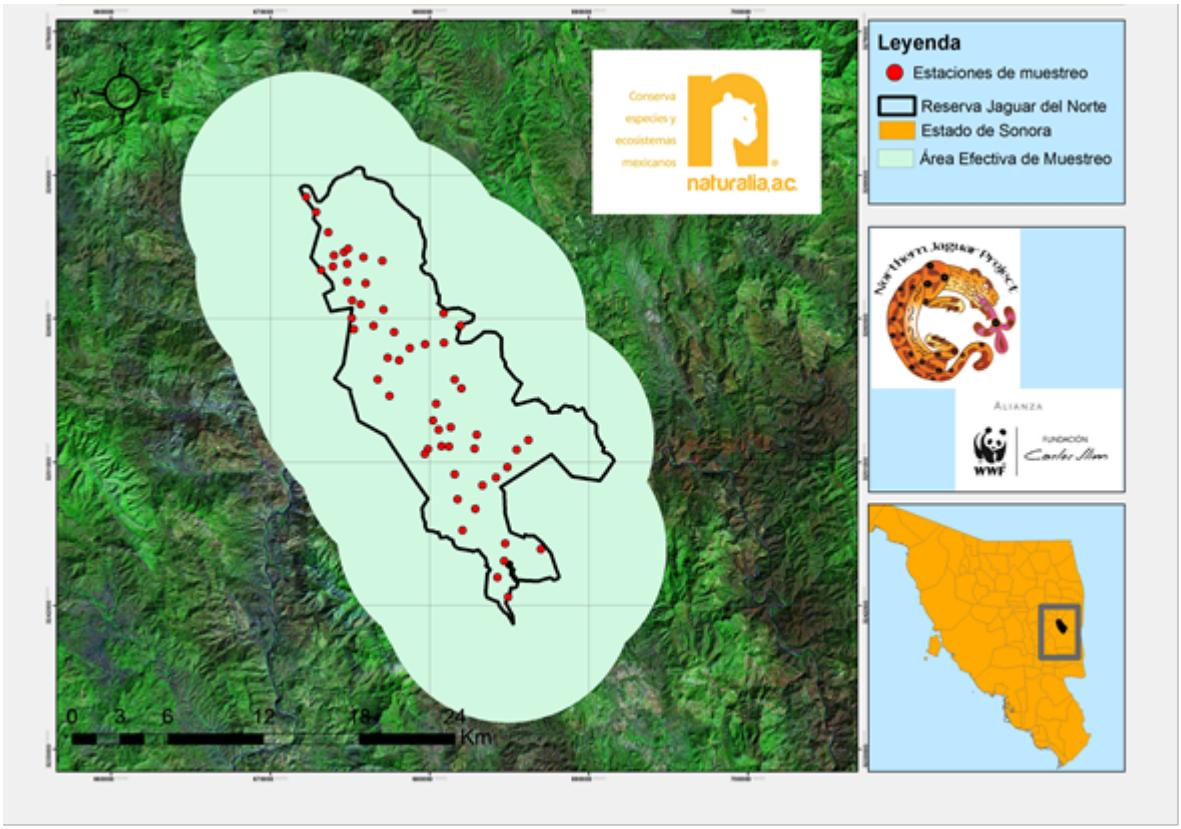

Figura 1. Colocación de trampas cámaras y área efectiva de muestreo para jaguar (Panthera onca) en la Reserva del Jaguar del Norte, Sahuaripa, Sonora.

(*Urocyon cinereoargenteus*). En cuanto a las aves se han registrado 214 especies, destacando el águila real (*Aquila chrysaetos*) y águila calva (*Haliaeetus leucocephalus*) y guacamaya verde (*Ara militaris*). En lo que respecta a la herpetofauna existen 85 especies; 17 anfibios y 68 reptiles (CONANP 2016; Flesch et al. 2015; Rorabaugh et al. 2011).

MÉTODOS

La metodología que se utilizó fue un muestreo de captura-recaptura empleando como herramienta el foto-trampeo para estimar la densidad de jaguares en el área de estudio mediante el modelo de población cerrada (Karanth y Nichols 1998; Silver et al. 2004). Se realizaron en total seis periodos de muestreo en el 2014. Se usaron 59 estaciones de muestreo (Figura 1). Cada estación estuvo separada aproximadamente de 1-3 km. Los polígonos conformados por las estaciones cubrieron el área mínima que abarca el ámbito hogareño de un jaguar según lo sugerido por Chávez et al. (2013). Cada muestreo tuvo una duración variable de entre 59-62 días (Dillon y Kelly 2007; Silver et al. 2004). Se consideró a cada periodo como un evento de muestreo y se asumieron los criterios de población cerrada (Trolle et al. 2007). Las cámaras se colocaron siguiendo la metodología de Karanth y Nichols (1998) y Chávez et al. (2013).

Por medio del registro fotográfico, se identificaron los individuos de jaguar por el patrón único de sus rosetas. Posteriormente, se elaboró un historial de captura para cada individuo registrado (Trolle y Kery 2003). Para obtener el número de jaguares que existen en el área muestreada se utilizó el programa MARK en su módulo CAPTURE (White 2008;

White et al. 1982). Para estimar la densidad poblacional, se dividió el valor de la abundancia estimada por el programa CAPTURE entre el Área Efectiva de Muestreo (AEM). El cálculo del área efectiva de muestreo (AEM) se realizó mediante el método descrito por Karanth y Nichols (1998) y Silver et al. (2004; Figura 1). Con la finalidad de comparar entre los periodos de muestreo y con otras regiones del país, se calcularon índices de abundancia (número de fotos/ número de cámaras * número de días de muestreo) con base en el criterio de eventos independientes (Conroy 1996).

RESULTADOS

Se logró registraron 14 especies de mamíferos, que incluyeron a las cuatro especies de felinos presentes en la reserva (jaguar, puma, lince y ocelote), así como a sus presas principales (venado cola blanca, pecarí de collar y liebre antílope). En lo que respecta a los índices de abundancia relativa se alcanzó un esfuerzo de muestreo de 21,170 días-cámara, donde el periodo con mayor días-cámara fue el de julio-agosto con 3,596 mientras que el más bajo fue el de enero-febrero con de 3,422. El felino más abundante en los seis periodos fue el gato montés y el de menor abundancia fue el jaguar (Figura 2).

Para la estimación de la densidad de jaguares en los seis periodos (Enero-Diciembre 2014), se identificaron un total de cuatro individuos de los cuales dos eran machos, una hembra y otro no se logró determinar el sexo. En cuanto a los resultados obtenidos del Programa MARK para este año se obtuvo una densidad máxima de 1.03 Ind/100Km^2 (38.6 mi^2), el modelo que se ajustó a la mayoría de los datos fue el M(o), el cual supone que la probabilidad de captura es la misma para cada animal en cualquier ocasión. El otro modelo que se ajustó en los datos fue el M(h), que incorpora la heterogeneidad individual, es decir, una única probabilidad de captura para cada individuo a consecuencia de la accesibilidad que estos tengan a las trampas por la actividad, la dominancia social o las diferencias en edad o el sexo; La probabilidad de captura ($\hat{P}$) estimada varió de 0.01 a 0.08. El cálculo del área efectiva de muestreo se basó en un área de amortiguamiento de 4.96 Km, que resultó en un AEM de 482 km^2 (185 mi^2; Tabla 1).

Tabla 1. Densidad (Ind/100Km^2) de jaguares (*Panthera onca*) registrados por medio de trampas cámara en la Reserva Jaguar del Norte durante el período Enero-Diciembre 2014.

DISCUSIÓN

El método de trampeo–fotográfico es una técnica eficiente para estimar y evaluar la distribución, abundancia y densidad de los felinos silvestres así como de sus presas en la RJN. En lo que respecta a las densidades de jaguar, la estimación máxima fue de 1.03 ind/100 km^2, la cual es muy similar a la que se calcula en otros estudios para la región donde se tiene 1 ind/100km^2 (Rosas-Rosas 2012; Amador et al. 2015), pero menor a la que se estima en otras reservas del estado como en la reserva Sierra de Álamos-Río Cuchujaqui (1.4 -2.15 ind/100km^2, Amador et al. 2017; Gutiérrez et al. 2012), en otras reservas del país como es: Chamela-Cuixmala en Jalisco (2 ind/100km^2; Nuñez, et al. 2011), Reserva de la Biósfera Montes Azules en Chiapas (3.55 ind/100km^2; De la Torre y Medellín 2011) y la Reserva de la Biósfera de Calakmul (3-7 ind/100km^2; Chávez et al. 2013). La densidad del jaguar está relacionada con la abundancia y disponibilidad de presas (Gutiérrez-González et al. 2012; Karanth et al. 2004). En estas regiones las poblaciones de jaguares son bajas debido a que en estas zonas requieren de mayor espacio para satisfacer sus necesidades de refugio y alimentación (Urness 1981). Los valores reportados en este estudio indican que la RJN alberga una densidad de jaguares relativamente baja, pero se cuenta con registros de cachorros lo que da gran relevancia ecológica para la especie y el sitio al ser una población reproductiva y fuente que mantiene sanos los procesos de intercambio y dispersión de individuos. La baja probabilidad de captura del jaguar estimada para este estudio, responde al comportamiento elusivo de la especie (Dillon y Kelly, 2007; Chávez et al. 2013). Sin embargo para la región noroeste de México es similar a lo obtenido en otros estudios (Rosas-Rosas y Bender 2012; Gutiérrez et al. 2012) debido a que habita en ecosistemas deserticos y territorios más amplios donde la disponibilidad esta menos concentrada.

Nuestros resultados nos llevan a recomendar seguir con los monitoreos sistemáticos en esta región de la RJN y otras poblaciones de jaguar colindantes (en Sierra del Bacatete y Sierra de Alamos) para determinar mejor la presencia y distribución de la especie que esta adaptada a condiciones climáticas extremas que aun no comprendemos por completo como influyen en su ecología y distribución.

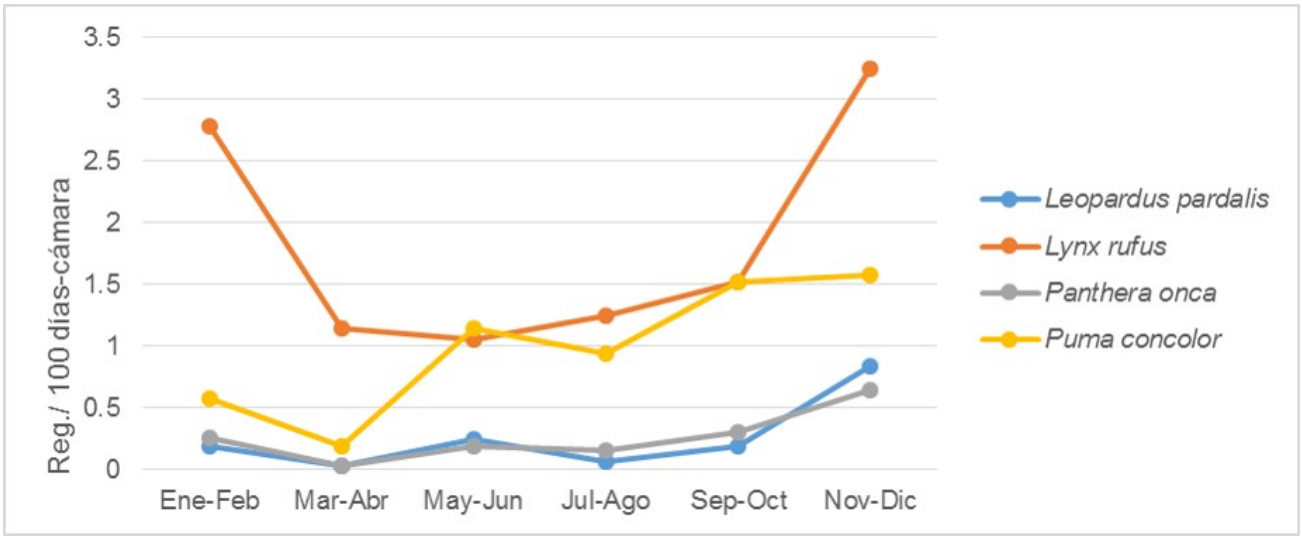

Figura 2. Índice de abundancia relativa de felinos silvestres silvestres en la Reserva Jaguar del Norte durante el periodo Enero - Diciembre 2014.

Tabla 1. Densidad (Ind/100Km^2) de jaguares (*Panthera onca*) registrados por medio de trampas cámara en la Reserva Jaguar del Norte durante el período Enero-Diciembre 2014.

Periodo	Enero-Diciembre 2014			
	Densidad	E.E.	Modelo de selección	Probabilidad de captura
Enero-Febrero	0.62	0.08	M (o)	0.05
Marzo-Abril	0.62	0.25	M (o)	0.02
Mayo-Junio	0.41	0.09	M (o)	0.04
Julio-Agosto	0.62	0.30	M (h)	0.01
Septiembre-Octubre	1.03	0.08	M (o)	0.02
Noviembre-Diciembre	0.62	0.28	M (o)	0.08

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Modeling occupancy of sparse species with a single survey: transborder variation in anthropogenic risk effects on bighorn sheep

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Species that are naturally sparse are often difficult to study, creating challenges for identifying factors affecting their population dynamics. Surveys of rare species also suffer from imperfect detection (failing to detect a species when it is present) that can mislead biologists if ignored. Hierarchical models provide a framework for understanding species' distribution and dynamics while accounting for imperfect detection, but hierarchical models require surveys to be replicated, which can be costly. Here, we present a novel approach to generate quasi-replicates on transects surveyed only once for bighorn sheep along both sides of the U.S.- Mexico border. Quasi-replicates allowed us to survey widely on both sides of the border and fit hierarchical models to estimate and describe bighorn sheep occupancy. We found strong effects of the border on bighorn sheep distribution, with survey sites in Mexico 1.6 times more likely to hold sheep than sites in USA. Border effects appear to arise due to the effects of human activity, consistent with the hypothesis that humans are viewed as a predation risk by sheep. Sheep generally preferred higher elevations but small hills in Mexico were as likely to be occupied as larger mountain ridges. However, in the U.S. small hills were very likely to be unoccupied by sheep. The marked difference in selection for the size of terrain features between the U.S. and Mexican sides of the border illustrates how transboundary research may be necessary to inform connectivity and landscape scale planning on both sides of the border.

Modelado de la ocupación de especies dispersas con una sola encuesta: variación transfronteriza en los efectos de riesgo antropogénico sobre el borrego cimarrón

Las especies que son naturalmente escasas a menudo son difíciles de estudiar, creando desafíos para identificar los factores que afectan su dinámica poblacional. Las encuestas de especies raras también sufren una detección imperfecta (no detectar una especie cuando está presente) que puede inducir a error a los biólogos si se ignoran. Los modelos jerárquicos proporcionan un marco para comprender la distribución y la dinámica de las especies a la vez que dan cuenta de la detección imperfecta, pero los modelos jerárquicos requieren que las encuestas se repliquen, lo que puede ser costoso. Aquí, presentamos un enfoque novedoso para generar cuasi-repeticiones en transectos encuestados solo una vez para borregos cimarrones a lo largo de ambos lados de la frontera con México. Las cuasi-repeticiones nos permitieron estudiar ampliamente en ambos lados de la frontera y ajustarnos a modelos jerárquicos para estimar y describir la ocupación de las ovejas de carnero. Encontramos fuertes efectos del borde en la distribución de borregos cimarrón, con sitios de estudio en México 1.6 veces más propensos a tener ovejas que sitios en EE. UU. Los efectos fronterizos parecen surgir debido a los efectos de la actividad humana, de acuerdo con la hipótesis de que los humanos son vistos como un riesgo de depredación por las ovejas. Las ovejas generalmente preferían las elevaciones más altas, pero las pequeñas colinas en México tenían la misma probabilidad de ser ocupadas que las crestas de montañas más grandes. Sin embargo, en los Estados Unidos, es muy probable que las pequeñas colinas estén desocupadas por las ovejas. La marcada diferencia en la selección para el tamaño de las características del terreno entre los lados de la frontera de los EE. UU. y México ilustra cómo la investigación transfronteriza puede ser necesaria para informar la conectividad y la planificación de la escala del paisaje en ambos lados de la frontera.

NOTE: A manuscript was not submitted to accompany this presentation.

Mountain-range carnivores' community within Janos Biosphere Reserve, Chihuahua, Mexico

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Worldwide local populations of carnivores are declining at alarming rates. The Janos Biosphere Reserve in Mexico comprises a diversity of ecosystems from grasslands to pine forest and holds the habitat of several species of carnivores, but there is no information about the status of their populations and habitat preferences. We installed 30 camera-tramps along an altitudinal range from 1600 to 2500 m asl and measure landscape covariates at different scales from 25 to 600 meters' circular buffers around each camera trap station to evaluate the species-specific scale of the effect for habitat use. We surveyed 19,955 camera days obtaining 7,409 records of fauna and recorded 12 species of carnivores which includes black bear, mountain lion and lynx. Our results show a higher species diversity in rugged sites with more proportion of pine forest, less secondary vegetation and moderate forest cover, however we found miscellaneous habitat preferences for each carnivore species at different landscape scales. We didn't find altitudinal patterns for species diversity or abundance. We also recorded bushmeat hunting, logging, narcotraffic and cattle ranching in all altitudinal ranges. As conservation actions, we propose the reinforce of community firefighting brigades, access restrictions by landowners to reduce illegal hunting and better forest management practices oriented to wildlife conservation. Our findings provide a novel and accurate evidence of the status of terrestrial carnivores in this species-rich but vanishing Biosphere Reserve, and can be used to prioritize conservation strategies in the area.

Comunidad de carnívoros de montaña dentro de la Reserva de la Biosfera Janos, Chihuahua, México

Las poblaciones locales de carnívoros están disminuyendo a tasas alarmantes. La Reserva de la Biosfera Janos en México, abarca una diversidad de ecosistemas, desde pastizales hasta bosques de pinos y alberga el hábitat de varias especies de carnívoros, pero no hay información sobre el estado de sus poblaciones y preferencias de hábitat. Instalamos 30 cámaras-trampas a lo largo de un rango altitudinal de 1600 a 2500 m asl y medimos las covariables del paisaje a diferentes escalas de 25 a 600 metros de buffers circulares alrededor de cada cámara trampa para evaluar la escala específica de la especie del efecto para el uso del hábitat. Se encuestó por 19,955 días de cámara obteniendo 7,409 registros de fauna y se registraron 12 especies de carnívoros que incluyen oso negro, puma y lince. Nuestros resultados muestran una mayor diversidad de especies en sitios accidentados con más proporción de bosque de pinos, menos vegetación secundaria y cobertura forestal moderada, sin embargo, encontramos preferencias de hábitats misceláneos para cada especie carnívora a diferentes escalas de paisaje. No encontramos patrones altitudinales para la diversidad o abundancia de especies. También registramos la caza de animales silvestres, la tala, el narcotráfico y la ganadería en todos los rangos altitudinales. Como acciones de conservación, proponemos el refuerzo de las brigadas comunitarias de lucha contra incendios, restricciones de acceso por parte de los propietarios para reducir la caza ilegal y mejores prácticas de manejo forestal orientadas a la conservación de la vida silvestre. Nuestros hallazgos proporcionan una evidencia novedosa y precisa del estado de los carnívoros terrestres en esta reserva de biosfera rica en especies pero que se desvanece, y se puede utilizar para priorizar las estrategias de conservación en el área.

NOTE: A manuscript was not submitted to accompany this presentation.

Ocelot (*Leopardus pardalis*) in Sonora, Mexico

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The ocelot (*Leopardus pardalis*) is a small tropical cat that ranges from South America north to southern Texas and southeastern Arizona. It is listed as Endangered in Mexico and the United States. Its distribution was summarized in Sonora in the Brown and López-G. 2001 Borderland Jaguars book, and in López-G. et al. (2003). Here, we present 70 recent wildlife camera observations of ocelots from 35 areas localities throughout its Sonoran range. Nowhere are ocelots dominant in the mammal fauna. Photographs of ocelots are uncommon on Rancho Ecológico Monte Mojino east of Álamos. Ocelot images are common in GreaterGood.org's Project WILDCAT ranches in the lower Río Bavispe Valley south of Granados, and occasional in the Sierra de la Madera near Moctezuma. Ocelots have been seen in the Área de Protección de Flora y Fauna Bavispe in the Sierras los Ajos, Buenos Aires, and el Tigre. They are uncommonly photographed on Rancho el Aribabi in the Sierra Azul, and present in Cajón Bonito on Rancho los Ojos Calientes, a Cuenca los Ojos Foundation property. In southern Sonora, ocelots primarily live in tropical deciduous forest and foothills thornscrub. In central Sonora and northeastern Sonora, they live in oak woodland and pine-oak forest. Ocelots have also been photographed in riparian habitats, including the Ríos Cuchujaqui, Mayo, Yaqui, Bavispe, and Cocóspera, and Arroyo Bacadéhuachi. Females with kittens have been seen on Rancho Pueblo Viejo in the lower Río Bavispe Valley and in Arroyo las Palomas on Rancho el Aribabi.

Ocelote (Leopardus pardalis) en Sonora, México

El ocelote (Leopardus pardalis) es un pequeño gato tropical que se extiende desde América del Sur hasta el sur de Texas y el sureste de Arizona. Está en la lista de En Peligro de Extinción en México y los Estados Unidos. Su distribución se resumió en Sonora en el libro Borderland Jaguars de Brown y López-G. 2001, y en López-G. et al. (2003). Aquí, presentamos 70 observaciones recientes de cámaras de vida silvestre de ocelotes de 35 localidades de áreas a lo largo de su rango sonorense. En ningún lugar predominan los ocelotes en la fauna de mamíferos. Las fotografías de ocelotes son poco comunes en Rancho Ecológico Monte Mojino al este de Álamos. Las imágenes de Ocelote son comunes en los ranchos Project WILDCAT de GreaterGood.org en el valle inferior del río Bavispe al sur de Granados, y ocasionalmente en la Sierra de la Madera cerca de Moctezuma. Se han visto ocelotes en el Área de Protección de Flora y Fauna Bavispe en las Sierras los Ajos, Buenos Aires y el Tigre. Son fotografiados de forma poco común en Rancho el Aribabi en la Sierra Azul, y están presentes en Cajón Bonito en Rancho los Ojos Calientes, una propiedad de la Fundación Cuenca los Ojos. En el sur de Sonora, los ocelotes viven principalmente en el bosque caducifolio tropical y las estribaciones de los matorrales. En el centro de Sonora y el noreste de Sonora, viven en bosques de robles y bosques de pino y encino. Los ocelotes también han sido fotografiados en hábitats ribereños, incluidos los ríos Cuchujaqui, Mayo, Yaqui, Bavispe y Cocóspera, y Arroyo Bacadéhuachi. Se han visto hembras con gatitos en Rancho Pueblo Viejo en el valle inferior del río Bavispe y en Arroyo las Palomas en Rancho el Aribabi.

NOTE: A manuscript was not submitted to accompany this presentation.

Session 46: Plants

Plants of the Peloncillo Mountains Emory Oak Savanna
(Photo by Daniel G. Neary USDA Forest Service, Forest Service, Rocky Mountain Station)

Abstracts and Papers
Ferguson
Gickhorn
Sanchez #1
Sanchez #2
Van Devender
Verrier

A Preliminary Flora of the Sierra Buenos Aires Sky Island, Sonora, Mexico

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The Sierra Buenos Aires Sky Island is part of a mountain complex; it is south of Sierra Los Ajos, and north of Sierra La Purica, entirely within the protection of Reserva Forestal Nacional y Refugio de Fauna Silvestre Ajos-Bavispe. It is accessible from the north by a road connecting Fronteras and Bacoachi, Sonora, Mexico. Previous vegetation surveys are few, notably a collection of 51 species was made by E. Lehto and D. Pinkava in March and June 1970 in the vicinity of Puerto Mababi at the pass on the north end. A much earlier collection, including several type specimens, was made by G. Thurber in 1851 near Mababi. As part of a Madrean Discovery Expedition (MDE), we made observations and collected voucher specimens in the Sierra Buenos Aires in August 2016 for a preliminary species list. Over 1050 records are available in the Arizona State University, Desert Botanical Garden, New York Botanical Garden, Madrean Archipelago Biodiversity Assessment, MDE (madreandiscovery.org), Universidad de Sonora, and University of Arizona databases. A total of 367 taxa of plants in 73 families were recorded. Dominant families are Fabaceae (51 taxa), Asteraceae (45 taxa), and Poaceae (44 taxa including 5 non-native). Nine species (2.4%) are non-native. The vegetation is grassland, oak woodland, and pine-oak forest. Noteworthy plants are *Arbutus xalapensis, Bouteloua eludens, Carex ultra, Coryphantha recurvata, Draba helleriana, Graptopetalum rusbyi, Mammillaria wrightii, Penstemon pinifolius,* and *Woodwardia fimbriata*.

Flora Preliminar de la Isla Serrana en la Sierra Buenos Aires, Sonora, México

La Isla Serrana de la Sierra Buenos es parte de un complejo de montañas; está al sur de Sierra Los Ajos, y al norte de Sierra La Purica, totalmente dentro de la protección de la Reserva Forestal Nacional y Refugio de Fauna Silvestre Ajos-Bavispe. Se puede acceder desde el norte por una carretera que conecta Fronteras y Bacoachi, Sonora, México. Las encuestas previas de vegetación son escasas, especialmente una colección de 51 especies fue hecha por E. Lehto y D. Pinkava en marzo y junio de 1970 en las cercanías de Puerto Mababi en el paso en el extremo norte. Una colección mucho más temprana, que incluía varios tipos de especímenes, fue hecha por G. Thurber en 1851 cerca de Mababi. Como parte de una Madrean Discovery Expedition (MDE), hicimos observaciones y recolectamos especímenes en la Sierra Buenos Aires en agosto de 2016 para una lista preliminar de especies. Más de 1050 registros están disponibles en la Universidad Estatal de Arizona, el Jardín Botánico del Desierto, el Jardín Botánico de Nueva York, la Evaluación de la Biodiversidad del Archipiélago Madrean, MDE (madreandiscovery.org), la Universidad de Sonora y las bases de datos de la Universidad de Arizona. Se registró un total de 367 taxones de plantas en 73 familias. Las familias dominantes son Fabaceae (51 taxones), Asteraceae (45 taxones) y Poaceae (44 taxones incluidos 5 no nativos). Nueve especies (2.4%) no son nativas. La vegetación es pastizales, bosques de robles y bosques de pino y encino. Las plantas dignas de mención son Arbutus xalapensis, Bouteloua eludens, Carex ultra, Coryphantha recurvata, Draba helleriana, Graptopetalum rusbyi, Mammillaria wrightii, Penstemon pinifolius y Woodwardia fimbriata.

NOTE: A manuscript was not submitted to accompany this presentation.

Efficacy of Distance Sampling to Estimate and Monitor Population Abundance for the Endangered Pima Pineapple Cactus

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The Pima pineapple cactus (*Coryphantha scheeri* var. *robustispina*, PPC) is a federally-listed species endemic to desert-scrub and semi-desert grassland communities in southern Arizona and adjacent Sonora, Mexico. The recommended survey method for this species attempts a full census of a focal area, which is both time and labor intensive. Given these constraints, such efforts are inefficient for estimating and monitoring population size over large areas with variable densities of cacti. Distance sampling (DS) is based on sampling theory and thus requires observing only a subset of the overall population to estimate abundance. While this method is often used to reliably estimate abundance of wildlife populations, it has not been widely used for plant populations. We tested the effectiveness of DS for estimating PPC abundance by comparing distance-based estimates to those from recent census efforts at 11 study sites in southern Arizona. Additionally, we assessed environmental factors that influence detection probability and densities of PPC. Density across all study plots averaged 1.47 individuals/ha with an estimated 294 individuals overall, and precision of estimates was high (CV = 0.139). Detection probability was negatively associated with increasing substrate size, and PPC abundance was negatively associated with increasing grass cover. Density and abundance were both estimated well by DS, with averaging 11.4% underestimation and with high correlation (r = 0.82) between distance- and census-based estimates despite much lower effort. Our results suggest DS is an effective and efficient method for estimating PPC abundance across large areas.

Eficacia del muestreo a distancia para estimar y monitorear la abundancia de la población en peligro del cactus piña Pima

El cactus de piña Pima (Coryphantha scheeri var. Robustispina, PPC) está en la lista federal de especies en peligro de extinción y una especie endémica de las comunidades de pastizales desérticos y semidesérticos en el sur de Arizona y Sonora, México. El método de encuesta recomendado para esta especie intenta un censo completo de un área focal, que requiere tanto tiempo como mano de obra. Dadas estas limitaciones, tales esfuerzos son ineficientes para estimar y monitorear el tamaño de la población en grandes áreas con densidades variables de cactus. El muestreo a distancia (DS, por sus siglas en inglés) se basa en la teoría del muestreo y, por lo tanto, requiere observar solo un subconjunto de la población total para estimar la abundancia. Si bien este método se utiliza a menudo para estimar con fiabilidad la abundancia de poblaciones de vida silvestre, no se ha utilizado ampliamente para las poblaciones de plantas. Probamos la efectividad de DS para estimar la abundancia de PPC mediante la comparación de estimaciones basadas en la distancia con las de censos recientes en 11 sitios de estudio en el sur de Arizona. Además, evaluamos los factores ambientales que influyen en la probabilidad de detección y las densidades de PPC. La densidad en todas las parcelas de estudio promedió 1.47 individuos / hectarea con un estimado de 294 individuos en general, y la precisión de las estimaciones fue alta (CV = 0.139). La probabilidad de detección se asoció negativamente con el aumento del tamaño del sustrato, y la abundancia de PPC se asoció negativamente con el aumento de la cobertura de la hierba. Densidad y abundancia fueron estimadas bien por DS, con una subestimación promedio de 11.4% y una alta correlación (r = 0.82) entre las estimaciones basadas en la distancia y en el censo a pesar de un esfuerzo mucho menor. Nuestros resultados sugieren que DS es un método eficaz y eficiente para estimar la abundancia de PPC en grandes áreas.

NOTE: A manuscript was not submitted to accompany this presentation.

Preliminary Flora and Vegetation of the Sierra La Púrica, Sonora, Mexico

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The Sierra La Púrica is a Sky Island mountain range north-northwest of Nacozari de García (municipality of the same name), Sonora, Mexico. It is part of the Bavispe Área de Protección de Flora y Fauna in the Comisión Nacional de Áreas Naturales Protegidas. The east side of the Sierra La Púrica drains into the Río Cabullona, an upper tributary of the Río Bavispe-Yaqui drainage. The western slopes drain into the Río Sonora. The Madrean Archipelago Biodiversity Assessment (MABA) Expedition Sierra La Púrica was in July and September 2013. A total of 945 records of specimens and observations are available in the Arizona State University, Madrean Archipelago Biodiversity Assessment, Universidad de Sonora, and University of Arizona databases. A total of 307 plant taxa in 66 families were recorded. Dominant families are Asteraceae (43 taxa), Fabaceae (41 taxa), and Poaceae (36 taxa + 13 non-native). Sixteen species (5.2%) are non-native. The vegetation is desert grassland, oak woodland, and pine-oak forest. Noteworthy species include *Zygadenus virescens, Bouteloua eludens, Helianthella quinquenervis, Hosackia alamosana, Mandevilla foliosa, Piptochaetium pringlei, Populus tremuloides, Quercus gambelii,* and *Stevia puricana*. Species protected in NOM 059, the Mexican endangered species law, include *Amoreuxia palmatifida* (Protegida), *Zigadenus virescens* (Protegida), *Crusea hispida* (Protegida), and *Juglans major* (Amenazada). *Stevia puricana* described by Billie L. Turner in 2015 is only known from the Sierra La Púrica.

Flora y Vegetación Preliminar de la Sierra La Púrica, Sonora, México

La Sierra La Púrica es una cadena montañosa de las Islas Serranas al noroeste de Nacozari de García (municipio del mismo nombre), Sonora, México. Es parte del Área de Protección de Flora y Fauna de Bavispe en la Comisión Nacional de Áreas Naturales Protegidas. El lado este de la Sierra La Púrica desemboca en el Río Cabullona, un afluente superior del drenaje del Río Bavispe-Yaqui. Las laderas occidentales drenan hacia el Río Sonora. La Expedición de Evaluación de la Biodiversidad del Archipiélago Madrense (MABA por sus siglas en inglés) Sierra La Púrica fue en julio y septiembre de 2013. Un total de 945 registros de especímenes y observaciones están disponibles en las bases de datos de Arizona State University, Madrean Archipiélago Biodiversity Assessment, Universidad de Sonora y University of Arizona. Se registró un total de 307 taxones de plantas en 66 familias. Las familias dominantes son Asteraceae (43 taxones), Fabaceae (41 taxones) y Poaceae (36 taxones + 13 no nativos). Dieciséis especies (5.2%) son no nativas. La vegetación es pastizales desérticos, bosques de robles y bosques de pino y encino. Las especies dignas de mención incluyen Zygadenus virescens, Bouteloua eludens, Helianthella quinquenervis, Hosackia alamosana, Mandevilla foliosa, Piptochaetium pringlei, Populus tremuloides, Quercus gambelii y Stevia puricana. Las especies protegidas en la NOM 059, la ley mexicana de especies en peligro de extinción, incluyen Amoreuxia palmatifida (Protegida), Zigadenus virescens (Protegida), Crusea hispida (Protegida) y Juglans major (Amenazada). Stevia puricana descrita
por Billie L. Turner en 2015 solo se conoce de Sierra La Púrica.

NOTE: A manuscript was not submitted to accompany this presentation.

Herbarium Network of Northwest Mexico: The first consortium of Mexican herbaria

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The Herbarium Network of Northwest Mexico (RHNM) emerged in 2015 with the initial participation of herbaria from six institutions in the Northwest region of Mexico: Autonomous University of Baja California (BCMEX), Center for Biological Research of the Northwest (HCIB), University of Sonora (USON), Interdisciplinary Research Center for Integral Regional Development of Durango Unit (CIIDIR), Autonomous University of Sinaloa (UAS) and CIAD-Mazatlán Regional Herbarium (HCIAD). So far, three RHNM meetings have been held (in Hermosillo, Ensenada and Durango). As a result of the third meeting of herbaria held in October 2017 in Durango, Mexico, six other herbaria from northern and central Mexico agreed to be new members of the RHNM, this could indicate that in the near future the network could have a national reach. The www.herbanwmex.net portal, administered by the Herbarium of the University of Sonora, is the official website of the RHNM and was established through a collaboration between the herbaria of northwest Mexico and the SEINet consortium. In this portal, you can currently consult data on almost 220 thousand botanical specimens, collected in the states of northwestern Mexico: Baja California, Baja California Sur, Chihuahua, Durango, Sinaloa and Sonora. This year, the number of RHNM records will increase thanks to the research grants that GreaterGood.org granted to students of some Mexican herbaria, including new members of the network; this, through its Madrean Discovery Expeditions program.

Red de Herbarios del Noroeste de México: El primer consorcio de herbarios mexicanos

La Red de Herbarios del Noroeste de México (RHNM) surgió en 2015 con la participación inicial de los herbarios de seis instituciones de la región noroeste de México: Universidad Autónoma de Baja California (BCMEX), Centro de Investigaciones Biológicas del Noroeste (HCIB), Universidad de Sonora (USON), Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional de Unidad Durango (CIIDIR), Universidad Autónoma de Sinaloa (UAS) y Herbario Regional CIAD-Mazatlán (HCIAD). Hasta el momento, se han llevado a cabo tres reuniones de la RHNM (en Hermosillo, Ensenada y Durango). Como resultado de la tercera reunión de herbarios celebrada en octubre de 2017 en Durango, México, otros seis herbarios del norte y centro de México acordaron ser nuevos miembros de la RHNM, esto podría indicar que en el futuro cercano la red podría tener un alcance nacional. El portal www.herbanwmex.net, administrado por el Herbario de la Universidad de Sonora, es el sitio web oficial del RHNM y se estableció a través de una colaboración entre los herbarios del noroeste de México y el consorcio SEINet. En este portal, actualmente puede consultar datos de casi 220 mil especímenes botánicos, recolectados en los estados del noroeste de México: Baja California, Baja California Sur, Chihuahua, Durango, Sinaloa y Sonora. Este año, la cantidad de registros de RHNM aumentará gracias a las becas de investigación que GreaterGood.org otorgó a los estudiantes dealgunos herbarios mexicanos, incluyendo a nuevos miembros de la red; esto, a través de su programa Madrean Discovery Expeditions.

NOTE: A manuscript was not submitted to accompany this presentation.

Madrean Discovery Expeditions Program in Sonora, Mexico

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There are 55 Sky Island mountain ranges or mountain complexes connected by oak woodland corridors in the Madrean Archipelgo between the Sierra Madre Occidental in Sonora and the Mogollon Rim in Arizona. Thirty-three of them are in Sonora, Mexico. In 2009 Sky Island Alliance began the Madrean Archipelago Biodiversity Assessment (MABA) Program to document the biodiversity of Sonoran Sky Islands. MABA biotic inventory Expeditions went to nine Sky islands, and Mini-Expedtions went to three others. All observations of animals and plants are publicly available in the MABA database. In 2015 GreaterGood.org (GGO) created the Madrean Discovery Expeditions (MDE) Program and the MDE database (madreandiscovery.com) to continue documenting biodiversity of the Sonoran Sky Islands. Groups of 40-65 biologists, land managers, teachers, students, photographers, etc. participated in MDE Expeditions to the Sierras Buenos Aires, Elenita, Juriquipa, and el Tigre. Mini-Expeditions went to the Sierras Alacrán, Manzanal, Murrieta, and San José. There were totals of 432 participants, 1977 participant/days, and 23232 participant/days on MDE Expeditions. About 1000 biological observations are made on each Expedition. The MDE and MABA databases are the primary sources of of biological information for conservation, research, and education in Sonora.

Programa de Descubrimiento Madrean Discovery en Sonora, México

Hay 55 cadenas montañosas de Islas Serranas o complejos montañosos conectados por corredores de bosques de roble en el Archipelgo Madrense entre la Sierra Madre Occidental en Sonora y el borde Mogollon en Arizona. Treinta y tres de ellos están en Sonora, México. En 2009, Sky Island Alliance comenzó el Programa de Evaluación de la Biodiversidad del Archipiélago Madrense (MABA por sus siglas en inglés) para documentar la biodiversidad de las Islas Serranas Sonorenses. Las expediciones bióticas de MABA fueron a nueve islas serranas y Mini-Expediciones a otras tres. Todas las observaciones de animales y plantas están disponibles públicamente en la base de datos MABA. En 2015 GreaterGood.org (GGO) creó el Programa Madrean Discovery Expeditions (MDE) y la base de datos MDE (madreandiscovery.com) para continuar documentando la biodiversidad de las Islas Serranas Sonorenses. Grupos de 40-65 biólogos, administradores de tierras, maestros, estudiantes, fotógrafos, etc. participaron en MDE Expediciones a las Sierras de Buenos Aires, Elenita, Juriquipa y el Tigre. Las Mini-Expediciones fueron a las Sierras Alacrán, Manzanal, Murrieta y San José. Hubo totales de 432 participantes, 1977 participantes / días y 23232 participantes / días en MDE Expeditions. Se hacen aproximadamente 1000 observaciones biológicas en cada Expedición. Las bases de datos MDE y MABA son las principales fuentes de información biológica para conservación, investigación y educación en Sonora.

Note: Full Paper Follows

Madrean Discovery Expeditions Program, Sonora, Mexico

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***Abstract**--There are 55 Sky Island mountain ranges or mountain complexes connected by oak woodland corridors in the Madrean Archipelgo between the Sierra Madre Occidental in Sonora and the Mogollon Rim in Arizona. Thirty-two of them ar in Sonora, Mexico. In 2009 Sky Island Alliance began the Madrean Archipelago Biodiversity Assessment (MABA) Program to document the biodiversity of Sonoran Sky Islands. MABA biotic inventory Expeditions explored nine Sky islands, and Mini-Expedtions to three other areas. All observations of animals and plants are publicly available in the MABA database. In 2015 GreaterGood.org (GGO) created the Madrean Discovery Expeditions (MDE) Program and the MDE database (madreandiscovery.com) to continue documenting the animals and plants of the Sonoran Sky Islands. Groups of biologists, land managers, teachers, students, photographers, etc. participated in MDE Expeditions to the Sierras Buenos Aires, Cucurpe, Elenita, Juriquipa, and el Tigre. Mini-Expeditions visited the Sierras el Alacrán, de la Madera (Magdalena), Manzanal, and San José, and the lower Río Bavispe Valley. There were 30-80 participants/Expedition, on 33 field days, and 26,276 participant/hours on six MDE Expeditions. About 1000 biological observations are made on each Expedition. The MDE and MABA databases are the primary sources of of biological information for conservation, research, and education in Sonora.*

INTRODUCTION

In 2007, Conservation International designated the Mexican Madrean Pine-oak Woodlands as a global biodiversity hotspot. This was a very large area that included both the Sierra Madre Oriental in eastern Mexico and the Sierra Madre Occidental (SMO) in western Mexico. Biodiversity has been defined as the variety of life in a particular hábitat or ecosystem. In practice, we simply record the numbers of species of animals and plants in an area. The Sierra Madre Occidental (SMO) extends in western Mexico from Jalisco and Zacatecas north to Chihuahua and Sonora (Figure 1), reaching its northern limit in Sonora in the Sierra Huachinera (30.25 N).

In 1870, geologist Raphael Pumpelly said "The region is crossed by parallel granite ridges, running generally north or northwest, and rarely more than sixty miles long and ten to thirty miles apart. The intervals between the mountains are occupied by plains rising gently from the centre to the ridges on either side, and extending around the ends of these. Thus the whole country is a great plain, out of which rise the many outlying sierras of the Rocky range, as islands from the sea" (Wallace 1965).

On the 1892-1894 expedition to resurvey the United States-Mexico boundary, Lieutenant David Dubose Gaillard described the Arizona-Sonora borderlands as "bare, jagged mountains rising out of the plains like islands from the sea" (Mearns 1907; Hunt and Anderson 2002). Gaillard was likely quoting Pumpelly! Later Galliard was the lead engineer on the Panama Canal construction project. Weldon Heald, a resident of the Chiricahua Mountains, coined the term 'Sky Islands' for the range where he lived more many years (Heald 1951).

Between the SMO and the Mogollon Rim in central Arizona, there are 55 isolated Sky Island (*Isla Serrana* in Spanish) mountain ranges or complexes of several ranges connected by oak woodland corridors (Deyo et al. 2013; Van Devender et al. 2013). Sky Islands crowned with oak woodland or pine-oak forest emerge from lowland 'seas' of desert grassland, foothills thornscrub, or tropical deciduous forest (TDF). Madrean Archipelago is an equivalent term to the Sky Islands Region that was first used by University of Arizona herpetologist/ecologist Charles H. Lowe. McLaughlin (1995), Warshall (1995), and Van Devender et al. (2013) expanded and refined the area and concept.

Figure 1. View from the Sierra el Tigre. Photo by Luis Gutiérrez, photoluis1, NortePhoto.com.

'Desert seas' in valleys surrounding the Sky Islands are desert grassland and Chihuahuan desertscrub in the north, Sonoran desertscrub to the west, and foothills thornscrub and tropical deciduous forest in the south. The analogy to oceanic islands (Warshall 1995) is limited because Sky Islands differ from true insular areas in high species diversity, low local and regional endemism, and low percentages of non-native species (McLaughlin, 1995). While any isolated area has potential for speciation in small populations, there are relatively few species restricted to the Sky Island mountains.

BIODIVERSITY

Species richness is enhanced in the Sky Island Region for many reasons. The western half of North America is mountainous, with topographically diverse habitats and vegetation zoned along elevational-climatic gradients. Biotic communities are concentrated in small geographic areas compared to the eastern United States where vegetation mostly changes along a north-south latitudinal gradient in relatively flat terrain.

The Madrean Archipelago is a convergence zone for six biotic provinces (Figure 2). The Rocky Mountains and Colorado Plateaus to the north have temperate climates. Chaparral vegetation and Mediterranean climates are Californian influences below the Mogollon Rim in Central Arizona. In the mid-continent, the grasslands of the Great Plains extend from Canada south onto the Mexican Plateau and westward into southeastern Arizona and northeastern Sonora as a mosaic with desert grassland in the valleys and Chihuahuan desertscrub on adjacent limestone slopes. On the western edge of the Sky Island Region, Sonoran desertscrub surrounds Sky Island ranges. In the lowlands of southern Sky Islands, foothills thornscrub (FTS) and tropical deciduous forest are in the lowlands. Oak woodland and pine-oak forest are in the uplands of the Sky Islands and the Sierra Madre Occidental. The transition between the New World tropics and the northern temperate zone is at about 29°N in east-central Sonora. The northern limits of FTS are at about 30°11'N east of Sinoquipe in the Río Sonora Valley and 30°26'N at Presa Angostura on the Río Bavispe. FTS does not reach Arizona,

but the northern limits of quite a few FTS species are in desert grassland or oak woodland in southern Arizona Van Devender et al. 1994).

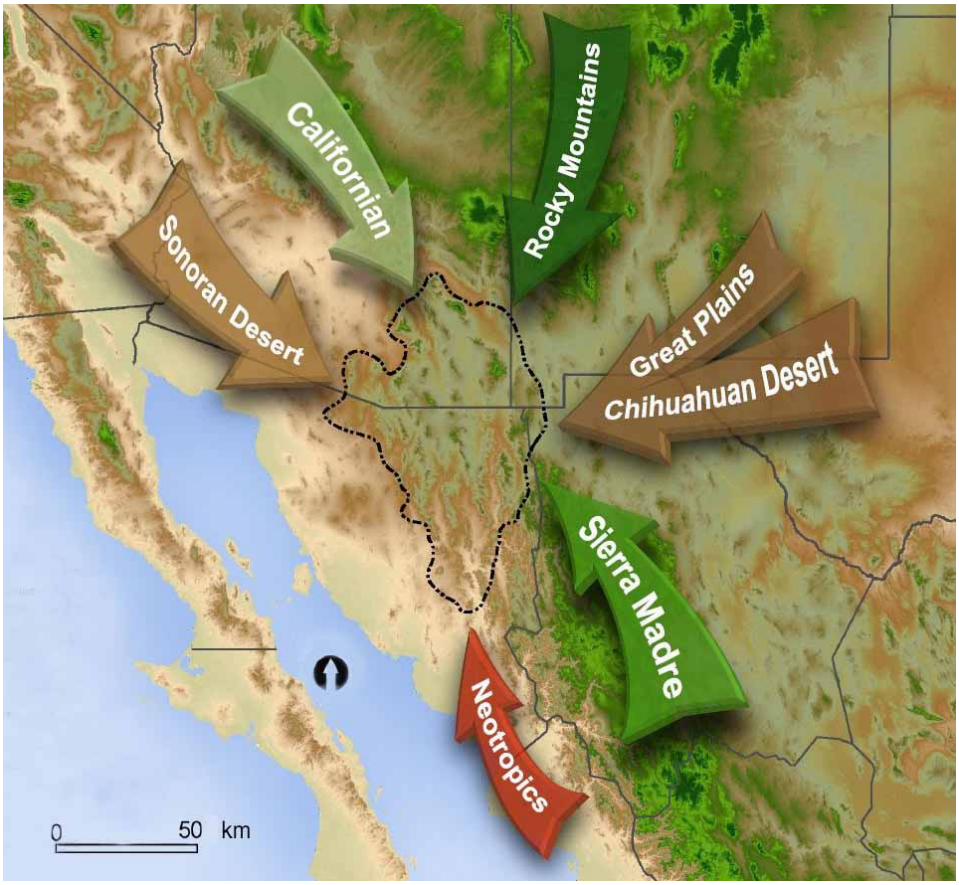

Figure 2. Biotic affinities of the Sky Islands Region (dotted line).

Sonoran Biotic Expeditions

By the 2010s, a great deal had been learned about the animals and plants of the Sky Islands in Arizona, but relatively little in the 32 Sky Islands in Sonora. In 2009, Sky Island Alliance began the Madrean Archipelago Biotic Assessment (MABA) program to document the animals and plants of the Sonoran Sky Islands. Expeditions of 20 to 60 biologists from Mexico and United States went to Sonoran Sky Islands to record animals and plants. Expeditions were important binational cultual gatherings that often resulted in new collaborations, knowledge-sharing, long-term friendships, greater appreciation of the landscapes and natural history of Sonora, and the need to protect them. MABA Expeditions went to the Sierras Aconchi, de los Ajos, Bacadéhuachi, de la Madera (Oposura), Mazatán (= Huérfana), la Púrica, San Antonio, San Luis, and el Tigre, and the Ciénega de Saracachi (Figure 3). MABA Expeditions Sierras la Mazatán and la Púrica were funded by GreaterGood.org. Smaller MABA Mini-Expeditions went to the Sierras el Alacrán, Anibácachi, Azul, las Avispas, Manzanal, and Murrieta, and the Northern Jaguar Reserve and Rancho el Valle.

In 2015 GreaterGood.org started the Madrean Discovery Expeditions (MDE) program to continue biotic inventories in the Sonoran Sky Islands. MDE Expeditions have gone to the Sierras Buenos Aires, Cucurpe, Elenita, Juriquipa, and Tigre, and Cajón Bonito (Figure 3). There were 30 to 80 participants (av. 54.2) on 33 field days. Most of the 26,276 man-hours

on the Expeditions were from volunteer citizen scientists and students. Mini-Expeditions went to the Sierras de la Madera (Magdalena) and San José, and Ranchos el Hoyo and Pueblo Viejo, lower Río Bavispe Valley. Two Expeditions are planned for the MDE program in future years.

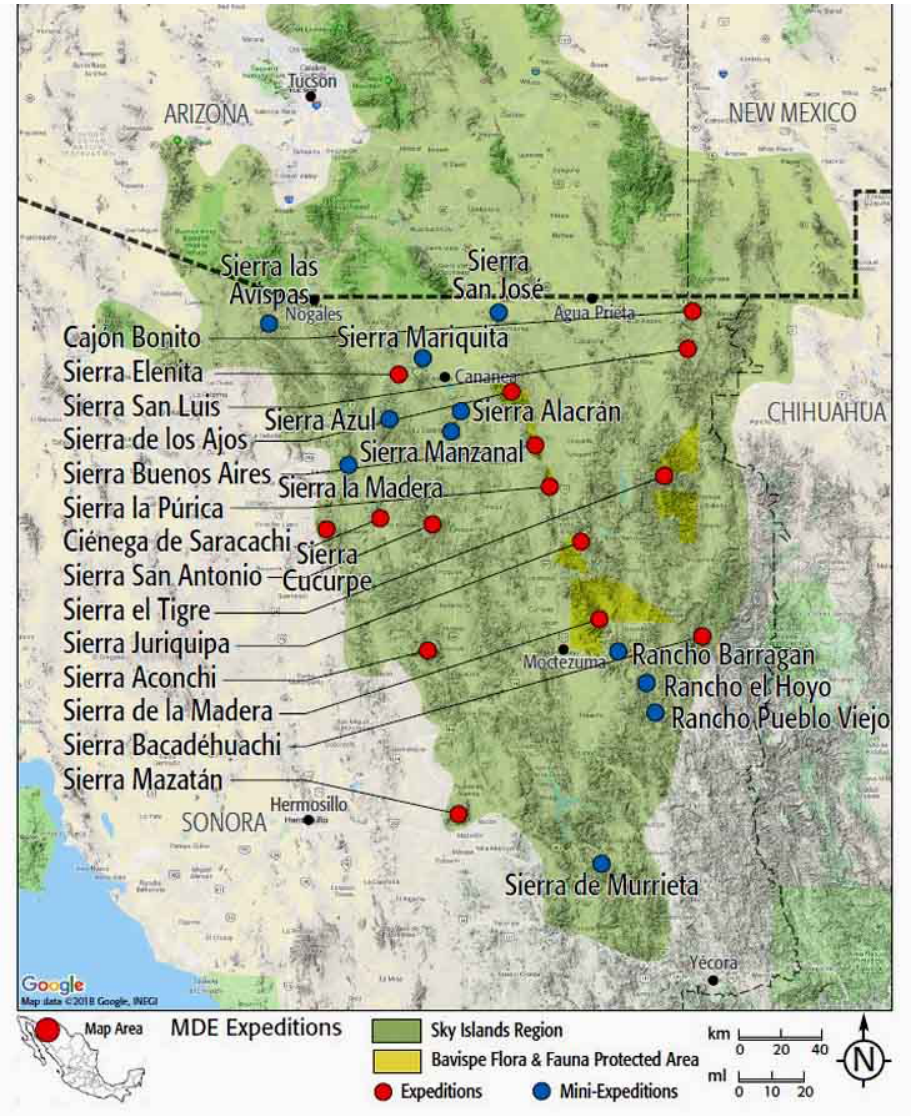

Figure 3. Map of the Sky Islands Region. Blue spots – MABA Expeditions. Blue triangles – MABA Mini-Expeditions. Red spots – MDE Expeditions. Red triangles – MDE Mini-Expeditions. Drafted by Dennis Caldwell.

All-species databases

A critical component of the MABA and MDE Expeditions is making biological observations publicly available for use in conservation, research, and education. In 2009, the all-species MABA database was created. MABA FLORA is directly linked to the SEINet herbarium databases. MABA FAUNA was an independent database. The MABA database mostly ceased activity since 2015, with 120,537 georeferenced records in the MABA database, including 75,921 animal (3,738 species) and 35,834 plant (2,188 species) récords from Sonora, Mexico. The MDE database (Madreandiscovery.org) was created in 2015 with the same structure to continue documenting the Sky Island biodiversity. Currently, there are 25,939

georeferenced records in the MDE database, including 9,771 animal (2438 species) and 10,911 plant (1296 species) récords from Sonora, Mexico. Previous récords are available through a link to the MABA database.

The MABA and MDE datasets are managed in a shared database in collaboration with iDigBio, SEINet, and >180 university collections. Records are both from historical sources (museum collections, literature, field notes, etc.) and new observations generated on biotic inventories to Sonoran Sky Island mountain ranges and a wide variety of trips on other projects. The FLORA databases are directly linked to the SEINet herbarium database network. The FAUNA databases are independent databases. With a combined total of 314,156 records (163, 119 animals, 151,037 plants), the MABA/MDE datbases are the best sources of biological records for Sonora.

Acknowledgments

Ed Gilbert wrote the SYMBIOTA software and set up the MABA and MDE databases. Sue Carnahan pointed out Pumpelly's 1870 use of the mountain islands. Careful reviews by Sky Jacobs and Frank Reichenbacher polished the text. Dennis Caldwell drafted the map. GreaterGood.org has strongly support the MDE program.

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Flora of Vascular Plants of the Santa Rita Mountains, Pima and Santa Cruz Counties, Southeast Arizona

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We present the Santa Rita Mountain Flora Project, intended to create the first complete botanical inventory of vascular plants of the range. This biologically rich Madrean Sky Island spans Pima and Santa Cruz counties with a defined study area encompassing approximately 150,850 ac (61,050 ha) or 236 mi^2 (611 km^2). Field work began August 2016 and is anticipated to conclude October 2018. This listing is specimen-based and currently includes 1,112 taxa in 105 families. The largest plant families are Asteraceae (187), Poaceae (133), Fabaceae (105), Euphorbiaceae (40) and Boraginaceae (31). *Euphorbia* (24), *Muhlenbergia* (21), *Dalea* (18), *Bouteloua* (12), *Cyperus* (12), *Desmodium* (12) and *Ipomoea* (12) are the largest genera. Eighty-nine taxa are new to the flora and 22 historically collected taxa were verified; 75 historical records remain unverified and are excluded from this report. Non-native plants are represented by 65 taxa (5.8%). The Santa Rita Mountains are the third most botanically diverse range in southern Arizona. The flora of this unique sky island faces many threats including anthropogenic impacts, long-term drought and climate change.

Flora de plantas vasculares de las montañas de Santa Rita, condados de Pima y Santa Cruz, sudeste de Arizona

Presentamos el Proyecto de Flora de la Montaña Santa Rita, destinado a crear el primer inventario botánico completo de plantas vasculares de la gama. Esta biológicamente rica Isla Serrana Madrense abarca los condados de Pima y Santa Cruz con un área de estudio definida que abarca aproximadamente 150,850 ac (61,050 ha) o 236 mi2 (611 km^2). El trabajo de campo comenzó en agosto de 2016 y se espera que concluya en octubre de 2018. Este listado se basa en muestras y actualmente incluye 1.112 taxones en 105 familias. Las familias de plantas más grandes son Asteraceae (187), Poaceae (133), Fabaceae (105), Euphorbiaceae (40) y Boraginaceae (31). Euphorbia (24), Muhlenbergia (21), Dalea (18), Bouteloua (12), Cyperus (12), Desmodium (12) e Ipomoea (12) son los géneros más grandes. Ochenta y nueve taxones son nuevos para la flora y 22 taxones recolectados históricamente fueron verificados; 75 registros históricos permanecen sin verificar y se excluyen de este informe. Las plantas no nativas están representadas por 65 taxones (5,8%). Las montañas de Santa Rita son la tercera variedad más botánicamente diversa en el sur de Arizona. La flora de esta singular isla serrana se enfrenta a muchas amenazas, incluyendo los impactos antropogénicos, la sequía a largo plazo y el cambio climático

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 47: Invertebrates

Santa Catalina Mountain landscape
(Photo courtesy of USDA Forest Service, Coronado National Forest)

Abstracts and Papers
Billings
Cañedo
Cabrera-Hernandez
Salazar
Silva-Kurumiya
Van Devender

Opening a Window on Western Monarchs: Arizona monarch butterflies tagged on the same day and site migrate to both California and Mexican overwintering regions

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Monarch butterflies (*Danaus plexippus*) of southeastern Arizona have only recently been found to make migration flights to both the California coast and central Mexico during the fall. An intensive, full-time field approach has led to a more complete and unique body of data, with significantly higher numbers of long-range, tagged monarch recoveries. In the fall of 2016, for the first time, monarchs tagged on the same day and site, in three separate instances, flew to opposite overwintering destinations in the United States and Mexico. This new discovery adds another critical piece of the puzzle, in the continuing quest to understand this unique migratory phenomenon.

Cómo abrir una ventana en las Monarcas occidentales: las mariposas monarca de Arizona marcadas el mismo día y el sitio migran a las regiones de hibernación de California y México

Recientemente se ha descubierto que las mariposas monarcas (Danaus plexippus) del sudeste de Arizona realizan vuelos de migración a la costa de California y al centro de México durante el otoño. Un enfoque de campo intensivo y de tiempo completo ha llevado a un conjunto de datos más completo y único, resultando en un número significativamente mayor de recuperaciones de largo alcance entre mariposas etiquetadas. En el otoño de 2016, por primera vez, mariposas etiquetadas el mismo día y en el mismo sitio, en tres instancias distintas, volaron a destinos de hibernación opuestos en los Estados Unidos y México. Este nuevo descubrimiento agrega otra pieza crítica del rompecabezas, en la búsqueda continua para comprender este fenómeno migratorio único.

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Monarch Butterfly Alliance

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The Monarch Butterfly Alliance is a group of Sky Island Alliance volunteers made up of students from the Bachelor of Biology at the University of Sonora and students from the Ecology program at the State University of Sonora working in Mexico for the conservation of the Monarch butterfly. We work with the conservation of the monarch butterfly with different activities such as workshops on the biology, ecology and conservation of this insect at all educational levels, we also do monitoring in Sonora due to the lack of information about the migratory phenomenon of the Monarch butterfly in the state, with that reason we aim to create a scientific article where the migratory route is verified and thus be able to create conservation programs knowing its route through Sonora. Our objectives are monitoring monarch butterfly and cotton buds in Sonora, dissemination with environmental education and propagation of native plants to eradicate invasive plants. We have been working for approximately two years and have taken the workshop to more than 3000 people in the state of Sonora. Were found 9 of the 15 species of the genus Asclepias, and 54 monarch butterflies in the

migration of autumn of the year 2016, in the year 2017 were found 50 monarch butterflies and 250 individuals of the genus. These records have been thanks to the monitoring of our members and the people who have led the workshop and have managed to find migratory Monarch butterflies.

Alianza Mariposa Monarca

La Alianza Mariposa Monarca es un grupo de voluntarios de Sky Island Alliance trabajando en México con la conservación de la mariposa Monarca, conformado por estudiantes de la Licenciatura en Biología de la Universidad de Sonora y Estudiantes de la carrera de Ecología en la Universidad Estatal de Sonora. Trabajamos con la conservación de la mariposa monarca con distintas actividades como talleres de la biología, ecología y conservación de éste insecto a todos los niveles educativos, también hacemos monitoreo en Sonora debido a la falta de información que hay acerca del fenómeno migratorio de la mariposa Monarca en el estado, con esa razón tenemos como objetivo crear un artículo científico donde se verifique la ruta migratoria y así poder crear programas de conservación conociendo su ruta por Sonora. Nuestros objetivos son monitoreo de mariposa monarca y algodoncillos en Sonora, difusión con educación ambiental y propagación de plantas nativas para erradicar las plantas invasivas. Tenemos trabajando aproximadamente dos años y hemos llevado el taller a más de 3000 personas en el estado de Sonora. Se encontraron 9 de las 15 especies del género Asclepias, y 54 mariposas monarca en la migración de otoño del año 2016, en el año 2017 se encontraron 50 mariposas monarca y 250 individuos del género. Estos registros han sido gracias al monitoreo de nuestros miembros y de las personas que han llevado el taller y han logrado encontrar mariposas Monarca migratorias.

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Soil Mite Diversity in Pine-Oak Woodland on the Mesa del Campanero, Sonora, México

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Although mites are a diverse and abundant component of most terrestrial ecosystems, little is known about soil mite diversity in northern Mexico. In this talk, we will present the results of a survey of soil mites in pine-oak woodland on the Mesa del Campanero in southeast Sonora. We collected a total of 96 samples of soil and litter from eight sites on four occasions between September 2016 and June 2017. Mites and other arthropods were extracted from these samples using Berlese-Tullgren funnels and then sorted under a dissecting microscope. This yielded a collection containing over 13,000 individual mites belonging to 76 morphospecies, including 39 apparently new records for the state of Sonora and 20 apparently new records for the country of México. Oribatids accounted for approximately 50% of our samples in all months except June, when the abundance of Prostigmatid mites exceeded 50%. As in soil mite studies conducted at other locations, we found that mite abundance was greatest in the litter and declined with increasing depth in the soil. In contrast, species richness did not significantly differ between the litter and soil at depths of 0-10 cm and 10-20 cm. Examination of the species accumulation curve for these samples suggests that as many as 60 additional soil mite species may occur at this location, indicating that much work remains to be done to characterize the acarofauna of the Madrean highlands.

Diversidad de ácaros del suelo en Pine-Oak Woodland en la Mesa del Campanero, Sonora, México

Aunque los ácaros son un componente diverso y abundante de la mayoría de los ecosistemas terrestres, se sabe poco sobre la diversidad de los ácaros del suelo en el norte de México. En esta charla, presentaremos los resultados de una encuesta de ácaros del suelo en un bosque de pino y roble en la Mesa del Campanero en el sureste de Sonora.

Recolectamos un total de 96 muestras de suelo y arena de ocho sitios en cuatro ocasiones entre septiembre de 2016 y junio de 2017. Se extrajeron ácaros y otros artrópodos de estas muestras utilizando embudos Berlese-Tullgren y luego se clasificaron bajo un microscopio de disección. Esto produjo una colección que contiene más de 13,000 ácaros individuales pertenecientes a 76 morfoespecies, incluyendo 39 registros aparentemente nuevos para el estado de Sonora y 20 registros aparentemente nuevos para el país de México. Las oribátidas representaron aproximadamente el 50% de nuestras muestras en todos los meses excepto en junio, cuando la abundancia de los ácaros Prostigmatid superó el 50%. Al igual que en los estudios de ácaros del suelo realizados en otros lugares, encontramos que la abundancia de ácaros fue mayor en la hojarasca y disminuyó a medida que aumentaba la profundidad en el suelo. En contraste, la riqueza de especies no difirió significativamente entre la hojarasca y el suelo a profundidades de 0-10 cm y 10-20 cm. El examen de la curva de acumulación de especies para estas muestras sugiere que pueden ocurrir hasta 60 especies adicionales de ácaros del suelo en este lugar, lo que indica que queda mucho trabajo por hacer para caracterizar la acarofauna de las tierras altas Madrenses.

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The Weevils (*Curculionidae*) of Mesa Tres Ríos, Sonora, Mexico

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Weevils in the family Cuculionidae were studied in the northernmost Sierra Madre Occidental in the vicinity of Mesa de Tres Ríos in the Municipality of Nácori Chico, Sonora, Mexico. In this area, the mountains reach 1,800 to 2,000 m in elevation, with some up to 2,400 m. The vegetation is oak, pine-oak and pine forests on slopes, and montane riparian deciduous forest in the canyon bottoms. The rainfall is one of the highest in Sonora, and temperatures are cool or cold most of the year. All invertebrates (ants, beetles, bugs, flies, spiders, beetles) were captured using a beating net and an aspirator on plants in the families Aceraceae, Ericaceae, Fagaceae, Pinaceae, and Plantanaceae between June 21 and September 30, 2017, The weevils were separated and preseved in 90% alcohol. Sixteen species of weevils were collected, with the greatest number of individuals in áreas dominated by pines. Observations and images are available in the Madrean Discovery Expeditions (MDE) database (madreandiscovery.org). This project was funded by the MDE Scholarship Fund.

The Weevils (Curculionidae) de Mesa Tres Rios, Sonora, Mexico.

Los gorgojos de la familia Cuculionidae fueron estudiados en la Sierra Madre Occidental más norteña en las proximidades de la Mesa de Tres Ríos en el Municipio de Nácori Chico, Sonora, México. En esta área, las montañas alcanzan altitudes de 1.800 a 2.000 m, con algunas hasta 2.400 m. La vegetación es de roble, pino-roble y bosques de pinos en laderas, y el bosque caducifolio ribereño de montaña en los fondos del cañón. La lluvia es una de las más altas en Sonora, y las temperaturas son frías o frías la mayor parte del año. Todos los invertebrados (hormigas, escarabajos, insectos, moscas, arañas, escarabajos) fueron capturados utilizando una red de ataque y un aspirador en las plantas de las familias Aceraceae, Ericaceae, Fagaceae, Pinaceae y Plantanaceae entre el 21 de junio y el 30 de septiembre de 2017, Los gorgojos fueron separados y preservados en 90% de alcohol. Se recolectaron 16 especies de gorgojos, con el mayor número de individuos en áreas dominadas por pinos. Las observaciones e imágenes están disponibles en la base de datos Madrean Discovery Expeditions (MDE) (madreandiscovery.org). *Este proyecto fue financiado por el Fondo de Becas MDE.*

Note: Full Paper Follows

Presencia de Curculionoidea en Mesa Tres Ríos, Sonora, México.

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***RESUMEN**--Se presentan datos de un inventario exploratorio de los picudos (Coleoptera: Curculionoidea) presentes en las inmediaciones de Mesa Tres Ríos, municipio de Nácori Chico, Sonora, México. La localidad se encuentra a 1,880 m sobre el nivel del mar. Se utilizó una red de golpeo para la captura de los organismos (Márquez-Luna 2005). Se realizaron 41 muestreos en área de estudio de 2,050 m^2 aproximadamente, representando cuatro diferentes ecosistemas (pino, pino-encino, encino y vegetación riparia), y durante un periodo de recolecta del 26 de junio al 30 de septiembre de 2017. Se registraron individuos de tres familias, ocho géneros, y siete especies de curculiónidos: Trichapion sp., Himatolabus pubescens, Anthonomus nanus, Curculio quercusgriseae, Lechriops californica, Phyllotrox sp., Sibinia ochreosa, Smicronyx imbricatus y S. spretus. De acuerdo con el conteo de los especímenes, el área que registra mayor presencia de individuos es la zona de pinos. Ahí, la temperatura es baja la mayor parte del año. En las montañas en donde se realizó el muestreo, algunas tienen una altitud de hasta 2,400 m sobre el nivel del mar, mientras que las otras van desde 1,800 a 2,000 m. El sustrato vegetal muestreado pertenece a las familias: Aceraceae, Ericaceae, Fagaceae, Pinaceae y Platanaceae, entre otros. Las observaciones e imágenes están disponibles en la base de datos Madrean Discovery Expeditions (madreandiscovery.org).*

***ABSTRACT**--Weevils in the family Cuculionidae were studied in the northernmost Sierra Madre Occidental in the vicinity of Mesa de Tres Ríos in the Municipality of Nácori Chico, Sonora, Mexico. In this area, the mountains reach 1,800 to 2,000 m in elevation, with some up to 2,400 m. The vegetation is oak, pine-oak and pine forests on slopes, and montane riparian deciduous forest in the canyon bottoms. The rainfall is one of the highest in Sonora, and temperatures are cool or cold most of the year. All invertebrates (ants, beetles, bugs, flies, and spidersbeetles) were captured using a beating net and an aspirator on plants in the families Aceraceae, Ericaceae, Fagaceae, Pinaceae, and Plantanaceae between June 21 and September 30, 2017, The weevils were separated and preseved in 90% alcohol. Sixteen species of weevils were collected, with the greatest number of individuals in áreas dominated by pines. Observations and images are available in the Madrean Discovery Expeditions (MDE) database (madreandiscovery.org). This project was funded by the MDE Scholarship Fund.*

INTRODUCCIÓN

La superfamilia Curculionoidea incluye aproximadamente 62,000 especies y 5,800 géneros asignados a siete familias: Anthribidae, Attelabidae, Belidae, Brentidae, Caridae, Curculionidae, Nemonychidae (Oberprieler et al. 2007). Los Curculionidae constituyen la familia mayor de Curculionoidea, con 51,000 especies conocidas (Oberprieler et al 2007). Se encuentran en todo el planeta, asociadas principalmente a angiospermas, pero también hay especies que se alimentan sobre líquenes, briofitas, pteridofitas y gimnospermas (Morrone 2014).

En México se han descrito 603 géneros y 3,594 especies, cerca de un 40% de las especies son endémicas y pertenecientes a seis familias, la única familia ausente en el país es Caridae (Anderson y O'Brien 1996). Aproximadamente el 85% de las especies de gorgojos mexicanos pertenecen a la familia Curculionidae y se clasifican en las subfamilias Barinidae, Brachycerinae, Cossoninae, Curculioninae, Cyclominae, Dryophthrinae, Entiminae, Molytinae, Platypodinae y Scolytinae. Los estudios taxonómicos sobre Curculionoidea son relativamente escasos; no existen revisiones modernas ni análisis filogenéticos para la mayoría de los taxones. A pesar de ser componentes importantes de todos los ecosistemas terrestres, para muchas especies se carece de información sobre su ecología, historia natural y características de los estadios inmaduros (Morrone 2014).

El presente trabajo surge con el fin de realizar un inventario de la presencia de picudos en el área conocida como Mesa Tres Ríos, municipio de Nácori Chico, Sonora (Figura 1). Por su territorio montañoso y por sus ecosistemas de pino,

Figura 1-- Vista desde la Sierra el Tigre. (Foto de Luis Gutiérrez, photoluis1, NortePhoto.com.).

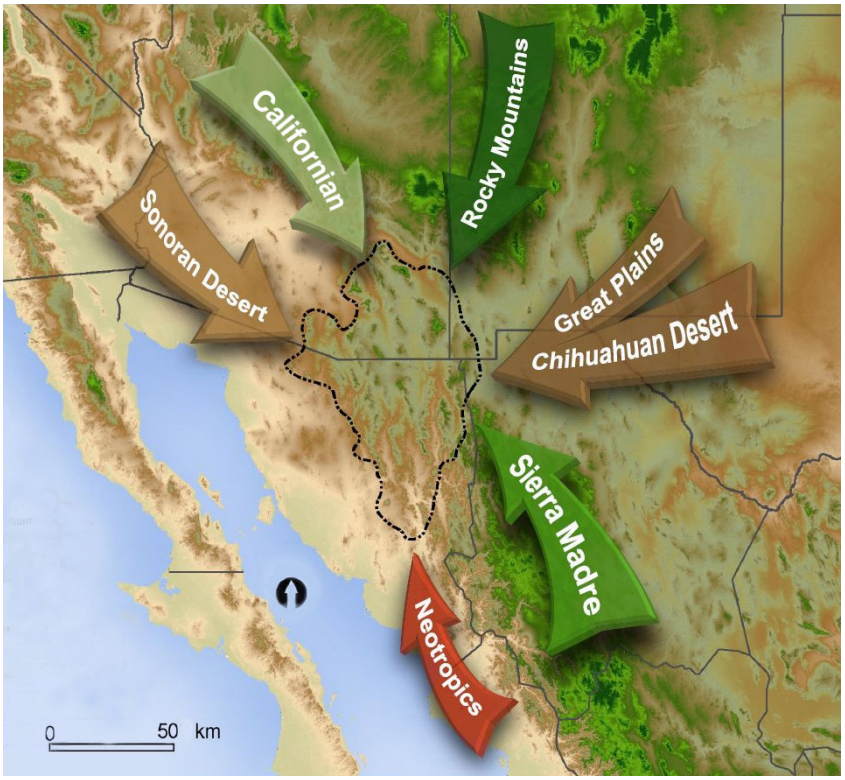

Figura 2. Afinidades bióticas de la región de las islas del cielo (línea de puntos).

pino-encino, encino-pino y encino (INEGI, 2000), puede y debe ser considerada como una isla del cielo para el Estado de Sonora (Figura 2), Mesa Tres Ríos colinda con tres afluentes importantes del Río Bavispe: San Antonio, Pie de la Cueva y La Cueva (INEGI, 2009).

METODOLOGÍA

El diseño de la investigación consistió en seleccionar un punto con el GPS ("Global Positioning System") en cada tipo de comunidad vegetal, y caracterizarla en una bitácora de campo con rasgos de: humedad, flora, fauna, topografía, estado del tiempo y registrando las coordenadas UTM ("Universal Transverse Mercator"). A partir de dicho punto, se realizaron cuatro transectos de 10 a 15 m en forma de cruz en dirección a los puntos cardinales (NE [Noreste], SE [Sureste], NO [Noroeste], y SO [Suroeste]). La recolecta comprendió los meses de junio a septiembre, realizando 41 muestreos. La técnica de captura usada fue la denominada “red de golpeo”, ideal para capturar insectos que se alimentan del follaje, e inicialmente tienden a no escapar a través de su capacidad de vuelo, como los curculiónidos (Márquez-Luna 2005). La técnica consiste en golpear la rama con un palo mientras se sostenía la red de golpeo en la parte inferior. Una vez capturados los insectos en la red de golpeo, los especímenes fueron succionados o tomados manualmente, y colocados en un frasco con alcohol al 90%. Las muestras fueron debidamente etiquetadas, con datos de tipo de vegetación (pino, pino-encino, encino, o vegetación riparia), planta muestreada (árbol o arbusto, de ser posible, la especie o familias), fecha, altitud, coordenadas, y recolector.

RESULTADOS

En total, se registraron individuos de tres familias, ocho géneros, y siete especies de curculiónidos: *Himatolabus pubescens* (Attelabidae); *Trichapion* sp. (Brentidae); *Anthonomus nanus, Curculio quercusgriseae, Lechriops californica, Phyllotrox* sp., *Sibinia ochreosa, Smicronyx imbricatus,* y *S. spretus* (Curculionidae), (Tabla 1). Las siguientes secciones documentan los patrones ambientales y de historia natural relacionados al inventario.

Al inicio de la actividad en campo, las lluvias se presentaron diariamente, por lo que los diferentes sustratos estaban en su mayoría mojados. La humedad en las plantas no fue impedimento para encontrar organismos como picudos, arañas, escarabajos, moscas, hormigas, chinches, garrapatas, pseudoescorpiones, entre otros. Hubo días en que las lluvias duraban hasta cuatro horas, incluso llovía por la mañana y por la tarde. Para el mes de agosto, las lluvias cesaron y el entorno empezó a cambiar, pues se empezaron a ver nuevas especies tanto de insectos como de artrópodos y las plantas empezaron a florecer. Para septiembre no se registró ningún día de lluvia, y la presencia de insectos en estado larvario fue evidente sobre las plantas, así como una variedad más de insectos. Para el caso particular de los picudos, al inicio de la recolecta fueron frecuentes en la jarilla *(Barkleyanthus salicifolius;* Asteraceae), pero conforme pasaban los meses estos empezaron a encontrarse en los pinos, encinos, bellotas y maples.
Se evaluaron las comunidades vegetales de la siguiente manera:

Pino

Esta fue la comunidad vegetal en la que se recolectaron más individuos (2,449), de los cuales se encontraron seis especies de picudos, siendo la más abundante los *Trichapion* sp., con una abundancia de 2,166 individuos que sobrepasa por mucho la abundancia de las demás especies, especialmente para el mes de septiembre. La especie menos frecuente fue *Smicronyx imbricatus,* con solo un individuo recolectado. Las especies restantes fueron *Himatolabus pubescens, Lechriops californica, Phyllotrox sp., Sibinia ochreosa,* y *Smicronyx spretus.*

Las especies antes mencionadas se encontraron mayormente en los pinos:*, Pinus engelmannii*, y *Pinus strobiformis* y otras especies como *Acer grandidentatum*. Evaluando también la jarilla (*Barkleyanthus salicifolius*), en la cual no se observó presencia de picudos.

Pino-Encino

Para esta comunidad vegetal se inició con los muestreos en julio. Registrando una menor cantidad de organismos recolectados, con un total de 14 individuos de las siguientes especies: *Trichapion* sp., *Phyllotrox* sp., *Sibinia ochreosa*, *Smicronyx imbricatus,* y *Smicronyx spretus.* Las cantidades de picudos fueron bajas, pero las especies fueron considerablemente variadas (Tabla 1). Evaluando en este escenario las siguientes especies de plantas: *Arbutus arizonica, Cupressus* sp., *Platanus wrightii y Quercus arizonica.*

Encino

En esta comunidad vegetal, el número de especies encontradas disminuyó en comparación de las anteriores, con un total de tres: *Trichapion* sp con 72., *Lechriops californica,* con tres y *Sibinia ochreosa* con 18*.* En esta comunidad vegetal se evaluaron principalmente las siguientes especies: *Arbutus arizonica, Quercus arizonica, Q. hypoleucoides y Q. jonesii.*

Vegetación Riparia

En este tipo de vegetación se encontraron seis especies de picudos; *Trichapion* sp.; *Anthonomus nanus, Curculio quercusgriseae, Phyllotrox* sp., *Sibina ochreosa,* y *Smicronyx spretus.* Al igual que la vegetación anterior, el mes de agosto fue el que presentó menor cantidad de picudos recolectados. La flora evaluada fue: *Salix gooddingii*, *Barkleyanthus salicifolius* y del género *Alnus.* En este tipo de vegetación se encontraron seis especies de picudos; *Anthonomus nanus, Curculio quercusgriseae, Phyllotrox* sp., *Sibina ochreosa,* y *Smicronyx spretus, Trichapion* sp*.* Al igual que la vegetación anterior, el mes de agosto fue el que presentó menor cantidad de picudos recolectados. El género *Trichapion* sp. fue uno de los más comunes en todas las comunidades vegetales. La flora evaluada fue: *Alnus oblongifolia, Barkleyanthus salicifolius, Salix gooddingii*.

DISCUSIÓN

La familia con mayor número de especies fue Curculionidae con siete, sin embargo, la abundancia por individuos en Curculionidae fue muy baja con 276 contra 2341 individuos de Brentidae, la cual cuanta con solo una especie *Tricapion* sp. El género más abundante fue *Trichapion* sp. (Brentidae). Las especies menos abundantes fueron *Anthronumus nanus, Curculia quercusgrisae,* y *Phyllotrox* sp.

La Tabla 1 muestra la abundancia de picudos recolectados por comunidad vegetal con relación al mes del año. Las comunidades de pino y de vegetación riparia, registraron seis especies; la comunidad de encino fue la que registro la menor riqueza con sólo tres especies. La comunidad de pino fue la que más individuos registró, especialmente del género *Trichapion* sp., teniendo un total de hasta 917 picudos para el mes de septiembre. Cabe aclarar, que para las otras comunidades (encino, pino-encino y vegetación riparia) no se muestreó el mes de junio.

Cabe mencionar que la distancia que separaba una comunidad vegetal de la otra, en ocasiones eran solo algunos metros, pero el resultado fue claro, la mayoría de las especies se encontraron en las zonas en donde predominaba el pino, sin tomar en cuenta la especie, otras como el *Curculio quercusgrisae* era muy común en la vegetación riparia. Hubo una comunidad vegetal (pino) en la cual se presentaron todas las familias. En general, la comunidad vegetal que menos individuos registró fue la de pino-encino, con una cantidad de 14 individuos en cinco especies.

Con las nueve especies recolectadas en los muestreos se confirma la presencia de Curculionidae en el área estudiada. Los muestreos realizados permitieron observar el aumento en la presencia de picudos al través de la temporada de lluvias, con la presencia de pocos individuos en el mes de junio y una abundancia mayor en agosto y septiembre. *Lechriops californica*, *Smicronyx imbricatus,* y *S. spretus* se recolectaron en el mes de julio, lo cual indica que tienen preferencia a cierto tipo de plantas con nuevos brotes.

Tabla 1. Resultado de los muestreos por comunidad vegetal, mostrando la abundancia absoluta y abundancia relativa.

Familia	Género y especie	Comunidad vegetal													Abundancia por especie	Abundancia relativa de especies (%)
		Pino				Pino-encino			Encino			Vegetación riparia				
		Jn[a]	Jl[b]	A[c]	S[d]	Jl[b]	A[c]	S[d]	Jl[b]	A[c]	S[d]	Jl[b]	A[c]	S[d]		
Brentidae	*Trichapion* sp.	5	428	861	917	0	1	2	29	1	42	41	3	11	**2341**	**89.215**
Attelabidae	*Himatolabus pubescens*	0	0	1	6	0	0	0	0	0	0	0	0	0	**7**	**0.267**
Curculionidae	*Anthonomus nanus*	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**	**0.038**
Curculionidae	*Curculio quercusgriseae*	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**	**0.038**
Curculionidae	*Lechriops californica*	0	17	10	0	0	0	0	0	1	2	0	0	0	**30**	**1.143**
Curculionidae	*Phyllotrox* sp.	0	0	0	0	1	0	0	0	0	0	0	0	1	**2**	**0.076**
Curculionidae	*Sibinia ochreosa*	158	15	6	12	1	1	2	1	0	16	4	0	0	**216**	**8.232**
Curculionidae	*Smicronyx imbricatus*	0	1	0	0	2	2	0	0	0	0	0	0	0	**5**	**0.191**
Curculionidae	*Smicronyx spretus*	0	1	9	2	0	0	2	0	0	0	2	0	5	**21**	**0.800**
Total de individuos por tipo de hábitat		**163**	**462**	**887**	**937**	**4**	**4**	**6**	**30**	**2**	**60**	**47**	**3**	**19**	**2624**	**100%**
		2449				**14**			**92**			**69**				

a: Jn: Junio

b: Jl: Julio,

c: A: Agosto

d: S: Septiembre

El presente trabajo es de gran valor como antecedente para el área, debido a que se registraron géneros que pueden incrementar en un futuro el número de especies, siempre y cuando se aumente el esfuerzo de muestreo en área y tiempo; de la misma manera puede ser utilizado como punto de referencia para dar seguimiento a futuras investigaciones sobre curculiónidos. El trabajo en equipo aumenta la eficacia al momento de llevar a cabo las recolectas, por lo que, se recomienda como mínimo dos personas para llevar al cabo el trabajo de campo.

CONCLUSIONES

Se encontraron tres familias de las seis registradas para México, lo que indica que sí hubo éxito a pesar de que el área de estudio fue muy reducida, de 2,050 m^2 aproximadamente. Con la técnica empleada de la red de golpeo, se logró el objetivo planteado. Aunque las comunidades vegetales, en algunas ocasiones, fueran diferentes, no afectó la recolecta

de insectos. En total se registraron tres familias, ocho géneros, y siete especies de curculiónidos en las comunidades vegetales evaluadas. Los resultados obtenidos son muy importantes ya que no se tenía registro de especies para el área.

Como se muestra en la Tabla 1, los meses de julio, agosto y septiembre, fueron los que presentaron mayor éxito, tanto de individuos como de especies y géneros, también, se deberá considerar la comunidad vegetal a evaluar por lo agreste del área de estudio en algunas zonas y/o localidades. El presente trabajo sobe picudos es el primero en su tipo en la región serrana de Sonora. Si bien se encontraron siete especies de curculionidos, de acuerdo con Anderson y O'Brien (1996), es posible encontrar más especies, esto debido a que mencionan el registro de 3,594 especies o familias en México, por lo tanto, Mesa Tres Ríos en el futuro, debe ser una nueva región propicia para localizar más especies o incluso, nuevas especies de picudos.

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Se presentan los siguientes agradecimientos: Universidad de la Sierra por su apoyo en el presente trabajo; GreatersGoods.org, por la beca escolar otorgada a Víctor Hugo Cabrera-Hernández; Tomas R. Van Devender, Director of Biodiversity Programs, por su asesoría en la identificación de especies; Ana Lilia Reina Guerrero, por su ayuda en la identificación de flora; Ejido Mesa Tres Ríos, por las facilidades durante los muestreos. A los revisores por sus atinados comentarios y sugerencias: Tomas R. Van Devender y John Palting.

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Monarch Butterflies in Sonora, Mexico

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The monarch butterfly (*Danaus plexippus* subsp*. plexippus*) migrates from southern Canada and the eastern United States south to Florida and southern Mexico in late summer/fall. This migration covers thousands of kilometers, with a corresponding multi-generational return north. Monarchs west of the Rocky Mountains migrate to southern California, where they are known to overwinter in Arizona and California. The Madrean Discovery Expeditions (MDE) database (madreandiscovery.org), reflecting extensive biotic inventories, has records of *D. plexippus* from 29 localities in Sonora, Mexico since 1979. The Alianza Mariposa Monarca group in Hermosillo has 42 observations in 2016-2017. Six additional records are from Naturalista (http://www.naturalista.mx). The total monarch butterfly records for Sonora is 77. The observations are widespread throughout temperate and tropical areas in the eastern half of Sonora from the Arizona border south to the Álamos area. A few monarchs have been seen in the Sonoran Desert at Bahía de Kino, the Guaymas area, Hermosillo, and Puerto Peñasco. Most observations are of single individuals. Monarchs were seen from November to May, with the most observations from September to November, documenting overwintering in Sonora. A few individuals from the western United States have been found overwintering in Michoacán. However, our observations do not support the migration of monarch butterflies from or through Sonora to southern Mexican winter refugia. We suggest that the main migration route for monarchs is the eastern half of the Mexican Plateau following the Sierra Madre Oriental southward. The Sierra Madre Occidental and Sierra Madre del Sur are migration barriers for western populations.

Mariposas monarcas en Sonora, México

La mariposa monarca (Danaus plexippus subsp. Plexippus) migra desde el sur de Canadá y el este de los Estados Unidos hacia el sur hasta Florida y el sur de México a fines del verano / otoño. Esta migración abarca miles de kilómetros, con el correspondiente retorno multigeneracional hacia el norte. Las monarcas al oeste de las Montañas Rocosas migran al sur de California, y se sabe que pasan el invierno en Arizona y California. La base de datos Madrean Discovery Expeditions (MDE) (madreandiscovery.org), que refleja extensos inventarios bióticos, tiene registros de D. plexippus de 29 localidades en Sonora, México desde 1979. El grupo Alianza Mariposa Monarca en Hermosillo tiene 42 observaciones en 2016-2017. Seis registros adicionales son de Naturalista (http://www.naturalista.mx). El total de registros de la mariposa monarca para Sonora es de 77. Las observaciones se han generalizado a lo largo de las zonas templadas y tropicales en la mitad oriental de Sonora, desde la frontera de Arizona al sur hasta el área de Álamos. Se han visto algunas monarcas en el Desierto de Sonora en Bahía de Kino, el área de Guaymas, Hermosillo y Puerto Peñasco. La mayoría de las observaciones son de individuos solos. Las monarcas fueron vistas de noviembre a mayo, con la mayoría de las observaciones de septiembre a noviembre, documentando el hibernación en Sonora. Algunos individuos del oeste de los Estados Unidos han sido encontrados hibernando en Michoacán. Sin embargo, nuestras observaciones no apoyan la migración de las mariposas monarcas desde o a través de Sonora al refugio de invierno del sur de México. Sugerimos que la principal ruta de migración para las monarcas es la mitad oriental de la meseta mexicana siguiendo la Sierra Madre Oriental hacia el sur. La Sierra Madre Occidental y la Sierra Madre del Sur son barreras migratorias para las poblaciones occidentales.

NOTE: A manuscript was not submitted to accompany this presentation.

Session 49: Citizen Science

Rincon Mountains, Coronado National Forest, Arizona
(Photo courtesy of the Coronado National Forest)

Abstracts and Papers
Cañedo
Depew
Jimenez-Canale
Powell
Sanderlin
Wilder

Monarch Butterfly Alliance

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The Monarch Butterfly Alliance is a group of Sky Island Alliance volunteers made up of students from the Bachelor of Biology at the University of Sonora and students from the Ecology program at the State University of Sonora working in Mexico for the conservation of the Monarch butterfly. We work with the conservation of the monarch butterfly with different activities such as workshops on the biology, ecology and conservation of this insect at all educational levels, we also do monitoring in Sonora due to the lack of information about the migratory phenomenon of the Monarch butterfly in the state, with that reason we aim to create a scientific article where the migratory route is verified and thus be able to create conservation programs knowing its route through Sonora. Our objectives are monitoring monarch butterfly and cotton buds in Sonora, dissemination with environmental education and propagation of native plants to eradicate invasive plants. We have been working for approximately two years and have taken the workshop to more than 3000 people in the state of Sonora. Were found 9 of the 15 species of the genus Asclepias, and 54 monarch butterflies in the migration of autumn of the year 2016, in the year 2017 were found 50 monarch butterflies and 250 individuals of the genus. These records have been thanks to the monitoring of our members and the people who have led the workshop and have managed to find migratory Monarch butterflies.

Alianza Mariposa Monarca

La Alianza Mariposa Monarca es un grupo de voluntarios de Sky Island Alliance trabajando en México con la conservación de la mariposa Monarca, conformado por estudiantes de la Licenciatura en Biología de la Universidad de Sonora y Estudiantes de la carrera de Ecología en la Universidad Estatal de Sonora. Trabajamos con la conservación de la mariposa monarca con distintas actividades como talleres de la biología, ecología y conservación de éste insecto a todos los niveles educativos, también hacemos monitoreo en Sonora debido a la falta de información que hay acerca del fenómeno migratorio de la mariposa Monarca en el estado, con esa razón tenemos como objetivo crear un artículo científico donde se verifique la ruta migratoria y así poder crear programas de conservación conociendo su ruta por Sonora. Nuestros objetivos son monitoreo de mariposa monarca y algodoncillos en Sonora, difusión con educación ambiental y propagación de plantas nativas para erradicar las plantas invasivas. Tenemos trabajando aproximadamente dos años y hemos llevado el taller a más de 3000 personas en el estado de Sonora. Se encontraron 9 de las 15 especies del género Asclepias, y 54 mariposas monarca en la migración de otoño del año 2016, en el año 2017 se encontraron 50 mariposas monarca y 250 individuos del género. Estos registros han sido gracias al monitoreo de nuestros miembros y de las personas que han llevado el taller y han logrado encontrar mariposas Monarca migratorias.

NOTE: A manuscript was not submitted to accompany this presentation.

Using Citizen Science, education and community involvement to preserve protect and restore springs and wetlands of the Southwest

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Springs and wetlands of the Southwest are remarkable habitats that support a much larger ecoregion. In the Southwest these areas are 'jewels' that hold precious water and become 'natural areas' that host an astounding biodiversity. With the appropriate restoration of native plants and wetland species, as well as thoughtful ecological planning and management these areas become an oasis for wildlife, an educational teaching tool, a source for community involvement and areas of ongoing research. They are the 'migratory waystations' and 'postage stamp habitats' of the Southwest. This talk will show, with specific examples, how these areas need to be protected and can be restored, as well as maintained and used by the community and research-based programs. We will specifically look at the changing climate, water, soils and water use in restoration of wetland projects in the southwest. With wise management, ecological decision making, planting appropriate native plants and the assistance of community partners and students, across the region, these areas of water in an arid land continue to be precious resources.

Usando Ciencia Ciudadana, educación y participación de la comunidad para preservar y proteger manantiales y humedales del Suroeste de los Estados Unidos.

Los manantiales y los humedales del suroeste de los Estados Unidos son hábitats notables que sustentan una ecorregión mucho más grande. En el suroeste de los Estados Unidos, estas áreas son "joyas" que contienen agua preciosa y se convierten en "áreas naturales" que albergan una biodiversidad asombrosa. Con la restauración adecuada de las plantas nativas y las especies de humedales, así como la planificación y gestión ecológica, estas áreas se convierten en un oasis para la vida silvestre, una herramienta de enseñanza educativa, una fuente de participación comunitaria y áreas de investigación en curso. Son las "estaciones de paso migratorias" y los "hábitats de franqueo postal" del suroeste. Esta charla mostrará, con ejemplos específicos, cómo estas áreas deben ser protegidas y pueden ser restauradas, así como también mantenidas y utilizadas por la comunidad y los programas basados en investigación. Analizaremos específicamente el cambio en el clima, el agua, los suelos y el uso del agua en la restauración de proyectos de humedales en el suroeste. Con una gestión sensata, la toma de decisiones ecológicas, la plantación de plantas nativas apropiadas y la asistencia de socios y estudiantes de la comunidad, en toda la región, estas áreas de agua en una tierra árida continúan siendo recursos valiosos.

NOTE: A manuscript was not submitted to accompany this presentation.

Outdoor activities as a new way to involve society in biological research

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Outdoor activities such as hiking, trekking and walking though natural paths and trails have taken a new toll on Sonoran society, becoming a trending activity, be it on the morning, noon andor night. This has caused an increase in the sighting of poisonous, non-poisonous, venomous and non-venomous animals, such as toads, frogs, snakes, vipers, Gila monsters, arachnids and such. By collaborating with the Tucson Herpetological Society, through the "Charles H. Lowe, Jr.

Herpetological Research Fund", we studied the herpetofauna biodiversity of the three most popular areas for outdoor activity in the city of Hermosillo, Sonora. This led to the formation of an outdoor activity group known as "Gila Hikers", consisting of people from all trades and professions. The formation of such group lead to an interest in the general public, as well as the state government, as to what can be found in such places and how the information provided may help. Throughout the year, we found protected species by Mexican law (NOM 059-SEMARNAT-2010) such as 2 different species of rattlesnakes, some unprotected toads, frogs, lizards and arachnids. The Gila Hikers group is currently aiming to keep researching and working alongside different government branches and public institutions such as universities, medical and research centers.

Actividades al aire libre como una nueva forma de involucrar a la sociedad en la investigación biológica.

Las actividades al aire libre como el senderismo, el trekking y el senderismo a través de senderos naturales y senderos han cobrado un nuevo precio en la sociedad de Sonora, convirtiéndose en una actividad de tendencia, ya sea en la mañana, al mediodía y / o en la noche. Esto ha causado un aumento en el avistamiento de animales venenosos, y no venenosos, como sapos, ranas, serpientes, víboras, monstruos de Gila, arácnidos y otros. Al colaborar con la Sociedad Herpetológica de Tucson, a través del "Fondo de Investigación Herpetológica Charles H. Lowe, Jr.", estudiamos la biodiversidad de la herpetofauna de las tres áreas más populares para actividades al aire libre en la ciudad de Hermosillo, Sonora. Esto condujo a la formación de un grupo de actividades al aire libre conocido como "Gila Hikers", que consta de personas de todos los oficios y profesiones. La formación de dicho grupo conduce a un interés en el público en general, así como en el gobierno estatal, en cuanto a lo que se puede encontrar en dichos lugares y cómo la información provista puede ayudar. A lo largo del año, encontramos especies protegidas según la ley mexicana (NOM 059-SEMARNAT-2010), como 2 especies diferentes de serpientes de cascabel, algunos sapos sin protección, ranas, lagartos y arácnidos. El grupo Gila Hikers actualmente apunta a seguir investigando y trabajando junto con diferentes ramas gubernamentales e instituciones públicas, como universidades, centros médicos y centros de investigación.

NOTE: A manuscript was not submitted to accompany this presentation.

Conservation in the Smartphone Age: Expanding our Approaches to Public Engagement

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The rapid pace of societal change, fueled in part by mobile, smartphone technology has begun changing how we interact with each other, make decisions, and engage on issues that impact our lives. What does this disruptive shift in communications mean for creating lasting conservation outcomes and in nurturing the next generation of natural scientists? While science and conservation activities must now employ outreach tools such as social media, a range of other mediums must be pursued with renewed energy: tried and true, "disconnected" experiential nature opportunities, collaborative engagement that reaches across real or perceived divides, and novel scientist/artist collaborations. Examples of these engagement strategies will be highlighted including Pima County's efforts along the Santa Cruz River and the Altar Valley, in addition to work of other conservation partners.

Conservación en la era de los Smart phones: ampliando nuestros enfoques para la participación pública

El rápido ritmo del cambio social, impulsado en parte por la tecnología de teléfonos móviles y teléfonos inteligentes, ha comenzado a cambiar la forma en que interactuamos entre nosotros, tomamos decisiones y participamos en los problemas que afectan nuestras vidas. ¿Qué significa este cambio disruptivo en las comunicaciones para crear resultados de conservación duraderos y para nutrir a la próxima generación de científicos naturales? Mientras que las actividades científicas y de conservación ahora deben emplear herramientas de alcance tales como las redes sociales, se debe buscar una gama de otros medios con energías renovadas: probadas y verdaderas, oportunidades de naturaleza experiencial "desconectadas", compromiso colaborativo que atraviesa divisiones reales o percibidas, y novedosas colaboraciones científico / artista. Se destacarán ejemplos de estas estrategias de participación, incluidos los esfuerzos del Condado de Pima a lo largo del río Santa Cruz y el Valle de Altar, además del trabajo de otros socios de conservación.

NOTE: A manuscript was not submitted to accompany this presentation.

Evaluating change in avian communities from wildfire in the Arizona Sky Islands

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The avifauna within the Sky Islands of southeastern Arizona includes species found nowhere else in the U.S. Thus, birdwatchers from across the globe visit the region, providing a vibrant state and local ecotourism industry. We initiated a study on birds across montane forest and woodland types in the Santa Rita, Santa Catalina, Huachuca, Chiricahua, and Pinaleño Mountains (Coronado National Forest) from 1991 to 1995. Since then, the region has been under increased stress from ongoing drought and wildfire, possibly associated with climate change. We know little about fire effects on populations and habitats of Neotropical migratory birds in this region. Our objectives were to determine if bird distribution patterns and species diversity changed over time and if changes were attributable to fire and climate change. Secondly, we wanted to evaluate relationships of fire severity and time since fire with these avian communities. During spring and summer 2014, we resampled birds and vegetation at 28 of the original transects (n = 328 count stations). We used multi-species, multi-season occupancy models in a Bayesian hierarchical framework to estimate species richness and community dynamics, while accounting for imperfect detection. We used time since fire and fire severity to assess temporal and spatial variation in fire effects. Results indicate positive and negative responses to fire by individual species, and changes in community dynamics. By re-sampling vegetation and birds following wildfire, our study can provide guidance with post-fire restoration, and assist with conserving avian community structure.

Evaluación del cambio en las comunidades avícolas a causa de los incendios forestales en las Islas Serranas de Arizona

La avifauna dentro de las Islas Serranas del sudeste de Arizona incluye especies que no se encuentran en ningún otro lugar en los Estados Unidos. Por lo tanto, los observadores de aves de todo el mundo visitan la región, proporcionando un vibrante estado y la industria del ecoturismo local. Iniciamos un estudio sobre aves a través de bosques montanos y tipos de bosques en las montañas Santa Rita, Santa Catalina, Huachuca, Chiricahua y Pinaleño (Bosque Nacional Coronado) de 1991 a 1995. Desde entonces, la región ha estado bajo mayor estrés por la sequía en curso e incendios forestales, posiblemente asociados con el cambio climático. Sabemos poco sobre los efectos del fuego en las poblaciones y hábitats de aves migratorias neotropicales en esta región. Nuestros objetivos fueron determinar si los patrones de distribución de aves y la diversidad de especies cambiaron con el tiempo y si los cambios fueron atribuibles a incendios y al cambio climático. En segundo lugar, queríamos evaluar las relaciones de gravedad del incendio y el tiempo desde el incendio con estas comunidades avícolas. Durante la primavera y el verano de 2014, volvimos a muestrear aves y vegetación en 28 de los transectos originales (n = 328 estaciones de conteo). Utilizamos modelos de ocupación multiespecífica y de varias temporadas en un marco jerárquico bayesiano para estimar la riqueza de especies y la dinámica de la comunidad, a la

vez que tomamos en cuenta la detección imperfecta. Utilizamos el tiempo desde la severidad del incendio y del fuego para evaluar la variación temporal y espacial en los efectos del fuego. Los resultados indican respuestas positivas y negativas al fuego por especies individuales y cambios en la dinámica de la comunidad. Al volver a muestrear la vegetación y las aves después de un incendio forestal, nuestro estudio puede proporcionar una guía para la restauración posterior al incendio y ayudar a conservar la estructura de la comunidad aviar.

Note: Full Paper Follows

Designing Local Citizen Science Projects to Address Scientific Questions and Contribute to Collaborative Conservation Efforts

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Abstract-- *Citizen science allows volunteers to actively participate in the scientific inquiry process and as a discipline has increased in recent years. Many citizen science efforts work across broad spatio-temporal scales, making it possible to address questions that typically cannot be assessed through single studies due to budgetary, time, and scale constraints. Citizen science provides an opportunity to collect data that would otherwise not be collected, contributes to knowledge of ecological and management topics, and involves citizens in ecological science and management issues. Citizens often are eager to participate in scientific efforts but may lack experience with design and implementation of rigorous monitoring programs. We present a general framework for designing a citizen science project to address scientific and management questions. We outline important steps in designing a smaller regional scale (confined to single locations or multiple locations within a region) citizen science effort, including selecting objectives that could be achieved with expected data, and conducting a pilot study to gauge volunteer workload and identify technical challenges. The Madrean Archipelago contains rich plant and wildlife communities as a biodiversity hotspot and supports a large population of engaged citizens. In our discussion, we describe how two citizen science case studies (i.e., partnering with a local non-governmental organization to sample Arizona Sky Island birds, BioBlitzes) can contribute to collaborative conservation efforts.*

INTRODUCTION

Citizen science has gained traction as a way to engage and increase public interest as well as address ecological science and management questions (Cooper et al. 2007; Dickinson et al. 2010; Kelling et al. 2009) over broad spatial and temporal scales (i.e., National Audubon Society's Christmas Bird Count [Droege 2007]). Citizen science is described as engaging citizen volunteers in scientific inquiry through participation in the structuring of science or management questions, collecting samples, and/or processing data (Silvertown 2009). Citizen science projects often have multiple objectives of evaluating scientific questions and increasing public engagement. In our paper, we focus on projects with both of these objectives and not with citizen science projects developed primarily to gather support for a particular issue. In many instances, the temporal and spatial scope of scientific studies is limited by budgetary and time constraints. Citizen science data tend to be collected at broad spatial scales but with coarse resolution (i.e., eBird [http://www.ebird.org; Sullivan et al. 2009], North American Breeding Bird Survey [BBS; Peterjohn 1994]). Such data can complement traditional studies conducted with greater resolution at fine spatial scales, but also limits the types of questions that can be addressed. There is often a tradeoff between data quality and quantity (Pacifici et al. 2017), whereby more data may be available at broader scales but with lower quality and effort. This tradeoff is particularly noticeable in broad-scale citizen science efforts. There are opportunities, however, for additional citizen science projects collected at fine spatial scales to address science and management questions and generate local community support. These small scale projects are better suited to answering more narrowly targeted (or focused) monitoring questions (*sensu* Nichols and Williams 2006), that address specific objectives under rigorous sampling designs that improve study relevance, data durability, and data integrity.

The Madrean Archipelago contains rich plant and wildlife communities, and is a biodiversity hotspot (Van Devender et al. 2013; Spector 2002). The region also has many engaged citizens, willing to contribute to scientific efforts. This provides a great opportunity to design and implement rigorous monitoring programs using these citizens (e.g., https://www.coronadooutdoors.org/). Organizations (e.g., Sky Island Alliance [https://www.skyislandalliance.org/], USDA Forest Service Rocky Mountain Research Station) within the region have recognized and capitalized on the interests of these citizens to include them within monitoring efforts. Several broad-scale (i.e., eBird, BBS, Sky Island Alliance cross-

border projects) and fine-scale (i.e., Sky Island Alliance mountain range projects) citizen science efforts also occur within the Sky Islands and the Southwest. These endeavors are notable for energizing citizens and providing conservation education opportunities through data collection activities. The goal of this paper is to strengthen the link between citizen science data collection efforts and realized potential of their data by providing guidance in study design for targeted science or management questions. Well-designed citizen science projects can result in greater motivation and participation among observers, because those observers are able to appreciate and directly witness the scientific impact of their efforts. These projects can also contribute towards broader recognition of citizen science as a valid tool within the research and monitoring toolbox.

We focus on research questions specific to monitoring plants and animals; however, the same general principles of study design are applicable to other project types (i.e., evaluating springs and water resources). Ecological citizen science efforts typically aim to answer questions related to change in ecosystem structure and function as a result of different stressor types. In the Southwest, environmental stressors can include climate change, wildfire, and insect outbreaks (Kupfer et al. 2005; O'Connor et al. 2015). Ecosystem change in the Southwest could also result from mechanical treatments, grazing, urbanization, prescribed fire, and other habitat modifications (Bock and Bock 1992; Krueper et al. 2003). We present a general framework for establishing guidelines that can result in effective citizen science monitoring efforts. These guidelines can be used to assess whether questions are appropriate for citizen science projects, and whether or not those projects can meet desired objectives. We illustrate this framework through two case studies from the Southwest.

GENERAL FRAMEWORK

Our framework for designing citizen science monitoring projects follows general monitoring study design guidelines to determine what, where, when, and how sampling should occur (Block et al. 2001; Morrison et al. 2008), highlighting caveats unique to citizen science projects. The framework includes the following sequential steps: (1) identifying objectives, (2) selecting appropriate state variables and vital rates to meet objectives, (3) conducting a pilot study, (4) conducting a power analysis to estimate variability and expected effort from citizen observers, and (5) adjusting the study design as appropriate based on results of that pilot study (Figure 1). Citizen science monitoring projects, if placed in an adaptive management framework (an iterative process where management actions are implemented and response variables are monitored and evaluated repeatedly), can assist with evaluating management actions and gaining knowledge about natural resources. In this framework, there will be thresholds that trigger specific actions related to determining if the right variables are being monitored, if modifications are needed in the study design, and if study objectives are being met (Moir and Block 2001; Nie and Schultz 2012; Schwartz et al. 2015).

Developing study objectives

The most important component of any monitoring project is identifying clear objectives (Yoccoz et al. 2001). Again, citizen science projects will often have multiple objectives related to evaluating scientific questions and increasing public engagement. Our focus here is primarily on the scientific objectives, but we do provide linkages between these two objective types. Objectives will dictate what is measured, why it is being measured, how change is assessed and overall study design. As with all potential studies, selecting an appropriate question that could feasibly be answered with expected granular (how much biological and sampling noise in the system) data in many citizen science projects is integral to project success. Both broad-scale (i.e., climate change correlates on migratory birds across the United States) and targeted (i.e., bird population response to forest thinning in a portion of a single National Forest) questions may be appropriate with citizen observer data. The type of citizen involvement may influence study design. Citizens may be more

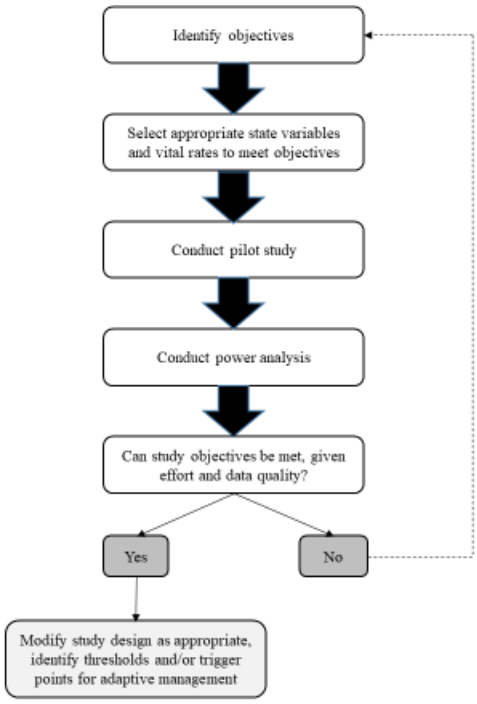

Figure 1--Framework for designing citizen science monitoring projects.

intimately tied to the resources of interest, so could have full understanding of the types of research questions that would support specific objectives. Therefore, citizens could be productive and active participants with this step in the process of developing research questions.

Data quality is an important consideration in determining achievable study objectives, and they can be evaluated via training and a pilot study (see below). In particular, studies have documented differences while comparing citizen and professional observers (Fitzpatrick et al. 2009; Sauer et al. 1994). For example, objectives related to assessments of rare species (which are typically difficult to detect) are less likely to be appropriate with citizen observer studies because the proportion of false positives is increased and the resulting data thus are more unreliable. In addition, the potential negative consequences from incorrect decisions are increased with rare species (McKelvey et al. 2008).

How to measure change

Most ecological studies are not structured as experiments (Block et al. 2001), and many monitoring efforts are not tightly linked to evaluating correlations related to stressors. However, monitoring is best done with specific objectives. Therefore, correlations to changes in ecosystem structure and function can be measured by changes in species richness, occupancy from local colonization or extinction, abundance, range, and/or diversity (Table 1). *A priori* knowledge about the system and research into similar ecosystems will help determine initial response variables that are biologically meaningful. The adaptive management process will determine if the right response variables are being measured. Appropriate response variables need to be biologically meaningful, sensitive to change, and easy to sample. Monitoring vital rates such as survival or reproduction is possible but requires skilled observers, greater effort (time, money), and may be infeasible with citizen science projects. Monitoring wildlife reproduction and survival may require physically handling animals, which has additional challenges with citizen observer studies due to requirements for extensive training and regulatory permits. However, citizen observers may monitor nests by counting number of young and sometimes number of fledged.

Table 1—Types and description of quantitative measures (monitoring state variables and vital rates) to assess change in ecosystem structure and function with citizen science projects. Although other quantitative measures are available, we list the most common and feasible variables and rates given typical citizen science projects. Appropriate response variables will be biologically meaningful, sensitive to change, and easy to sample. The table is adapted from Holthausen et al. (2005: Table 4), Schwartz et al. (2015), and Sanderlin et al. (*unpublished data*).

Monitoring state variable(s) and vital rates	Description	Achievable by citizens	Derived state variable(s) and vital rates from data collected
Occupancy	Occupancy is the presence of an organism at a given location, estimated via site-occupancy models to account for imperfect detection (Mackenzie et al. 2006; MacKenzie et al. 2002).	Species detections, nest detections, camera or hair snare surveys, track detections, scat collection, eDNA samples	Several derived state variables and vital rates are possible with data collected in an occupancy framework. Changes in occupancy status over time are estimated with local extinction and colonization probability with multi-season occupancy models. The range distribution (geographic range at a particular point or points in time) can be estimated via occupancy models with presence-absence data (Mackenzie et al. 2006; MacKenzie et al. 2002) or via maximum entropy modeling with presence-only data (Phillips et al. 2006). Range distribution change over time can be estimated across multiple points in time where populations expand, contract, or remaining constant. Species richness (number of species in a given area) is best estimated with multi-species occupancy models (Dorazio et al. 2006; Mackenzie et al. 2006). Species evenness and diversity both require the number of species and abundance of each species. Species turnover can be estimated with local colonization and extinction (i.e., Sauer et al. 2013) while accounting for imperfect detection. Density (number per unit area), λ or finite rate of increase (abundance change over unit of time)
Abundance	The number of plants or animals in a given location at a specific time.	Counts, camera surveys, non-invasive genetic surveys (i.e., hair snare or scat surveys)	
Phenology	First observed date of phenological state.	Bird arrival dates, first flowering dates, first incubation dates at monitored nests	

Pilot Study

Given specific objectives and quantifiable measures of change, the next step is conducting a pilot study to gauge volunteer workload and physical capabilities, technical challenges with communication and training, and system variability. Schedules are often more irregular with volunteer-based sampling than with a paid workforce, and study designs must be robust in this regard. A pilot study will also expose citizen observers to field sampling and potentially demanding physical environments. Such exposure will provide valuable information to both researchers and volunteers as to citizen observer physical capabilities. The field sampling exposure may also highlight potential deficiencies or strengths in observer training and data collection abilities. This information can then be used to modify methodologies prior to beginning the full study (see *Case Study 1*). Finally, there may be technical challenges related to communication and training that need to be identified through this process. Training needs may differ by observer age, experience, knowledge, etc. Therefore, identification of training needs for citizens is a critical component of the pilot study. If modifications are implemented, a pilot study must show that parameters of interest can still be measured and adequate data collected for the desired precision in point estimates.

One of the most important pilot study components is evaluating observer detection probability as well as the frequency of misidentification. These processes can lead to false negative and/or false positive errors. Misidentification may be greater in citizen science data sets (Dickinson et al. 2010) and a potential source of error (Miller et al. 2011; Ruiz-Gutiérrez et al. 2016). Incorporating study design actions to quantify species misidentification (i.e., double-observers [Nichols et al. 2000], ancillary data like online quizzes [Bonney et al. 2009; Ruiz-Gutierrez et al. 2016]), will reduce parameter bias. Additionally, extensive training should mitigate some of these detection errors. Another potential pitfall is differences in detection between common and rare species for citizen versus professional observers, which could lead to inflated species richness estimates (Gardiner et al. 2012).

Power analysis and evaluation of study feasibility

Conducting a power analysis will determine how much effort is needed to detect a given effect size (in this context, how much effort is needed to detect change in response variables by a predetermined amount). Basic power analysis principles apply (Morrison et al. 2008). The unique challenge of citizen science studies is the sampling effort (frequency and intensity) expected through time, and often there is a tradeoff between data quality and quantity. It can be challenging to sustain a consistent sampling effort through time, and biological time constraints may apply (i.e., breeding birds can only be sampled at certain times of the year). Increased number of participants could potentially mitigate some data quality issues. Another important component is optimizing study design based on required accuracy and precision tradeoffs for parameter estimates and costs required to achieve those accuracy goals (Field et al. 2005; Sanderlin et al. 2014). If objectives cannot be met with available resources, monitoring should not be implemented (Legg and Nagy 2006) because it is difficult to justify hard work of citizen observers without tangible results, and poorly designed efforts could lead to poor morale, and potentially lower future citizen recruitment. Public engagement may be a secondary objective, however, and in some cases may be more achievable than scientific or management monitoring objectives.

After the power analysis is completed, an evaluation of study objectives must be conducted that considers the expected effort and data quality. If objectives are not achievable, either modify objectives and continue the process again, or discontinue project efforts altogether. If objectives are achievable, adjust the study design (if needed) and proceed with identifying thresholds and/or trigger points for adaptive management (Moir and Block 2001; Nie and Schultz 2012; Schwartz et al. 2015), if appropriate.

CASE STUDIES

Case Study 1

Our first case study from Ganey et al. (2017) illustrates how citizen science was used to monitor change in occupancy of bird species and species richness after a wildfire in the Chiricahua Mountains, Arizona. The local communities of Portal and Sierra Vista rely heavily on ecotourism for their livelihoods, which in turn relies on a vibrant bird community,

consisting of specific birds sought for viewing. Thus, the communities have a vested interest in conservation efforts. Rocky Mountain Research Station (RMRS) scientists studied bird communities and their associated habitats within five Sky Island mountain ranges, including the Chiricahua Mountains, in the early 1990s (Block et al. 1992; Sanderlin et al. 2013). Using a structured sampling design and previously developed sampling protocols, RMRS partnered with local Portal and Sierra Vista community members via Friends of Cave Creek Canyon to re-sample birds within the same general areas in the Chiricahua Mountains from 2013-2014, following the 2011 Horseshoe II fire.

A pilot study was implemented to: (1) evaluate whether or not the biological population of interest could be sampled to meet objectives, (2) determine amount of sampling effort expected (including observer detection probability), (3) identify coordination challenges, and (4) evaluate whether or not it was physically possible to conduct the monitoring using citizen observers. One identified challenge was that some volunteers were not physically able to traverse randomly-located RMRS transects sampled during the 1990s. Therefore, new bird monitoring transects were established along trails and roads in the vicinity of initial RMRS transects. Pilot study data confirmed these new transects yielded similar vegetation and bird occurrence data as original transects (Ganey et al. 2017; Sanderlin et al. *unpublished data*). In addition, RMRS had a 4-person professional crew sample birds for an additional year at both the original (1990s) and modified locations, to evaluate potential differences in data quality between professional and citizen observers (Ganey etal. 2017; Sanderlin et al. *unpublished data*). Results suggested that citizen data could be used (Sanderlin et al. *unpublished data*) with modifications of additional visits by citizens to increase parameter accuracy (Sanderlin et al. 2014). The citizen science project thus extended number of years data were collected, including years after large wildfires. Supplemental years can be critical in population trend studies, especially with rare species missed during one time period, even if present.

Case Study 2

Our second case study is the development of BioBlitz events in the U.S. southwest. BioBlitzes are comprehensive, multi-taxa species inventories collected at a single location during a single day or weekend. These events are becoming popular to increase local community involvement and provide conservation education. Data are usually collected and uploaded to larger databases (i.e., iNaturalist) for broad-scale pattern analyses. It is challenging to standardize sampling effort (i.e., time of year, number of participants, locations) with data collected under these protocols. We describe species inventory development and operation steps that will assist in ability to address science and management questions (Table 2).

Presence-only data are difficult to use for monitoring or answering targeted questions, due to sampling differences over spatial and temporal scales and sampling methods, often violating assumptions required to build species distribution models (Yackulic et al. 2013). However, species inventories can be combined with studies standardized by sampling effort (Pacifici et al. 2017; Miller et al. *unpublished data*) to generate species distribution maps for monitoring distribution change (expansion, contraction), species richness, and colonization and extinction probabilities. BioBlitz events often focus on public engagement objectives; however, there is great potential for also meeting scientific objectives with the use of these advanced statistical models.

SUMMARY AND CONCLUSIONS

Data collected by citizen observers can contribute to collaborative conservation efforts by expanding the spatio-temporal scope of monitoring efforts. These efforts can increase interest in and commitment to resource management among interested citizens. However, special care must be taken to evaluate feasibility of meeting monitoring objectives given resulting data quality in citizen science efforts. Our general study design framework provides a template for key steps in ensuring citizen monitoring data provides useful information. The five steps we described will help ensure the best use of valuable resources and citizen observer time commitments.

Data integrity is important for any project, and includes use of data quality controls in the field and within databases, relational databases for sorting and cleaning data, and data archiving procedures (Sanderlin et al.,

Table 2—Steps in developing and conducting a species inventory (i.e., BioBlitz) with citizen observers. We include important considerations for each step in the process that increase data usability in addressing science and management questions.

Project step	Description
Research	Identify event objectives (what, where, when, how). Practice using technology applications with event device(s) to identify any potential issues citizen observers might encounter. A visit to the event location will identify if cellular service is available, and plan accordingly (e.g., paper data sheets if not). Label and create the event with the event date and location within the project database (i.e., iNaturalist) before event.
Event preparation	Develop clear instructions about how to use technology applications (i.e., iNaturalist) and confirm expert participation to help in field identification during the event, in addition to helpers for each expert to take/upload pictures to app at the event. This helps ensure all data are recorded (thus available for analysis). Participants must be trained in specific BioBlitz protocols of data collection. Finally, participants should be encouraged to take/upload pictures to increase diversity in participation opportunities.
Species inventory event	Participants should take pictures of observations and upload to application. Emphasis during the event should be on taking pictures and (at least) placing observations in general categories (i.e., plant, animal, structure). Further identification can be completed later, by citizen observers and/or experts. Spending more time on recording observations with a device (i.e., phone, tablet) than identifying observations allows for a more complete inventory.
After event	If pictures were not uploaded during the event, observations from data sheet(s) should be uploaded, preferably with pictures to aid in proper identification (data integrity).
Project evaluation	Provide evaluation form for participants to fill out before leaving the event (i.e., what worked, what did not work, suggestions for future events, were objectives achieved). These questions aid project organizers in study design modifications, gauging satisfaction in volunteer experience, and predictions of future participation (survey effort).

unpublished data). In addition to using these standard data integrity measures, statistical expertise may be necessary to overcome statistical and computational challenges of incorporating citizen observer data uncertainty so data can contribute towards science and management questions. Furthermore, attention with how to display data as they are collected (or soon thereafter), disseminating results, and measuring outcomes are especially important with citizen science projects to demonstrate links between citizen efforts and scientific results and maintain enthusiasm for participation (Bonney et al. 2009). This includes providing results from previous years (if possible), sending participants data collection summaries (i.e., number of units observed, any rare or unusual sightings) after data are collected for the year, providing PDFs of published studies with all names listed in the acknowledgments, and offering to present results at local organization meetings (i.e., local Audubon chapters, Native Plant Society, school groups).

Finally, citizen science projects often have multiple objectives: to evaluate scientific questions and to promote science in society through educational opportunities. Arguably, projects labeled as citizen science may be heavily weighted towards one or the other objective, but ideally both components are given consideration. Furthermore, efficient use of citizen observers and data they collect will likely result in a better citizen experience and greater participation with knowledge that their efforts contribute towards answering pertinent science and management questions.

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Serra Hoagland and Christina Vojta provided helpful reviews to early manuscript drafts.

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Border BioBlitz – Bridging the wall with data

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On March 3rd, 2018 the Next Generation Sonoran Desert Researchers and collaborating organizations undertook a Border BioBlitz along a 1 km swath each side of the U.S.-Mexico border. This is a one-day communal effort recorded numerous species using the iNaturalist.org / Naturalista.mx platforms. This talk will highlight the results of this broad collaboration and discuss the creation of low-cost models to connect citizen and expert science to large scale conservation and research challenges.

Border BioBlitz: Haciendo un puente de datos en el muro fronterizo

El 3 de marzo de 2018, la próxima generación de investigadores del desierto de Sonora y organizaciones colaboradoras realizaron un Border BioBlitz a lo largo de un kilómetro a cada lado de la frontera entre los Estados Unidos y México. Este es un esfuerzo comunal de un día que registró numerosas especies usando las plataformas iNaturalist.org / Naturalista.mx. Esta charla resaltará los resultados de esta amplia colaboración y discutirá la creación de modelos de bajo costo para conectar la ciencia ciudadana y experta con los desafíos de conservación e investigación a gran escala.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 51: Fire

Murphy Fire, Coronado National Forest near Nogales, AZ
(Photo by Daniel G. Neary, USDA Forest Service, Rocky Mountain Research Station)

Abstracts and Papers
Gottfried
Barton
Swetnam

Fire Effects on the Ecology of the Cascabel Watersheds, Coronado National Forest, Madrean Archipeligo

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Effects of cool-season (November-April) and warm-season (May-October) prescribed burning treatments and a spring wildfire on ecological characteristics and hydrologic functioning of the oak savannas on the Cascabel Watersheds in the Southwestern Borderlands Region of Arizona and New Mexico are reported in this paper. The impacts of the fire events on ecological characteristics such as the tree overstory, herbaceous plants and shrubs in the understory, and the mammals, birds, and herpetofauna on the watersheds are examined. Transpiration, formation of water repellent soils, hillslope soil erosion and deposition, streamflow regimes, and sediment depositions are among the hydrologic functions evaluated. The paper examines linkages among the ecological characteristics and the hydrologic functioning features. Results should be useful in planning management activities in similar oak savannas within Southwestern Borderlands Region.

Efectos de fuego en la ecología de las cuencas en el Archipeligo de Madre

Los efectos de la estación fría (noviembre-abril) y la estación cálida (mayo-octubre) prescribieron tratamientos de quema y un incendio forestal en primavera sobre las características ecológicas de las sabanas de roble en las cuencas de Cascabel en la región de las fronteras fronterizas del suroeste de Arizona y Nuevo México se informan en este documento. Se examinan los impactos de los incendios en las características ecológicas, como la historia de los árboles, las plantas herbáceas y los arbustos en el sotobosque, y los mamíferos, las aves y la herpetofauna en las cuencas hidrográficas. documento examina los vínculos entre las características ecológicas y las características del funcionamiento hidrológico. El documento examina los vínculos entre las características ecológicas y biológico. Los resultados deberían ser útiles en la planificación de actividades de gestión en sabanas de roble similares dentro de la región de las fronteras del suroeste.

Note: Full Paper Follows

Fire Effects on the Ecology of the Cascabel Watersheds, Coronado National Forest, Madrean Archipeligo

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Abstract--*Experimental watershed studies can provide answers to new challenges facing land managers and society including the impacts of fires and climate change on upstream and regional hydrology. The Cascabel Watersheds long-term prescribed fire study provides a unique opportunity to monitor climate change and its effects on biological resources because of its location in an oak savanna situated between deserts or grasslands and the higher elevation oak-pine woodlands of the southwestern United States and northwestern Mexico. Continuing studies on the Cascabel Watersheds in southwestern New Mexico are evaluating the effects of cool-season prescribed fires (November-April), warm-season prescribed fires (May-October) and a wildfire on a range of physical and biological characteristics. The study has been conducted on 12 gauged watersheds ranging in size from 8 to 24 ha. Ecosystem data were collected at permanent locations. The large foundation of physical and biological records from the Cascabel watersheds provides a basis for evaluating potential future climate change in the region.*

Key words: experimental watersheds**;** oak savannas; fire effects; prescribed fire; climate change, ecosystem monitoring, southwestern United States, Southwestern Borderlands Region

INTRODUCTION

Experimental watershed studies were established in many locations throughout the world to learn about the interrelationship between forests and hydrology and how land management practices impact the relationship. The Cascabel Watersheds long-term prescribed fire study was established to determine the impacts of cool-season (November-April) and warm-season (May-October) prescribed fires and a wildfire on the hydrologic and biological characteristics of the Madrean oak savannas in the Southwestern Borderlands Region of Arizona, New Mexico, and Mexico (Gottfried et al. 2007b). An additional goal is to increase the general knowledge about the hydrology and ecology of this region. The study site includes 12 gauged watersheds, meteorological stations, and permanent grids to collect biological and physical information. The Cascabel Study, because of its instrumentation and database, provides an excellent platform to monitor climate change in a region where drier and hotter conditions are projected by most authorities (Archer and Predick 2008, Seager et al. 2007).

The Southwestern Borderlands Region is known for its vast biological diversity and beauty. The region contains many isolated mountain ranges that are separated by deserts or grasslands. Six major biological provinces meet in the Borderlands (Bodner et al. 2005). This border region contains representative plants and animals from the Rocky Mountains in the north and the Sierra Madre Mountains of Mexico in the south. The mountains also provide important northern and southern migration routes for many wildlife species.

The area has a long history of human occupation (Fish et al. 2006). Fires caused by lightning or by Native American people were a major ecological factor in the borderlands region prior to European settlement. Periodic fires maintained grasslands, and reduced the encroachment and growth of woody vegetation, and the accumulation of woody fuels (Gottfried et al. 2009). However, the role of fire declined in the late 19th Century when the transcontinental railroad was completed in the region and cattle ranching became the dominant industry. Overgrazing caused a decline in the herbaceous cover which had carried fires throughout the landscape. Aggressive fire suppression by land management

agencies also reduced fire's influence. Tree-ring data support evidence for the decline in fires since 1880 (Kaib et al. 1999).

Public and private land managers were concerned about the lack of natural fires in the Borderlands Region. The resulting increase in woody species was affecting biological diversity and productivity of the grasslands. The Peloncillo Programmatic Fire Plan was developed by the U. S. Forest Service, Coronado National Forest, to reintroduce landscape level prescribed and managed fire into the federal lands within the Peloncillo Mountains (Gottfried et al. 2009). One of the issues was whether prescribed fires should be ignited during the cool season (November through April) or the warm season (May through October). This issue was related to questions about the effects of fire on several endangered or threatened species (Gottfried et al. 2009). It was assumed that the cool-season burns would be less detrimental to these species but that a warm-season burn during the normal fire season would be more beneficial to the native grasses and leave the soil bare for a shorter period of time prior to the start of the monsoon rains.

All interested parties agreed that any reintroduction of fire into the area must have a sound scientific basis but there had been a lack of research information for the region. The Rocky Mountain Research Station of the U.S. Forest Service, through its Southwestern Borderlands Ecosystem Management Unit, initiated and supported several research studies, including the Cascabel Watershed Study, to contribute to the scientific basis for developing and implementing a comprehensive ecosystem management plan to restore natural processes; improve the productivity and biological diversity of grasslands and woodlands; and to sustain a viable rural economy and social structure in the region (Gottfried and Edminster 2005). The intention of this study is to evaluate the effects of fire on as many ecosystem components as was feasible. This paper will describe the on-going Cascabel Study, some of the recent findings related to prescribed fire and climate change, and the role that the Cascabel Watersheds can play in providing scientists and land managers with knowledge needed to adapt to the changing environment.

OAK SAVANNAS

Oak (*Quercus* spp.) woodlands and savannas cover several million hectares of arid and semi-arid lands in the American Southwest and northern Mexico and are representative of dryland forests and savanna throughout the world (McPherson 1992). Oak ecosystems serve as a transition between the higher elevation woodlands and the lower-elevation desert grasslands and shrub communities. Emory oak (*Q. emoryi*), alligator juniper (*Juniperus deppeana*), white oak (*Q. arizonica*), and a number of other tree species are characteristic of the woodlands and savannas in southeastern Arizona. Savanna tree canopies occupy less area than in the denser woodlands and, consequently, support a higher level of herbaceous production (Ffolliott et al. 2008). Perennial grasses include several species of grama (*Bouteloua* spp.), Texas bluestem (*Schizachyrium cirratum*), and other species.

Long-term precipitation measured at the Cascabel Ranch in New Mexico averaged 554 ± 30 mm. The region is marked by two precipitation seasons, one in the winter and the other during the summer monsoon season. More than half of the annual precipitation occurs during the summer season. Snowfall is uncommon but occurs at higher elevations during the winter and melts rapidly. The region has experienced a severe drought since 1999 with dry winters and low monsoon precipitation.

THE CASCABEL WATERSHED STUDY

The Cascabel Watershed Study was initiated in 2000 in the oak savannas on the southeastern side of the Peloncillo Mountains in Hidalgo County, New Mexico, USA. The objective is to provide private and public land managers with basic information about the oak savanna ecosystem and about the impacts of fire treatments that will support management decisions. The Cascabel area consists of 12 small watersheds ranging in size from 8 to 24 ha (Figure 1). The total area covers about 182.6 ha. A central ridge divides the watersheds into two groups of six. Half of the watersheds drain to the north and half drain to the south. The watersheds (lat 31°33'N, long 108°59' W) are largely within the Douglas Ranger District of the Coronado National Forest and include a small area of the adjacent Diamond A Ranch. Elevations range from 1,640 to 1,705 m. The bedrock geology is Tertiary rhyolite overlain by Oligocene-Miocene conglomerates and sandstone (Youberg and Ferguson 2001). Soils have been classified as Lithic Argustolls, Lithic Haplustolls and Lithic Ustorthents (Robertson et al. 2002). Streamflow is intermittent although large flows can occur following high intensity

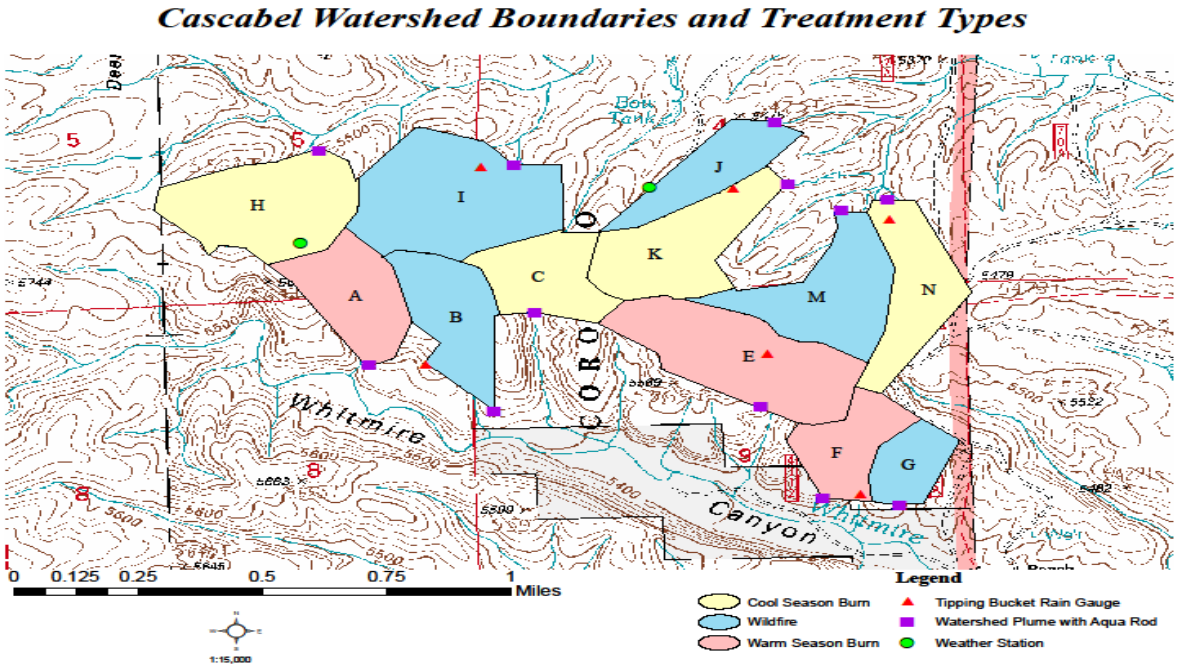

Figure. 1 Map of the Cascabel Watersheds indicating the watershed designations, treatments, and the location of the flumes, weather stations, and tipping bucket rain gauges. (Map courtesy of Tonto National Forest GIS personnel.)

rainfall events (Gottfried et al. 2006). The Southwest has been suffering from drought since the late 1990s, and precipitation since the study began only averaged 394 mm yr^{-1} with about 60 percent occurring during the summer monsoons (Gottfried et al. 2011). The watersheds have only received light livestock use during the study period because herds were reduced during the drought.

Instrumentation and Measurements

Hydrologic instrumentation, climate measurements, soil measurements, geomorphologic conditions, and fire severities on the 12 gaged are discussed in more detail in Gottfried et al. 2021a. Ecological measurements of vegetation, fire effects, fuel and soil conditions, and wildlife were collected at sample points along a series of transects that run perpendicular to the main channel and extend from ridge to ridge. Most biological resources were measured in the spring and in the fall following the winter and summer precipitation periods.

Treatments

The pre-treatment period at Cascabel ran longer than expected because of the regional drought. Statistical evaluations indicated that at least 30 streamflow events were necessary to determine any changes and to group the watersheds for the burning treatments. Sufficient data were collected by 2007 but burning was delayed until 2008 because of potentially dangerous fire conditions in the area. In March 2008, the four watersheds designated for the cool season prescribed burn (Watersheds C, H, K, and N) (Figure 1) were burned by the Douglas Ranger District, Coronado National Forest. Three of the watersheds (Watersheds A, E, and F) designated for the warm-season burn were ignited on May 20, 2008. Burning operations were terminated that evening because of high winds and the transfer of some fire fighting units to another fire. The fire on these three watersheds was essentially out the next morning but winds increased, with gusts of about 96.6 km hr^{-1}, which blew some of the remaining firebrands into the control watersheds and the remaining unburned watershed. The resulting wildfire, officially designated as the Whitmire Fire, eventually covered 1,615 ha. Consequently, the original objective had to be modified to evaluate the impacts of cool-season and warm-season prescribed burning treatments and a wildfire on the oak savanna ecosystem.

FIRE SEVERITY EFFECTS

Fire severities were determined on 421 sample points using the system developed by Hungerford (1996) that relates fire severity based on the appearance of litter, duff, woody material, and soil conditions to discrete classes of severity that range from low to high (Ffolliott et al. 2011c, Stropki et al. 2009). Classification of severity ratings at the points on each watershed were extrapolated to a watershed basis to determine the percentage of the watershed that was unburned or burned at the different severities. It was determined that 85% of the areas receiving the cool-season treatment had been exposed to a low severity fire, 5% had been exposed to a moderate severity fire, and the remaining area had not been burned. The spatial distributions of severities observed on the watersheds that had the warm-season prescribed fire and the wildfire were similar (Ffolliott et al. 2011a). The low severity burns were attributed to the discontinuous and limited accumulations of fuels and to the relatively high wind speeds. Statistical analyses did not indicate any significant differences in severity among the prescribed fire treatments and the wildfire. Therefore, the data were combined to compare with pre-treatment conditions for several resource parameters. Parenthetically, Neary et al. (2010) measured locations within the watersheds where high fire severities occurred. These were in pockets of heavy accumulations of litter, duff, and other organic debris. Fire combustion temperatures varied by season and vegetation type. Average combustion temperatures during the cool-season and warm-season burns were statistically similar. No measurements occurred during the wildfire.

RESULTS

A number of publications have presented information about the hydrologic, geological, and biological components of the oak savanna ecosystem prior to the burning treatments and the wildfire. Several publications report on the archeological, historical, and sociological aspects of the study. While some post fire results have been published, a comprehensive evaluation of the fire effects remains for the future.

Physical Attributes

A discussion of the physical responses of the Cascabel watersheds to fire is reported in Gottfried et al. (2021a). These responses include hydrologic, soil water repellency, hillslope erosion, and channel dynamics.

Biological Resources

Ground Cover: The percentage of ground cover of plant material, litter, slightly decomposed organic debris on the soil surface, bare soil, and bedrock is useful in predicting the rates of hillslope erosion. This information was collected in 30.5- by 45.7-cm sampling frames at three locations around the main sampling points before and after the burning events (Ffolliott et al. 2011c). There were no statistically differences among watersheds and burning treatments. Bedrock, litter, and plant material were the largest components of the ground cover prior to the fires, and the cumulative percentage of components other than plant material was 75 based on the rating system discussed by Bedell (1998). There were significant increases in the percentage of plant material and bedrock after the fires while the relative amounts of litter and bare soil declined. The increase in plant material was related to an increase in downed woody material. The Bedell rating was 67. However, it was concluded that the changes were probably inconsequential in terms of future management and would not impact hillslope erosion or herbaceous plant production.

Overstory Tree Cover: The overstory tree cover was measured after the three fire treatments (Ffolliott et al. 2011b). Results were pooled together because all watersheds received low severity burns and differences among treatments were not detectable. Approximately 78% of the trees that were present before the fires survived initially. Eighty percent of the oak trees and 75% of the juniper trees survived. The crowns of 80% of the surviving oak and juniper trees were

scorched or top killed. However, basal sprouting was observed on 37 % of the surviving oak and 11% of the surviving juniper. A greater number of large trees (≥ 23 cm diameter at root collar) survived than small and medium trees. Species richness and the spatial distribution of trees at Cascabel were not impacted by the treatments. The conclusion was that the effects from the three types of fires were minor and would not impact management.

Herbage Production - Estimates of the production of early- and late-growing grasses, forbs, and total herbage were obtained before and following the burning events on the Cascabel Watersheds by the weight-estimate procedure originally outlined by Pechanec and Pickford (1937). The production of the early-growing plants reflected temperature and antecedent soil moisture, while the production of late growing plants was responsive to the summer rains. Seasonal production of these plants before the prescribed burns and wildfire was highly correlated (r = +0.658) with the seasonal precipitation amounts (Ffolliott et al. 2008). However, relationships involving temperature and relative humidity were insignificant. The same general relationships were observed following the fires.

The prescribed burns and wildfire had a statistically significant impact on the production of grasses, and total herbage for both seasons (Ffolliott et al. 2012). Depending on the event, there was a five to seven-fold increase in the production of early-growing grass species while increases in late-growing grasses were of a smaller magnitude. Total herbage production increased relative to pre-fire levels because of the dominance of the grass component. It is likely that the release of nutrients by the burning event and reduced tree cover have contributed to these increases. Impacts of the fires on the relatively minor forb component are inconsistent; however, the production of early-growing forbs increased following the warm-season prescribed burn and wildfire. Shrub growth was not affected by the three fire events. The persistence of the effects into the future is currently unknown.

Wildlife: The prescribed burning season and the wildfire did not affect the use of the watersheds by two keystone species-- Coues white-tailed deer (*Odocoileus virginianus couesi*) and desert cottontail (*Sylvilagus audubonii*) (Ffolliott et al. 2012a). Fecal pellet-groups were counted at the permanent sampling points in the spring, after the winter season, and in the fall, after the summer rains. Counts in the spring were higher than counts in the fall for both species. The deer appear to stay in the lower elevation savannas during the winter and spring where weather conditions are relatively mild, and move into the higher, cooler and moister elevations during the summer. Higher spring counts for cottontail could be related to high birth rates during the winter and to subsequent predation during the summer.

Surveys of bird species and numbers were also conducted around a subset of the watershed sampling points during the spring and fall before and after treatments (Ffolliott et al. 2011a). Some species were tallied occasionally while others were observed more frequently. More bird numbers and species were tallied in the fall after the monsoons than in the spring. However, it was difficult to isolate the effects of the fires because of the large variability in tallies of bird species and numbers throughout the study period.

Data Management

A geographically referenced multiple-resource data management system has been developed for the Cascabel Study (Chen et al. 2009). The system is designed to enable researchers and land managers to store, interpret and analyze data collected at Cascabel using a readily available computer program. Data are divided into three categories, i.e., watershed descriptors, biological characteristics, and hydrologic characteristics. Global positioning system measurements reference the data to locations on the watersheds. The data can be transferred across files to facilitate analyses. This system should be applicable to other oak savannas within the Southwestern Borderlands Region.

CLIMATE CHANGE IN THE BORDERLANDS

Climate models predict that the arid southwest will become drier during this century and that this transition is already occurring (U.S. Forest Service 2010, Archer and Predick 2008, Seager et al. 2007). These models also indicate that temperatures will continue to rise, precipitation will fluctuate, and there will be an increase in extreme weather (Gottfried et al. 2009). A warmer climate could affect the density and viability of less drought-tolerant species of plants and animals causing them to decline or disappear from the landscape. Native plants could be replaced by more drought-

tolerant non-native herbaceous species (Archer and Predick 2008). Mesquite (*Prosopis* spp.), a native woody species which is present at Cascabel, could increase in importance and possibly replace the oak and juniper cover on some sites. A warmer and drier climate would affect water supplies for ranchers and increase the potential for more frequent and larger outbreaks of wildfires and insect infestations.

The Cascabel Watersheds with its intensive design of established hydrologic and meteorological instruments, ecological sampling grids, and more than 10 years of records would be ideal for continued monitoring of climate changes in the Borderlands Region into the future. Understanding and predicting the adaptive capacity of ecosystems under changing climate will be important (Peterson et al. 2010). Managers need to base their decisions on the availability of reliable, long-term meteorological, hydrologic, and ecological information. Long-term data are vital for monitoring climate and ecological changes and the impacts of land management since short-term studies may provide an erroneous view of long-term dynamics. Documenting and understanding changes will require intensive and extensive monitoring that could integrate field, laboratory, and modeling efforts (Peterson et al. 2010). Data from Cascabel could be combined with weather data collected at neighboring ranches and at government, research, and university stations in the United States and, possibly, in adjacent areas of Mexico to provide a bi-national view of climatic dynamics in the greater Southwestern Borderlands Region.

Carbon dynamics in the Borderlands will change as the climate warms. Drier conditions and greater temperatures could cause a decline in the native vegetative cover of herbaceous, shrubs, and trees or replacement by less "desirable" species. Less carbon could be sequestered under these conditions. Would a replacement vegetative cover of more drought tolerant non-native species or of genetically adapted native species compensate for this change? Jackson et al. (2002) found a negative relationship between precipitation and changes in soil organic carbon when grasslands were invaded by woody species, with drier sites gaining carbon and wetter sites losing it. Soil organic carbon is a key part of the carbon balance in grasslands and woodlands. A carbon monitoring initiative at the Cascabel Watersheds could provide a basis for modified management strategies to sequester more carbon by retaining more woody species and healthier herbaceous cover.

CONCLUSIONS

The Cascabel Watershed Study was established to answer specific management questions about the impacts of reintroducing fire into the oak savanna ecosystem of the Southwestern Borderlands Region and to increase the information available about its basic ecology and hydrology. The pre-and post fire information has filled gaps in this knowledge that can be used in planning and implementing management activities. The available data management system makes the Cascabel results easier to obtain. The research team and its cooperators are re-visiting the research goals at Cascabel to include evaluations of the impacts of a changing environment on the hydrology and ecology of oak savannas in the region. Long-term environmental monitoring is important to assess the direction and degree of climate changes to adapt to new situations. Because of its established protocols, the Cascabel Watersheds represent an ideal site for monitoring future climate change in the oak savannas and the entire Borderlands Region. Results from Cascabel could be combined with records from other locations in neighboring areas of the United States and northern Mexico to give a fuller view of climate change in this arid and semi-arid region.

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The impacts of a megafire on woody plant composition, diversity, and structure in a Madrean Evergreen Woodland, Chiricahua National Monument, Arizona

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The Madrean woodlands of the Sky Islands of Arizona are diverse ecosystems, maintained by frequent, low-intensity fire before Euro-American settlement. Fire suppression and climate change have triggered a surge in large, higher-severity fires throughout the Southwest—events with major impacts on vegetation. We investigated the effects of the 2011 Horseshoe Two megafire on woody plant species composition, diversity, and structure in Chiricahua National Monument by resampling a network of inventory plots established prior to the fire. Ordination with all vegetation types combined revealed no clear directional changes in species composition from before to after the fire. When each type was analyzed separately, however, it became apparent that the vegetation shifted away from pines, Douglas-fir, and Arizona cypress towards oaks, manzanita, and cacti. Surprisingly, fire induced significant increases in woody plant diversity. Forest structural diversity exhibited the opposite result: simplification of structure for all vegetation types as a result of the wildfire, a pattern that was amplified in sites subject to high fire-severity. Our results highlight the importance of fire as a regulator of Madrean Evergreen Woodlands. While increases in woody plant diversity demonstrate the potential benefits of fire as a key disturbance process in this system, the shift in composition and the decline in forest structural complexity may have broad consequences for wildlife. Continued monitoring of temporal changes in vegetation in response to wildfire in Sky Island systems will facilitate a better long-term understanding of the effects of a changing fire regime on the composition, diversity, and structure of Madrean evergreen woodland vegetation.

Los impactos de un mega incendio sobre la composición, diversidad y estructura de la planta leñosa en un bosque de hoja perenne de la región Madrean, Monumento Nacional Chiricahua, Arizona

Los bosques madrileños de las Islas Serranas de Arizona son ecosistemas diversos, mantenidos por incendios frecuentes de baja intensidad antes del establecimiento euroamericano. La supresión de incendios y el cambio climático han desencadenado un aumento de los incendios de gran magnitud y mayor gravedad en todo el sudoeste, con grandes impactos en la vegetación. Investigamos los efectos del megaincendio Horseshoe Two 2011 sobre la composición, diversidad y estructura de especies de plantas leñosas en el Monumento Nacional Chiricahua mediante el remuestreo de una red de parcelas de inventario establecidas antes del incendio. La ordenación con todos los tipos de vegetación combinados no reveló claros cambios direccionales en la composición de las especies antes y después del incendio. Sin embargo, cuando cada tipo se analizó por separado, se hizo evidente que la vegetación se alejaba de los pinos, el abeto de Douglas y el ciprés de Arizona y se acerca a los robles, la manzanita y los cactus. Sorprendentemente, el fuego indujo aumentos significativos en la diversidad de plantas leñosas. La diversidad estructural de los bosques exhibió el resultado opuesto: simplificación de la estructura para todos los tipos de vegetación como resultado del incendio forestal, un patrón que se amplificó en sitios sujetos a una alta severidad del fuego. Nuestros resultados resaltan la importancia del fuego como regulador de los bosques maduros de hoja perenne. Si bien los aumentos en la diversidad de plantas leñosas demuestran los beneficios potenciales del fuego como un proceso clave de perturbación en este sistema, el cambio en la composición y la disminución de la complejidad estructural del bosque pueden tener amplias consecuencias para la vida silvestre. El monitoreo continuo de los cambios temporales en la vegetación en respuesta a los incendios forestales en los sistemas de las Islas Serranas facilitará una mejor comprensión a largo plazo de los efectos de un régimen de fuego cambiante en la composición, diversidad y estructura de la vegetación arbórea de hoja perenne.

NOTE: A manuscript was not submitted to accompany this presentation.

The Fuel Moisture Index

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Measuring ecosystem phenology via remote sensing enables prediction of risk factors related to disturbance and overall ecosystem health. For example, estimating the (1) risk and potential severity of future wildfires, (2) likelihood of an insect or disease outbreak, or (3) severity of drought morbidity and mortality, are each informed variously by antecedent weather conditions and the physical characteristics of the organisms' phenotypes, as measured from earth observing systems (EOS). Fuel Moisture Stress Index (FMSI) was first proposed by Yool (2001), as a means of measuring the variation in live fuel moisture and thus its relative rigor or stress. We provide an empirical basis for FMSI, in context, with EOS data from the past 40 years. FMSI is derived using the formula for the standard score, or z-score. It is computed using the pixel's NDVI recorded for a given time step/period in a given year, and the NDVI mean and NDVI standard deviation for the same time step/period across the entire time series. Tracking the FMSI for each year for a given pixel's 'phenoperiod' roughly yields, with some statistical rigor, interannual trends in (as we like to say) 'climate forcing' and are amenable to inferential analyses. Prediction of potential fire behavior from remotely sensed imagery is an essential task for fire managers. FMSI could be used to assess the level of local drying in live vegetation which contributes to the ERC and potential flammability of the landscape in near real time. Utilizing a publicly available cloud computing service, Google Earth Engine, and a version control system, Github, users can repeat our analyses or calculate FMSI anywhere else globally within the time period of the reference EOS satellite platforms at no cost.

El índice de humedad del combustible

La medición de la fenología del ecosistema a través de la teledetección permite predecir los factores de riesgo relacionados con la perturbación y la salud general del ecosistema. Por ejemplo, estimar el (1) riesgo y severidad potencial de futuros incendios forestales, (2) la probabilidad de un brote de insecto o enfermedad, o (3) severidad de la morbilidad y mortalidad por sequía, cada uno se informa diversamente por las condiciones meteorológicas anteriores y las características físicas de los fenotipos de los organismos, medido desde los sistemas de observación de la Tierra (EOS por sus siglas en inglés). El índice de estrés de la humedad del combustible (FMSI por sus siglas en inglés) fue propuesto por primera vez por Yool (2001), como un medio para medir la variación en la humedad del combustible vivo y por lo tanto su rigor o estrés relativo. Proporcionamos una base empírica para FMSI, en contexto, con datos de EOS de los últimos 40 años. FMSI se deriva usando la fórmula para el puntaje estándar o z-score. Se calcula utilizando el NDVI del píxel grabado para un paso / período de tiempo determinado en un año determinado, y la media del NDVI y la desviación estándar del NDVI para el mismo paso / período de tiempo en toda la serie temporal. El seguimiento de la FMSI para cada año para el "fenoperíodo" de un píxel dado produce aproximadamente, con cierto rigor estadístico, tendencias interanuales en (como nos gusta decir) "forzamiento climático" y son susceptibles de análisis inferencial. La predicción del comportamiento potencial del fuego a partir de imágenes de detección remota es una tarea esencial para los administradores de incendios. FMSI podría utilizarse para evaluar el nivel de secado local en la vegetación viva que contribuye al ERC y la inflamabilidad potencial del paisaje en tiempo casi real. Utilizando un servicio de computación en la nube disponible públicamente, Google Earth Engine y un sistema de control de versiones, Github, los usuarios pueden repetir nuestros análisis o calcular FMSI en cualquier parte del mundo dentro del período de tiempo de las plataformas de satélite EOS de referencia sin costo.

NOTE: A manuscript was not submitted to accompany this presentation.

Session 52: Hydrology

Tandem Parshall Flumes, Cascabel Watersheds, Peloncillo Mountains, Coronado National Forest
(Photo by Daniel G. Neary USDA Forest Service, Rocky Mountain Station)

Abstracts and Papers
Abrell
Gottfried
Paretti
Tucci

Occurrence and fate of emerging contaminants in some Northern Madrean Archipelago watersheds

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Since 2000 we have known that contaminants of emerging concern, for example pharmaceuticals and personal care products, are present in some of the Madrean Archipelago's surface water, primarily as a result of treated wastewater effluent. Today we have results from studies of more types of water in more parts of the archipelago. Special interest has been paid to the watersheds' capacity to serve as a resource for safe drinking water. By employing strategic sample design we have seen that terrestrial soils and sediments in the archipelago can attenuate organic contaminants in ground water, thereby polishing water for important uses further along the hydrologic cycle. Examples from multiple data sets obtained within the archipelago will be shared and discussed.

Ocurrencia y destino de contaminantes emergentes en algunas cuencas del Archipiélago Madrense Norteño

Desde el año 2000, sabemos que los contaminantes de preocupación emergente, por ejemplo productos farmacéuticos y productos para el cuidado personal, están presentes en algunas de las aguas superficiales del Archipiélago Madrense, principalmente como resultado del efluente de aguas residuales tratadas. Hoy tenemos resultados de estudios de más tipos de agua en más partes del archipiélago. Se ha prestado un interés especial a la capacidad que tienen las cuencas hidrográficas para servir como un recurso de agua potable. Al emplear un diseño estratégico de muestra, hemos visto que los suelos y sedimentos terrestres en el archipiélago pueden atenuar los contaminantes orgánicos en el agua subterránea, y de ese modo pulir el agua para usos importantes a lo largo del ciclo hidrológico. Se compartirán y discutirán ejemplos de conjuntos de datos múltiples obtenidos dentro del archipiélago.

NOTE: A manuscript was not submitted to accompany this presentation.

Fire effects on the soils and hydrology of the Cascabel Watersheds in the Coronado National Forest, Madrean Archipeligo

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Effects of cool-season (November-April) and warm-season (May-October) prescribed burning treatments and a spring wildfire on ecological characteristics and hydrologic functioning of the oak savannas on the Cascabel Watersheds in the Southwestern Borderlands Region of Arizona and New Mexico are reported in this paper. The impacts of the fire events on ecological characteristics such as the tree overstory, herbaceous plants and shrubs in the understory, and the mammals, birds, and herpetofauna on the watersheds are examined. Transpiration, formation of water repellent soils, hillslope soil erosion and deposition, streamflow regimes, and sediment depositions are among the hydrologic functions evaluated. The paper examines linkages among the ecological characteristics and the hydrologic functioning features. Results should be useful in planning management activities in similar oak savannas within Southwestern Borderlands Region.

Efectos de fuego en la ecología y hidrológica de las cuencas en el Archipeligo de Madre

Los efectos de la estación fría (noviembre-abril) y la estación cálida (mayo-octubre) prescribieron tratamientos de quema y un incendio forestal en primavera sobre las características ecológicas y el funcionamiento hidrológico de las sabanas de roble en las cuencas de Cascabel en la región de las fronteras fronterizas del suroeste de Arizona y Nuevo México se informan en este documento. Se examinan los impactos de los incendios en las características ecológicas, como la historia de los árboles, las plantas herbáceas y los arbustos en el sotobosque, y los mamíferos, las aves y la herpetofauna en las cuencas hidrográficas. La transpiración, la formación de suelos repelentes al agua, la erosión y deposición de suelos de laderas, los regímenes de flujo de corrientes y los depósitos de sedimentos se encuentran entre las funciones hidrológicas evaluadas. El documento examina los vínculos entre las características ecológicas y las características del funcionamiento hidrológico. El documento examina los vínculos entre las características ecológicas y las características del funcionamiento hidrológico. Los resultados deberían ser útiles en la planificación de actividades de gestión en sabanas de roble similares dentro de la región de las fronteras del suroeste.

Note: Full Paper Follows

Fire Effects On the Soils and Hydrology of the Cascabel Watersheds in the Coronado National Forest, Madrean Archipeligo

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***ABSTRACT**--Effects of cool-season (November-April) and warm-season (May-October) prescribed burning treatments and a spring wildfire on the soils and hydrologic functioning of the oak savannas on the Cascabel Watersheds in the Southwestern Borderlands Region of Arizona and New Mexico are reported in this paper. The impacts of the fire events on transpiration, formation of water repellent soils, hillslope soil erosion and deposition, streamflow regimes, and sediment depositions are among these soil and hydrologic functions. Results should be useful in planning management activities in similar oak savannas within Southwestern Borderlands Region.*

Keywords: fire effects, hydrologic functioning, oak savannas, prescribed burning, southwestern United States, Arizona, New Mexico

INTRODUCTION

Information on edaphicl characteristics and hydrologic functioning of the oak savannas in the Southwestern Borderlands Region had been limited until establishment of the Cascabel Watersheds on the eastern side of the Peloncillo Mountains in western New Mexico by the Rocky Mountain Research Station of the U.S. Forest Service. Oak savannas and woodlands cover several million acres of arid and semi-arid lands in the American Southwest and northern Mexico and are representative of dryland forests and savannas throughout the world (McPherson 1997). The Coronado National Forest in southern Arizona supports more than 761,000 ac of oak savannas and woodlands and the Tonto National Forest supports 94,000 . Oak savannas are situated in the transition between the higher-elevation oak woodlands and the lower-elevation desert grasslands and shrub communities in the region. While Niering and Lowe (1984), working in the Santa Catalina Mountains near Tucson, Arizona, described this band of vegetation as “open woodlands,” the term “oak savannas” is preferred to differentiate this ecosystem from the more extensive oak woodlands. Oak savannas are more open in stand structure than the oak woodlands, and, therefore, a higher level of herbage production can occur (Ffolliott and Gottfried 2005, 2010, Ffolliott et al. 2008b).

Fire was a natural occurrence in oak ecosystems in the region before Euro-American settlement. However, natural fire frequencies, burning characteristics, and impacts on ecological characteristics and hydrologic functioning have been altered since the late 1800’s because of two main factors. Past livestock grazing practices removed significant portions of the fire-carrying herbaceous vegetation and past aggressive fire suppression policies of management agencies reduced the number and aerial extent of many of the burning events. These past practices and policies have resulted in unnaturally high tree densities on many sites with the trees more susceptible to insects, diseases, and stand-replacing wildfire. A decline in production of herbaceous plants in the understories, often excessive loadings of flammable fuels, and invasion of mesquite (*Prosopis glandulosa*) and other woody plants onto productive grasslands added to the problem. As a consequence of these undesirable conditions, management agencies with support from their collaborators, including local staked holders and private organizations, became interested in re-introducing more natural fire regimes into the region’s ecosystems including the oak savannas. However, more information on the impacts of burning on the ecological characteristics, soil conditions, and hydrologic functioning in the ecosystems was needed before such a program could be initiated. There were concerns how burning in the cool-season (November-April) or warm-season (May-October) would affect the ecology and hydrology of the savanna ecosystem, particularly the impacts of burning season on two listed species-the threatened New Mexico ridge-nosed rattlesnake (*Crotalus willardi obscurus*) and the Arizona listed Palmer’s agave (*Agave palmeri*), which is important to the endangered lesser long-nosed bat

(*Leptonyceris curasoae*). Obtaining the necessary information was the primary reason for the establishment of the Cascabel Watersheds in a representative oak savanna (Edminster and Gottfried 1999, Gottfried and Edminster 2005, Gottfried et al. 2000, 2005). This paper reports on some of the soil and hydrology impacts.

CASCABEL WATERSHEDS

The Cascabel Watersheds were instrumented by the Rocky Mountain Research Station of the U.S. Forest Service in 2001 to study the effects of prescribed burning treatment on the ecological characteristics and hydrologic functioning of the watersheds. These watersheds are representative of the oak savannas found in the Malpai Borderlands and in the adjacent mountains of Arizona, New Mexico, and northern Sonora, Mexico. The Mapai Borderlands are situated within the larger Southwestern Borderlands Region as shown in Figure 1.

Characteristics

There are contain twelve watersheds in the Cascabel Watershed Study ranging from about 20 ac to almost 60 ac. They are situated 5,380 to 5,590 ft in elevation. Physiographic features of these watersheds are summarized in Table 1. Long-term annual precipitation measurements at the nearby Cascabel Ranch have averaged 21.8 in. However, a prolonged drought impacted the Southwestern Borderlands from the middle of the 1990s through the end of the study when the data and interpretations presented in this paper were collected. Annual precipitation in this drought has averaged 14.9 in. Bedrock geology of the watersheds is Tertiary rhyolite overlain by Oligocene-Miocene conglomerates and sandstone. Soils are classified as Lithic Argustolls, Lithic Haplustrolls, or Lithic Ustorthents. The depths of these soils are generally less than 20 in to bedrock. Mostly intermittent streamflow events originate on the watersheds with occasional large flows generated by high-intensity summer rains. Nearly 60 percent of the annual streamflow volume results from winter rains while the highest peak streamflows are generated by high-intensity rainstorms in the summer.

Dominant tree species are Emory (*Quercus emoryi*), Arizona white (*Q. arizonica*), and Toumey (*Q. toumeyi*) oak and alligator juniper (*Juniperus deppeana*). Minor components of the overstory are red berry juniper (*J. coahuilensis*), border pinyon (*Pinus bicolor*), and the tree-form of mesquite. (The term “tree overstories” refers to these species regardless of their size or position in the canopy.) The composition of tree species in the overstory is representative of the oak savannas in the region (Figure 2). The average acre at Cascabel contains 35 trees of all species and size classes (Ffolliott et al. 2008b).

Among perennial grasses are blue (*Bouteloua gracilis*), sideoats (*B. curtipendula*), slender (*B. repens*), and hairy (*B. hirsuta*) grama; bullgrass (*Muhlenbergia emersleyi*); common wolfstail (*Lycurys phleoides*); and Texas bluestem (*Schizachyrium cirratum*). Forbs include species of mariposa lily (*Calochortus* spp.), verbena (*Verbena* spp.), and lupine (*Lupinus* spp.). Beargrass or sacahuista (*Nolina microcarpa*), fairyduster (*Calliandra eriophylla*), common stool (*Dasylirion wheeleri*), pointleaf Manzanita (*Arctostaphylos pungens*), Fendler’s ceanothus (*Ceanothus fendleri*), and Mexican cliffrose (*Purshia Mexicana*) are shrubs and half-shrubs in the understory. Shrub-forms of the oak species and mesquite are also present on many sites (Ffolliott et al. 2006b). Palmer’s agave (*Agave palmeri*) is a scattered succulent. Annual plants are largely absent on the watersheds.

Additional information on vegetative, geologic, edaphic, and hydrologic characteristics of the watersheds is found in publications by Ffolliott and Gottfried (2010), Ffolliott et al. (2008b), Gottfried and Ffolliott (2013), Gottfried et al. (2012a, 2007b), Hendricks (1985), Neary and Gottfried (2004), Neary et al. (2008b), Osterkamp (1999), Robertson et al. (2002), Youberg and Ferguson (2001), and Vincent (1998).

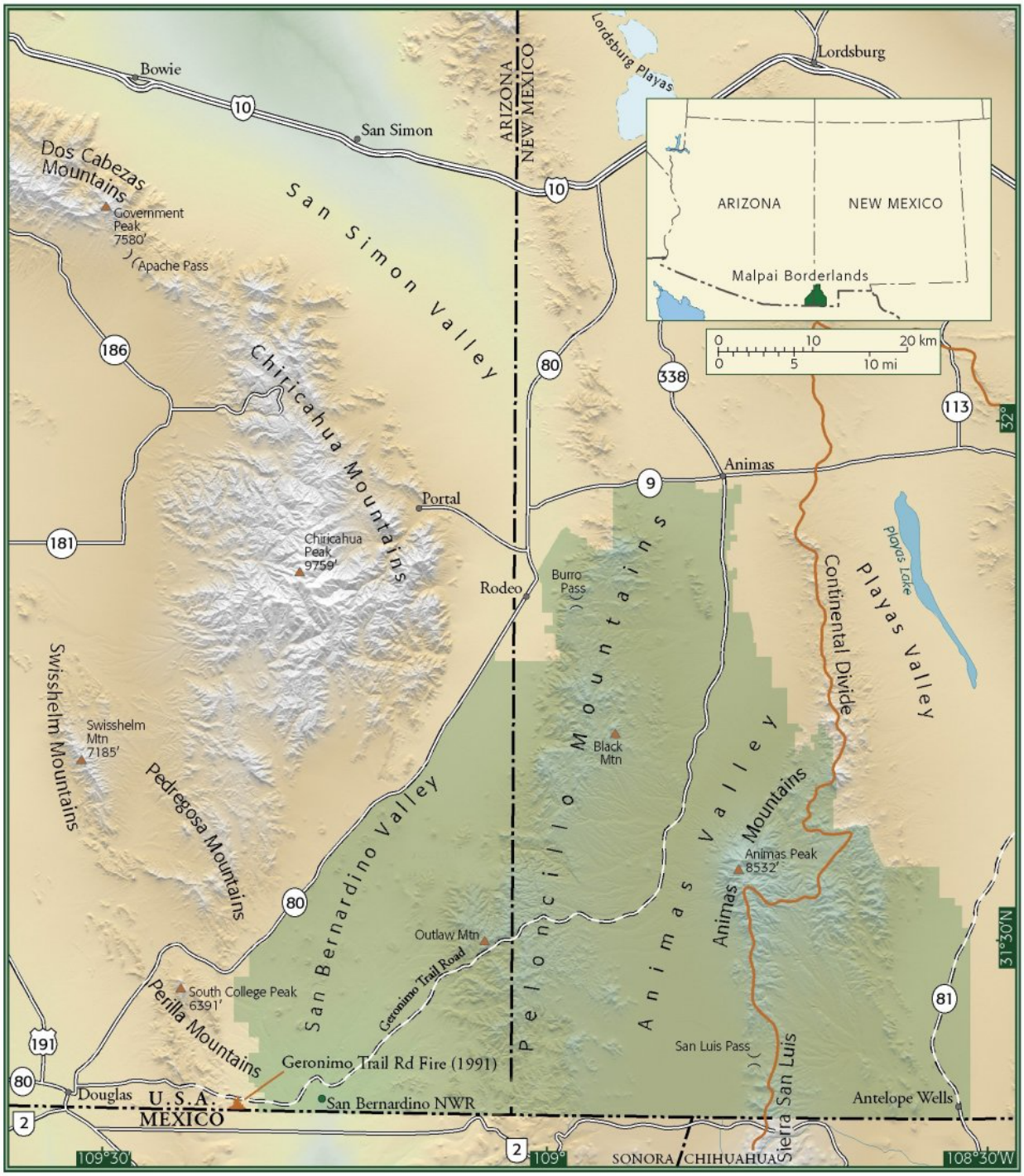

Figure 1. The Cascabel Watersheds (arrow) are located within the oak savannas of the Malpai Borderlands - an area of approximately 802,750 acres in the larger Southwestern Borderlands Region.

Table 1. Topographic characteristics of the Cascabel Watersheds, Peloncillo Unit, Coronado National Forest (From Gottfried et al 2000).

Watershed	Area	Average Elevation	Average Slope	Channel Length	Channel Slope	Watershed Length
	ac	ft	%	ft	%	ft
A	34	5552	22.8	1248	5.6	1434
B	37	5535	28.4	1938	7.0	2363
C	33	5530	17.5	797	2.5	1434
D	25	5510	17.1	956	6.3	1407
E	40	5503	18.5	2177	5.3	2549
F	31	5463	16.2	1407	6.0	1593
G	20	5460	17.4	743	6.7	1168
H	55	5562	18.7	1805	5.0	2443
I	83	5533	16.6	2522	3.8	3000
K	38	5503	16.2	2257	4.4	2469
M	45	5475	27.1	2177	4.1	2655
N	27	5485	9.0	1381	3.6	2124

Figure 2. Composition of tree species on the Cascabel Watersheds is representative of that found in the oak savannas of the region. Oak species are dominant in the tree overstory. (Photo by Daniel G. Neary, USDA Forest Service).

Research Program

The goal of the research program at Cascabel was to evaluate the effects of cool-season (November through April) and warm-season (May through October) prescribed burning treatments on ecosystem characteristics and hydrologic functioning (Gottfried et al. 2000, 2005, 2007a). It was anticipated that these evaluations would be compared to unburned (control) watersheds to determine the effects of the prescribed burning treatments. Following the required hydrologic calibration period, Watersheds C, H, K, and N (Figure 3) were burned in the cool-season in early March 2008. Three of the four watersheds designated for warm-season burning (Watersheds A, E, and F) were ignited on May 20, 2008 with burning of the fourth (Watershed I) delayed to a later date because of the shifting weather conditions. However, wind gusts up to 60 mph in the early morning of May 21 blew firebrands onto the remaining watershed scheduled for warm-season burning and the four control watersheds. The resulting wildfire - called the Whitmire Wildfire - crossed the boundaries of the Cascabel watersheds to burn almost 4,000 ac. As a result, the original goal of the research program was modified to evaluate the effects of cool-season and warm-season prescribed burning treatments and the Whitmire Wildfire on the biological and hydrologic resources of the watersheds (Figure 3).

The original study on the Cascabel Watersheds was to burn four watersheds by prescribed fire in the cool-season, to burn four watersheds in the warm season, and to keep four watersheds as unburned controls. It was necessary to modify this study design after the Whitmire Wildfire as shown in this figure. Watershed I was originally designated to be burned in the warm season but instead burned as a result of the wildfire. Atmospheric conditions during the prescribed burning treatments and wildfire are summarized in Table 2. The information presented in this table was obtained from a weather station located in the middle of the watersheds.

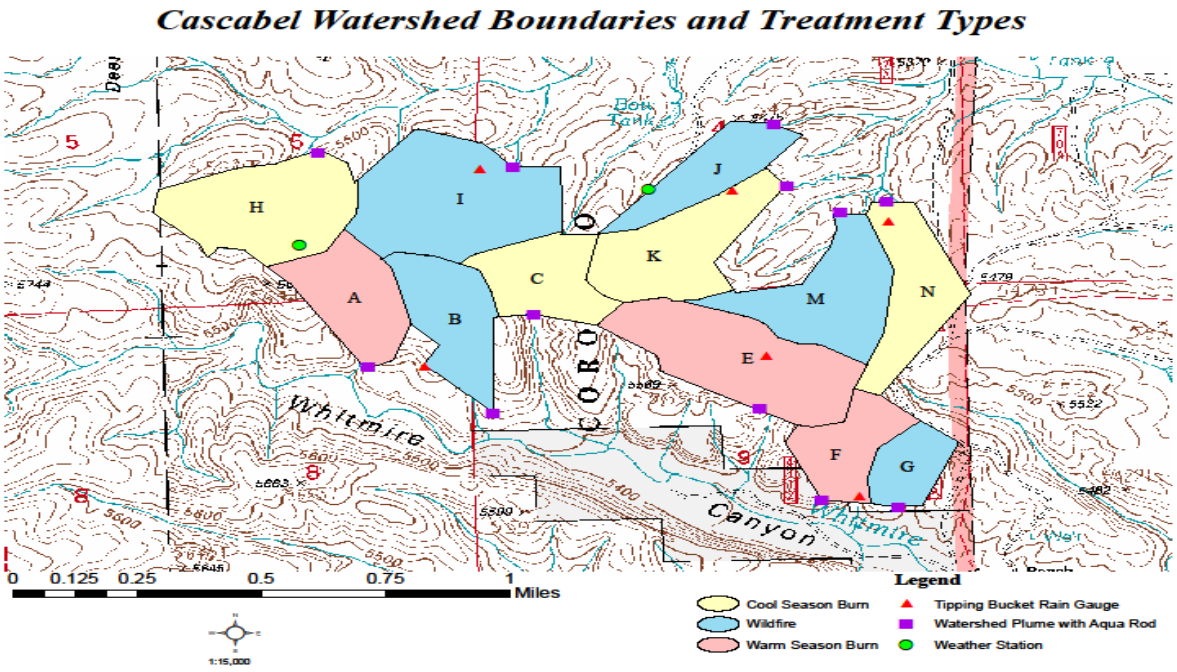

Figure 3. Cascabel Watersheds boundaries and treatments, Coronado National Forest (From Ffolliott et al. 2012).

The original study on the Cascabel Watersheds was to burn four watersheds by prescribed fire in the cool-season, to burn four watersheds in the warm season, and to keep four watersheds as unburned controls. It was necessary to modify this study design after the Whitmire Wildfire as shown in this figure. Watershed I was originally designated to be burned in the warm season but instead burned as a result of the wildfire.

Severity of the Burning Events

A system that relates fire severity to the response of the soil-resource to burning events (Hungerford 1996) was the basis for assessing the severity of the prescribed burning treatments and wildfire within 0.10-acre plots at sampling locations on the watersheds (see Study Protocols section of this paper). This system relates the post-fire appearance of litter, duff, and woody materials and soil conditions to classes of fire severity that range from low to moderate to high.

Table 2. Average atmospheric conditions from 0700 to 1800 hours during the prescribed burning treatments and wildfire on the Cascabel Watersheds. The information presented in this table was obtained from a weather station located in the middle of the watersheds.

Treatment	Date	Temperature (°F)	Relative humidity (%)	Wind Speed (MPH)
Cool season	March 4	56.2	15.6	4.7
Cool season	March 11	62.5	20.2	3.4
Warm season	May 20	89.7	15.8	8.3
Wildfire begins	May 21	85.3	15.6	17.1

Details of the system are found in publications by Neary et al. (2005), DeBano et al. (1998). Classifications of fire severity at the plots were extrapolated to a watershed-basis to determine the percentages of each of the Cascabel Watersheds that were unburned or burned at low, moderate, or high severities.

These extrapolations indicated that 85 percent of the four watersheds burned by the cool season prescription had been exposed to a low severity fire; a moderate severity fire occurred on 5 percent of the watersheds; and 10 percent of the watersheds were unburned. Spatial distributions of fire severities on the three watersheds that experienced the warm-season prescription and the one watershed burned by the Whitmire Wildfire, and those burned in the wildfire were similar to the distributions of fire severities of the cool-season burn as shown in Figure 4. It was concluded, therefore, that the Cascabel Watersheds (collectively) had burned at a low severity by the three burning events. The low severities were attributed largely to the small and scattered accumulations of flammable fuels on the watersheds before the burning events and to the high wind-speeds during the burns.

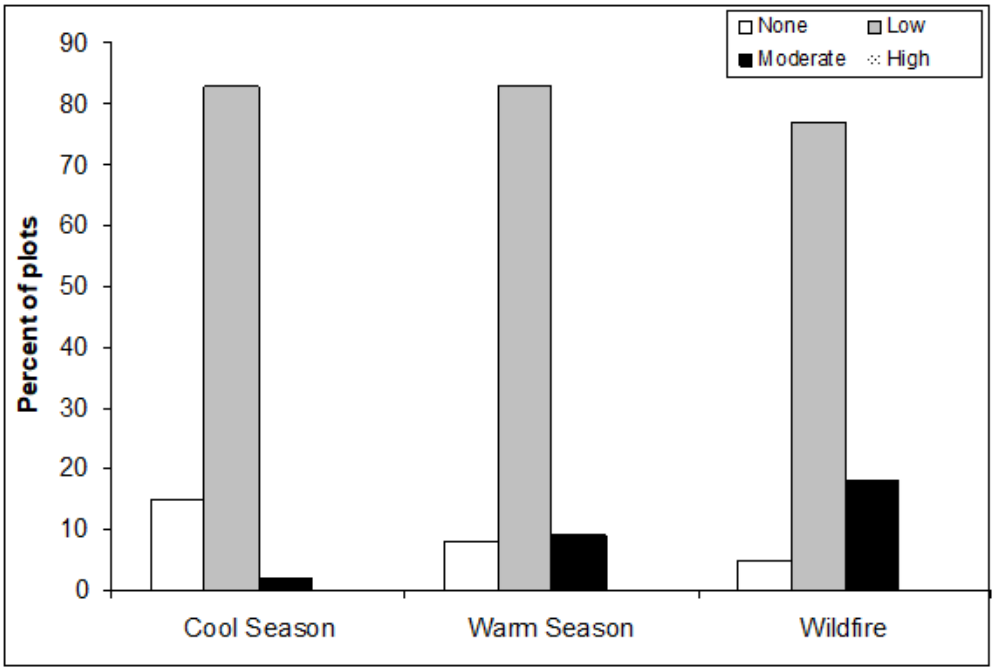

Figure 4. Fire severities of the cool-season and warm-season prescribed burning treatments and the Whitmire Wildfire on the Cascabel Watersheds based on the percent of the severities within 0.10-acre plots located at the sampling locations. Fire severities were derived from a classification system relating fire severity to the soil response to burning. These values were extrapolated to a watershed basis.

While high severity burns were not observed on the sampling locations, high fire severity occurred on scattered sites within the watersheds (Koestner et al. 2008a, Neary et al. 2008a, 2010). These sites were largely pockets where "heavy accumulations" of litter, duff, and other organic debris had built up before the burns. Fire combustion temperatures varied by season and vegetation type (Neary et al. 2010). Neary et al. (2010) reported mean temperatures during the cool season burn between 150°C for light grass and 292°C for heavy grass and maximum temperatures 997°C under yucca plants and 945°C under oak. Average combustion temperatures during the cool-season and warm-season burns were statistically similar. No measurements occurred during the wildfire.

STUDY PROTOCOLS

Between 35 and 45 permanent sampling locations were established on each of the 12 Cascabel Watersheds to measure ecological characteristics and hydrologic functioning and to monitor changes related to the fire events. These sampling locations were spaced along randomly-placed transects oriented perpendicular to the main stream channels and extending from ridge to ridge. Intervals between these sampling locations varied with the area and configuration (shape) of the watersheds. A total of 421 sampling locations were established on the 12 watersheds.

Precipitation Measurements

Precipitation is the main input in the water budget for an area. Therefore, two weather stations with recording gages were installed on the Cascabel Watersheds – one on the western edge of the watersheds and one on a side-ridge in the middle of the area. Precipitation, temperature, wind speed and direction, relative humidity, and other meteorological characteristics were measured at these weather stations (Figure 5) and the data was stored electronically and later downloaded to a computer and transferred to the Flagstaff Laboratory for review and analysis. The precipitation amounts measured at the weather stations was supplemented by measurements obtained at seven recording dipping-bucket gages situated throughout the area.

Hydrologic Functioning

Transpiration

Transpiration with evaporation represents the largest loss of precipitation falling on a watershed (Brooks et al. 2013), and, therefore, it is a key component in the water budget for oak ecosystems in the region (Ffolliott 2005). To quantify this component on the Cascabel Watersheds, instantaneous transpiration rates were measured on 16 Emory oak trees with a sap-flow meter (Swanson 1994) in late spring, summer, and early fall of 2004. Two of the trees selected for measurement were located on southerly aspects and two trees on northerly aspects on each of two transects of the sampling locations on two of the watersheds. The instantaneous measurements of transpiration obtained were transformed to estimates of daily transpiration by applying the equations of Schaeffer et al. (2000) and Barret et al. (1995), and the procedure outlined by Shipek et al. (2004).

Earlier studies of transpiration by oak trees in the oak woodlands of the region (Ffolliott et al. 2003, Ffolliott and Gottfried 1999) found that daily transpiration cycled throughout a year from high values following the summer and winter rains to intervening low values. There was a similar cycle of daily transpiration by Emory oak trees on the Cascabel Watersheds, and, therefore, this cycle was the basis to estimate annual transpiration of the 16 oak trees selected for measurement. It was also determined that the relationship of annual transpiration to the daily transpiration rate of oak trees in the earlier studies was representative of the Emory oak trees measured at Cascabel. This relationship was "coupled" with the frequency of occurrence of Emory oak trees with the respective vapor pressure deficit values on the watersheds to estimate annual transpiration in inches on an area basis.

Figure 5. One of the two weather station installed on the Cascabel Watersheds to measure precipitation and other meteorological characteristics. (Photo by Gerald Gottfried, USDA Forest Service).

Water Repellent Soils

Water repellent soils impact on the hydrologic functioning of a watershed by decreasing infiltration in a manner that is similar to a hardpan layer. Decreasing infiltration rates resulting from the formation of these soils can (in turn) increase overland flows of water and ultimately streamflows and the entrainment of soil particles in these flows. Distillation of organic compounds in the litter and duff layers in the combustion phase of a fire is one mechanism that causes the formation of water repellent soils (DeBano 1981, 2003). Therefore, the occurrence of water repellent soils after the burning events was determined within temporary 0.10 ac plots at the sampling locations by the water-drop penetration method of Letey et al. (2000) and applying the criteria specified by National Interagency Fire Center and outlined by Clark (2001). In applying these procedures, the litter and duff layers were cleared to expose the mineral soil, a drop of distilled water was placed on the mineral soil surface, and the time required for the drop to penetrate the soil surface recorded (Figure 6). This procedure was then repeated because the precise location of a water repellent layer (if a layer existed) was not known. The longest duration of the two times recorded for the water drop to penetrate the soil surface was related to the criteria of the National Interagency Fire Center to determine the level of water repellency - that is, no repellency; slight repellency – less than 10 seconds; moderate repellency - 10 to 40 seconds; or strong repellency - more than 40 seconds.

Hillslope Soil Erosion and Deposition

Soil erosion and deposition were measured on the hillslopes of the watersheds in the spring and fall both before and after the burning events. Spring measurements were indicative of the movement of soil by overland flows of water occurring in the winter while the fall measurements were a reflection of the soil movement resulting from overland flows in the summer. Obtaining these measurements involved measurements of three erosion pins surrounding every third sampling location. The magnitude of soil erosion was measured by the distance from the cap of a pin to the soil surface while deposition was the accumulation of soil on top of the cap (Figure 7). Measurements at the three pins were averaged to estimate soil erosion or deposition at the sampling location. After the measurements were taken, the erosion pins were re-set to be flush with the soil surface to facilitate the subsequent measurements. The magnitudes of soil erosion and deposition in the interval between the successive measurements were assumed equal when there was no measureable change in the soil surface relative to an erosion pin on occasion or - what is less likely - neither soil erosion nor deposition occurred in the interval. A bulk density value of 75 pounds per cubic foot developed from a series of soil samples on the watersheds was applied to convert the averages of the measurements of soil erosion and deposition obtained on the watersheds into tons per acre.

Figure 6. The time for a water droplet placed on a soil surface to penetrate into the surface is a measure of the level of water repellency of the soils at a sampling location. (Photo by Daniel G. Neary, USDA Forest Service)

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Figure 7. An erosion pin consisting of a metal nail with a washer welded to the top was inserted into the soil surface to measure soil erosion and deposition. The distance between the cap of the pin and the soil surface represented a measure of erosion while the amount of soil that accumulates on top of the cap was a measure of deposition. (Photo by Daniel G. Neary, USDA Forest Service).

Streamflow

Two prefabricated Parshall flumes were installed on each of the Cascabel Watersheds to monitor streamflow volumes and peak flows. A 9-inch flume with a rated flow capacity of 4.03 cubic feet per second (cfs) measured the more commonly encountered low flows while either a 3- or a 4-foot flume with flow capacities of 42.7 or 57.5 cfs, respectively, measured the less frequent larger flows (Figure 8). The smaller flumes were later converted to Replogle long-throated flumes to increase the accuracy of measuring low flows. Streamflow stages were measured by pressure-sensor recorders that were activated by stage-changes that equaled or were greater than 5 mm (approximately 0.2 in). The recorders were downloaded to laptop computers monthly with the data sets transferred to computers for analysis at the Southwest Forest Science Complex in Flagstaff, Arizona.

Figure 8. Two prefabricated Parshall flumes were installed on each of the Cascabel Watersheds to measure streamflow. A smaller flume measured low flows of water while the larger flume had a capacity to measure the infrequent larger flows. (Photo by Gerald Gottfried, USDA Forest Service).

Streamflow measurements began in 2001 to establish pre-fire relationships among the streamflows originating on the watersheds through regression analysis. These measurements represented the calibration period that was necessary before the burning treatments could be scheduled (Brooks et al. 2013). Once statistically acceptable relationships were obtained, the prescribed burning treatments were scheduled. Relationships of post-fire streamflow regressions are then compared to the pre-fire regressions to evaluate effects of the burns on streamflow regimes. Streamflow measurements on the watersheds continue.

Channel Erosion-Degradation: A series of cross-sections of stream channels above the flumes were measured in 2003, 2006, and 2009 to determine whether there were changes in channel morphology in the respective intervals. A total of 142 cross-sections located at 100 m (328 ft) intervals in the channels were measured at each time. More specifically, permanently referenced points along the cross-sections were surveyed with a level and stadia rod. An integration of sediment-degradation (incisions) processes was reflected by these measurements (Koestner et al. 2010, 2008b). Differences in the cross-sectional measures in the interval between 2003 and 2006 represented pre-fire conditions while post-fire conditions were embedded in differences measured in the interval between 2006 and 2009.

Sediment Depositions: A retention dam and basin were constructed above the flumes on each of the watersheds to accumulate the sediment particles deposited in the basins (Figure 9). Walls of the dams were tied into the channel sideslopes and had a spillway to allow high streamflow volumes to pass over. There was an average of 11 surveying lines in each basin that were reference to a permanent benchmark. A series of permanently referenced points on these lines were surveyed to measure the accumulations of sediment in the basin. Volumes and the volume differences between surveys were calculated by the WinXSPRO program (Hardy et al. 2005) and the average end-area method of Dendy et al. (1979). An average bulk density value of 69.3 pounds per cubic foot representing a composite of values obtained from the literature was used to also express the cubic-foot volumes of sediment depositions in corresponding measures in tons.

Figure 9. A sediment basin was located above the flumes on each of the Cascabel Watersheds to accumulate sediment that is deposited near the outlets of the watersheds. (Photo by Daniel Neary, USDA Forest Service).

EFFECTS OF THE BURNING EVENTS ON HYDROLOGIC FUNCTIONING

Transpiration

Annual transpiration of oak trees on the Cascabel Watersheds was 4.8 inches of water or approximately 30 percent of the assumed annual precipitation. The effect of thinning post-harvesting rootstocks of oak trees in the woodlands to three, two, or one basal sprout on annual transpiration is presented in Table 3. While transpiration of an individual stump sprout was small, the large number of stump sprouts in the harvested stand translated into larger transpiration values regardless of the thinning treatment (Ffolliott and Gottfried 1999). Effect of the burning events on transpiration rates of sampled oak trees was not measured. However, it was assumed to be "slightly" less than transpiration before the burns because of the minimal loss of trees in the fires (Figure 10).

Table 3—Annual transpiration in stands of thinned Emory oak coppice and the percent of annual precipitation transpired by the coppice in 2001 (Ffolliott et al. 2003, and Shipek et al. (2004).

Thinning Treatment	Daily Transpiration	Total Transpiration per Unit Area of Coppice	Total Transpiration Coppice Plus Trees	Annual Rainfall Transpiration 2001
	L	mm yr^{-1}	mm yr-1	%
One Sprout	7.48 ± 0.31	68	181	33.5
Two Sprouts	17.7 ± 0/86	160	273	50.5
Three Sprouts	23.7 ± 1.12	215	328	60.7
Control	35.3 ± 1.72	320	433	80.2
*Estimated transpiration for mature Emory oak trees was 17.5 L/day (Shipek et al. 2004)				

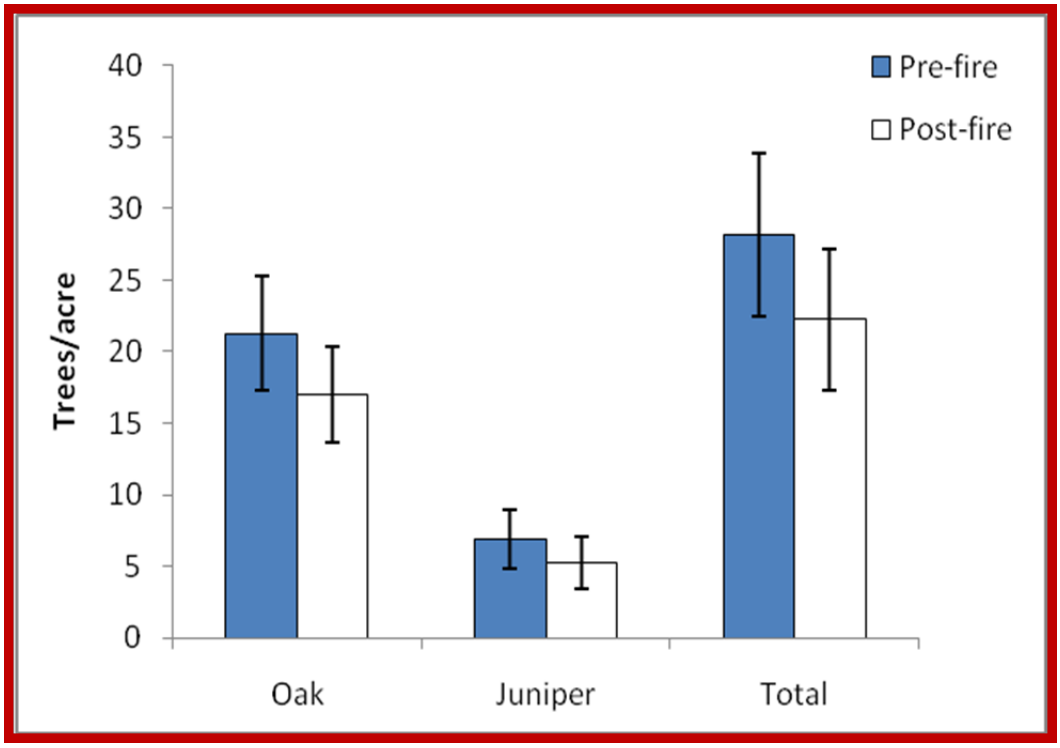

Figure 10. Average number of oak and juniper trees per acre before and after prescribed fires and wildfire.

Ground Cover

Bedrock, fine sediment, coarse sediment, vegetation, and woody debris were the largest components of ground cover before the burns with the percentages of bare soil significantly less than these components (Ffolliott et al. 2012a) Differences in ground cover components following the burning events were insignificant and, therefore, pooled for analysis. There were significant increases in the percentages of plant material and bedrock following the burning events while the percentages of litter and bare soil decreased. The increase in plant material was largely the result of the increase in downed woody material that is included in the component. The changes in ground cover following the burns were likely inconsequential in terms of the hydrologic functioning of the watersheds (Ffolliott et al. 2012a). The measure of ground cover decreased from 75 percent before the watersheds were burned to 67 percent after the burning events. This small change by itself should not impact on future management actions on the watersheds.

Water Repellent Soils

Water repellent soils that formed as a result of the burning events were limited in both occurrence and level of repellency and confined mostly to the soil surface. No water repellency was found on about 90 percent of the sampling locations, slight water repellency on 5 percent of the locations, and moderate or strong repellency on the remaining locations (Stropki et al. 2009) (Figure 6). The limited occurrence and low levels of water repellent soils were expected because the low severity of the burns constrained formation of water repellent soils (Figure 11). However, Neary et al. (2006) reported high levels of water repellency in isolated locations within the prescribed burned areas usually associated with fuel accumulations.

Occurrences and the levels of water repellent soils have been related to fire severities in other studies with a greater occurrence and higher level of repellency associated with higher fire severities (Huffman et al. 2001, Doerr et

al. 2000, DeBano 1981, 2000). But, because of the low levels of water repellency on the Cascabel Watersheds, such a relationship was not observed in this study. Furthermore, the water repellent soils on the watersheds had mostly broken down within a year of the burning events by a downward erosion of the hydrophobic layers until they had eroded away. It has been concluded, therefore, that the water repellency that had formed following the burns had little lasting impact on the hydrologic functioning of the watersheds.

Hillslope Soil Erosion and Deposition

Hillslope soil erosion and deposition in channels were analyzed separately because they represent separate processes of soil movement. Results of a Shapiro-Wilk test of normality that the frequency distributions for both soil erosion and deposition were non-normal. Therefore, occurrences of statistical differences in the measurements were determined by the non-parametric Mann-Whitney test of significance. This test was applied because estimates of the respective processes were deemed independent of each other. It was found that there were no significant differences in either soil erosion or deposition at the 0.10 level of significance either before or after the burning events and, therefore, the respective data sets were pooled for analysis.

Soil Erosion

Differences in soil erosion measurements in the spring following the winter rains and measurements in the fall after the summer rains were insignificant before the burning events. Annual hillslope soil erosion in this period averaged 14.2 tons per acre across the 12 watersheds. Examples from Watersheds A and I, which cover the geomorphic gradient, are shown in Figure 12. Thes pre-fire values show some f the inter-watershed variability. However, soil erosion following the burns was greater than pre-fire soil erosion following the winter rains but lower after the summer rains. The seasonal measurements of post-fire soil erosion appeared to “balanced” each other out on an annual basis because there was no significant difference in annual soil erosion as a result of the burns.

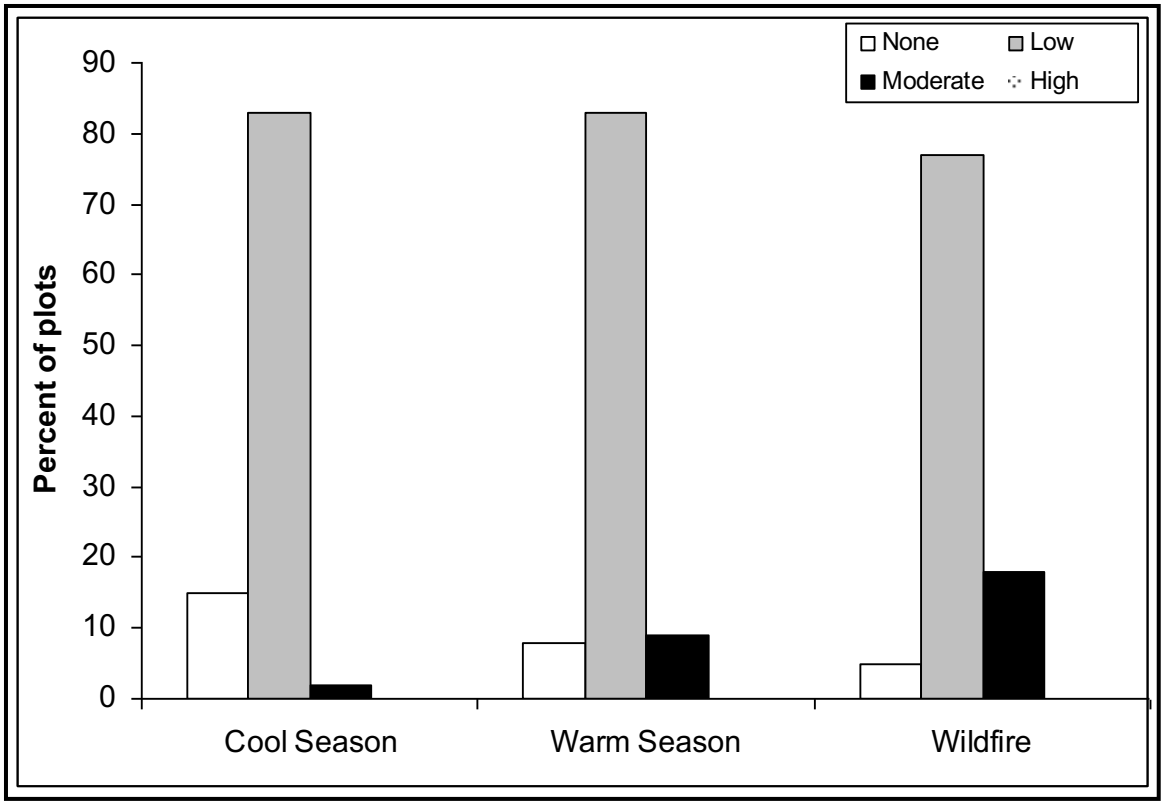

Figure 11. Severities of three fire situations on the 12 Cascabel Watersheds, Coronado National Forest. Arizona.

Table 4. Soil erosion from side slopes of Cascabel Watersheds A and I in Spring and Fall measurements of 2005.

Watershed	Spring 2005	Fall2005	Total
	Tons ac^{-1}	Tons ac^{-1}	Tons ac^{-1}
A	9.94 ± 1.25	10.80 ± 2.33	20.74
I	17.70 ± 1.25	4.62 ± 0.95	22.32
Total	27.64	15.42	

That the annual erosion of soil after the burning events was within the range of the pre-fire value was a result of similar erosive forces caused by the impacts of rain drops in the two periods. Absence of widespread water repellent soils after the burns, and the likelihood of little change in the overland flows of water necessary to dislodge soil particles on the hillslopes of the watersheds also contributed to this finding.

There were no significant relationships between the magnitudes of soil erosion and the rainstorm events necessary to generate overland flows of water or the characteristics of vegetation at the sampling locations. However, soil erosion was significantly less on the upper slopes of the watersheds than on the lower slopes. This finding could be attributed to a possibility of "thinner soil profiles" on the upper slopes. Unfortunately, measurements of soil depths on the slopes of the watersheds are not available to confirm this possibility.

Deposition

Deposition of soil after the winter rains was also compared to the deposition following the summer rainstorms to determine whether seasonal differences occurred before the burning events. It was determined that while the deposition of soil after the winter rains differed from the deposition following the summer rains, the differences in deposition within the seasons and years were inconsistent. Annual deposition of soil before the burns averaged 6.3 tons per. However, post-fire deposition of soil after the winter rains was statistically similar to the pre-fire deposition but was significantly greater following the summer rains for an unknown reason. Annual deposition of soil after the burns averaging 9.4 tons per acre was also greater because of the difference in deposition measured following the summer rains. Depositions of soil were not related to rainstorms or vegetation at the sampling locations. While there were significantly greater depositions of soil on the lower slopes than on the upper slopes of the watersheds before the burning events, there was little relationship of the depositions to slope position following the burns.

Streamflow

Streamflow originating on the Cascabel Watersheds is intermittent rather than ephemeral because most of the streamflow events are a response to either summer or winter rainstorms and cease at other times. (Strictly speaking, the intermittent streamflow that takes place is "stormflow" in that it occurs in response to a rainfall event of sufficient magnitude to satisfy the soil-water deficits on a watershed or a sequence of smaller rainfall events that in total satisfy these deficits.) A limited number of streamflow events occurred on the watersheds both before and after the prescribed burning treatments and wildfire. That few flows were observed was due to the drought conditions encountered throughout the period of record.

Variability of Streamflow Volumes and Peaks

Watersheds in arid and semiarid regions generally have lower infiltration capacities and shallower soils with lower capacities to store soil moisture than watersheds in more humid regions (Brooks et al. 2013). Therefore, watersheds such as those at Cascabel would be expected to respond more quickly to streamflow-generating rainstorms with comparatively more variable streamflow volumes and peaks than watersheds in other regions. Such has been the case on the Cascabel Watersheds with a "high level of variability" in the recorded streamflow volumes and peaks since the stream-gauging network became operational. Gottfried et al. (2007) attributed much of this variability to the meteorological characteristics of the streamflow-generating rainstorms; the geology, geomorphology, and soils of the watersheds; and the orientation of the watersheds relative to the track (movement) of the streamflow-generating storms. Comparisons of pre- to post-fire streamflow regimes were often inconclusive because of the high variability in the respective data sets.

Effect of Large High-Intensity Rainstorm on Streamflow

Analysis of the streamflow response to a large high-intensity rainstorm on August 23, 2005 by Gottfried et al. (2006) provides insight on the effects of a storm of this magnitude on streamflow volumes and peaks. Total rainfall in this storm - one of the largest in the Cascabel period of record – varied across the watersheds from 1.36 in to nearly 3 in with the highest rainfall intensities ranging from 1.90 to 3.31 in hr^{-1} (Tables 5 and 6). Because a series of smaller storms on August 10, 11, 14, and 20 had likely satisfied the soil-moisture deficits on the watersheds, antecedent soil moisture conditions on the watersheds were "relatively high" before the storm of August 23. It was not surprising, therefore, that the storm generated streamflow volumes that overtopped the larger flumes on four of the watersheds.

Highest estimated streamflow peak resulting from the storm was 2.75 $m^3\ sec^{-1}$ (76.8 $ft^3\ sec^{-1}$) on Watershed H while the smallest peak was 0.906 $m^3\ sec^{-1}$ (32 $ft^3\ sec^{-1}$) on Watershed F. (Streamflow peaks were estimated on the watersheds with overtopped flumes from channel and slope measurements.) A reason for this range in streamflow peaks could have been the respective times of concentration for the watersheds; that is, the time required for the entire watersheds to contribute streamflow at their outlets. Watershed H is nearly 1.8 times larger in area than Watershed F. Channel conditions would also affect the times of concentration (Neary and Gottfried 2004). The channel on Watershed H is 11

percent rock and 68 percent coarse alluvium while the channel on Watershed F is 21 percent rock and 42 percent coarse alluvium.

Table 5. Precipitation for the storm event of August 23, 2005, by watershed.

Station	Total Precipitation	Start Time	End Time	Peak Precipitation
	in (mm)	MST	MST	in hr^{-1} (mm hr^{-1})
H	2.36 (59.94)	1200	1600	1.90 (48.26)
J2	2.33 (59.18)	1200	1600	1.93 (49.02)
A-B	2.64 (67.06)	1201	1544	2.94 (74.68)
E	2.03 (51.56)	1212	1552	2.24 (56;90)
F-G	1.36 (34.54)	1209	1549	1.52 (38.61)
I	2.99 (75.95)	1206	1547	3.31 (84.07)
K	2.81 (71.37)	1213	1602	3.19 (79.75)
M-N	1.43 (36.32)	1221	1552	1.98 (50.29)

Table 6. Peak flows from the Cascabel Watersheds for the August 23, 2005, storm event.

South Watersheds	Peak Flow	North Watersheds	Peak Flow
	$ft^3\ sec^{-1}$ ($m^3\ sec^{-1}$)		$ft^3\ sec^{-1}$ ($m^3\ sec^{-1}$)
A	67.2 (1.90)	H	76.8 (2.17)
B	69.0 (1.95)	I	52.6 (1.49)
C	51.2 (1.45)	J2	61.9 (1.75)
E	59.8 (1.69)	K	67.9 (1.92)
F	24.6 (0.70)	M	65.0 (1.84)
G	34.0 (0.96)	N	31.3 (0.59)

Channel Erosion-Degradation

None of the burning events had an apparent effect on the erosion-degradation processes of the stream channels. Although there is a great variability among the channels on the 12 watersheds, Koestner (2012) concluded that the channels were not at risk to these processes because of the bedrock-lined channels on the watersheds. It was also possible that the limited streamflow events that occurred between the consecutive measurements of channel cross-sections might have been insufficient in the totality of their "erosive power" to impact on the morphology of the stream channels (Figure 13). That is, the soil particles entrained in these episodic streamflow-events were likely insufficient their magnitude, size, and shape to significantly erode the channels.

Possible changes in channel morphology were difficult to evaluate, however, because the intervals between successive measurements of the channel cross-sections could have obscured changes that might have occurred in a channel at a point in time within an interval. Also, effects of the burning events on channel morphology could not be isolated because the interval between the 2006 and 2009 measurements integrated conditions occurring both before and after the burns.

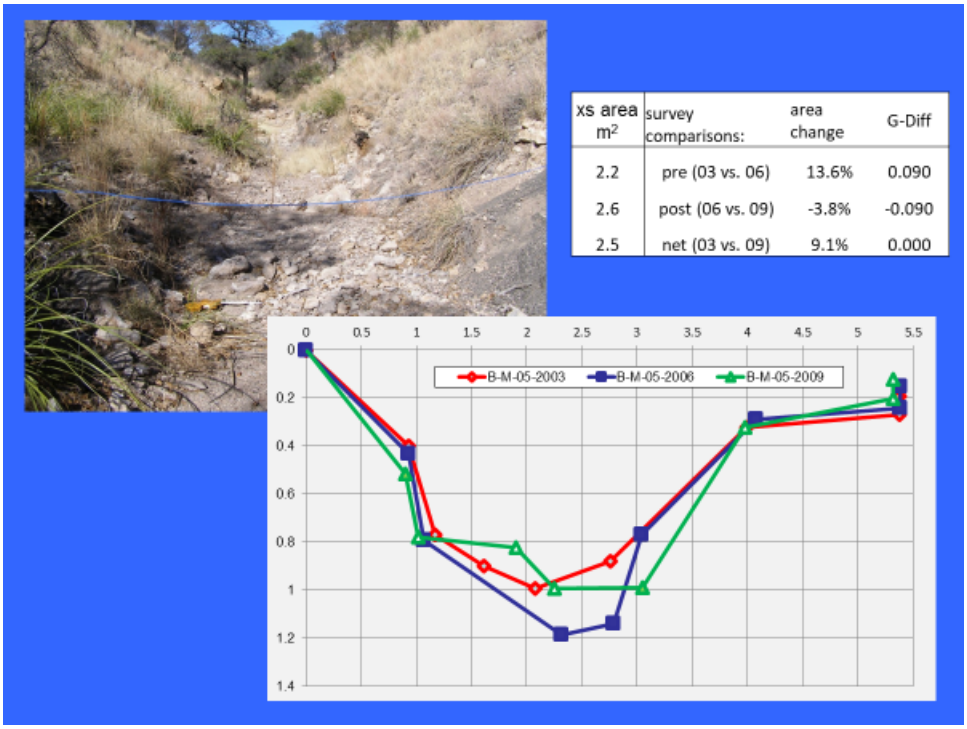

Figure 12. Cross-section measurements of the stream channel of a Cascabel Watershed made in 2003, 2006, and 2009. The cross-section measurements in the intervals shown indicate the lack of a significant effect on erosion-degradation of the stream channels of the watershed. (Photo by Daniel Neary, USDA Forest Service; Graph by Karen Koestner, USDA Forest Service).

Sediment Depositions

Soil particles that had eroded from one site on a hillslope were either deposited downslope on another hillslope site or transported to a stream channel to accumulate as sediment. Depositions of sediment particles in a sediment basin were affected by the proximity of the source of soil erosion to the basin; the size-class distributions of soil particles entrained in overland flows of water; and the efficiency of moving the sediment particles from one part of a basin to another. Accumulations of sediment were also reflected by the re-distribution of sediment particles in the overland flows of water.

Measurements of the sediment accumulations behind the dams forming the sediment basins provide a perspective on the magnitude of sediment depositions as shown in Figure 13. (The amount of entrained sediment passing over the spillways of the dams in the occasional large streamflow events is unknown and, therefore, cannot be included in the sediment budgets for the watersheds.) The deposition of sediment in the basin on Watershed A was measured for the 20-month period of August 2003 to March 2005 – when the sediment accumulation to the point in time was measured and the removed from the basin - and for the 10 months between April 2005 and January 2006. Approximately 52.2 cubic feet (1.8 tons) of sediment were deposited in the first period while 190 cubic feet (6.6 tons) of sediment had accumulated in the second period that included the large high-intensity rainstorm of August 23, 2005 (see Streamflow section of this paper). On an annual basis, these totals were equivalent to 31.3 ft^3 (1.1 tons) and 218 ft^3 (7.6 tons) per year, respectively. The deposition of sediment in the basin on Watershed I for the one period of December 2003 to January 2006 was 190.3 ft^3 (6.6 tons) or 91.5 ft^3 (3.1 tons) per year.

Figure 13. Sediment accumulating behind one of the sediment dams forming the sediment basins provides a perspective of the range of sediment textures in depositions in the watershed channels (Photo by Daniel G. Neary, USDA Forest Service, Rocky Muntain Research Station).

There was little relationship between the accumulations of sediment in the basins of the two watersheds and the volume of soil eroded from the hillslopes of the watersheds that might have been deposited in the basins in the corresponding periods of time. (This latter value was approximated as the difference in the soil erosion and deposition on the hillslopes of the watersheds in the respective time periods.) Contribution to the sediment accumulations by channel erosion-degradation processes was negligible.

Additional Information on Hydrologic Functioning

Additional information on the general hydrology of the Cascabel Watersheds including precipitation patterns are found in Gottfried et al. (2014, 2012b, 2007b). References containing additional information on the transpiration of oak trees in the region are Ffolliott et al. (2003) and Shipek et al. (2004). More details on the formation of water repellent soils as a result of the burning events are presented in Neary et al. (2008a) and Stropki et al. (2009). Further comparisons of hillslope soil erosion and deposition are found in publications by Ffolliott et al. (2013, 2010a), Kauffman (2009), and Kauffman et al. (2007). Gottfried et al. (2014, 2007b, 2006) present additional information on streamflow regimes of the watersheds. More details of the channel erosion-deposition processes are found in (Koestner 2012) and Koestner et al. (2008b, 2010). Further information on sediment depositions can be obtained in Gottfried et al. (2014).

Hydrologic Functioning

Annual transpiration by a sample of Emory oak trees before the burning events was 30 percent of annual precipitation – a value that was less than that for Emory oak trees in the more densely-stocked oak woodlands of the region. While the effect of the burns on the transpiration rates of oak trees was not determined directly, it was likely somewhat less than before the burns because of the minimal loss of trees in the fires. Water repellent soils that formed as a result of the low-severity burns were largely broken down within one year and, therefore, were assumed to have a minimal impact on the hydrologic functioning of the watersheds. Effects on the burning events on hillslope soil erosion and deposition were minimal. However, both pre- and post-fire soil erosion and deposition were measured in a period of prolonged drought.

The regional drought has limited the number of streamflow events that can be analyzed to ascertain any effects of the fire treatments on streamflow volumes and quantities. Variability of the intermittent streamflow volumes and peaks originating on the watersheds also limited a comparison of streamflow regimes before and after the burning events. However, a large high-intensity, summer rainstorm generated streamflow volumes that overtopped the larger flumes on four of the watersheds provides insight on the streamflow regimes. None of the burning events had a measureable effect on the erosion-degradation processes of the bedrock-lined stream channels. The limited number of streamflow events that have occurred might have been insufficient in total to significantly impact on the morphology of the stream channels. There was little relationship between accumulations of sediment in the sediment basins and the estimated volume of soil particles eroded from the hillslopes that reached the channels. The contribution of channel erosion-degradation to sediment depositions was negligible.

SUMMARY AND CONCLUSIONS

Management Implications

Information presented in this paper should be useful to land managers, local stakeholders, and other decision-makers interested in the re-introduction of a historical fire regime into the oak savannas of the Southwestern Borderlands Region. More specifically, the overcrowding of trees in the overstories; the accompanying decrease in production of herbaceous plants including forage species in the understories; the loss of wildlife habitats; and the often excessive loading of flammable fuels that are found on some sites could be alleviated to some extent by prescribed burning treatments of low severity at specified temporal intervals. Moreover, effects of these treatments on the hydrologic cycle and functioning of the oak savannas will likely be minimal. However, fire specialists should view the findings obtained at Cascabel as a case study. It should be recognized that prescribed burns of low severity - such as those on the Cascabel Watersheds - on other sites in the oak savannas of the region might not “produce” the same results as those reported in this paper. Additional evaluations of the impacts of prescribed burning treatments of varying intensities and severities and seasonal timing of ignitions on ecological characteristics and hydrologic functioning will be necessary to formulate comprehensive and effective management strategies to achieve the desired benefits on other sites. A change in protocols for implementing prescribed burning treatments in “less restrictive” weather and other fuel conditions might also be considered.

Of increasing interest to people in the Southwestern Borderlands Region and elsewhere are the effects that possible climatic changes might exert on ecological, hydrological, and socio-economic conditions. Climatic models suggest that air temperatures should increase, precipitation amounts will fluctuate, and “extreme weather events” might increase in the southwestern United States as a consequence of climatic changes (Archer and Predick 2008, Seager et al. 2007). Assuming that these changes occur, the compositions, densities, and viability of less drought-tolerant species of plants and animals are likely to be altered with some species disappearing and replaced by more drought-tolerant invasive species. A warmer and drier climate would also limit the water resources available for people while increasing the potential for more frequent and larger wildfires. The Cascabel Watersheds – with more than 10 years of meteorological, ecological, and hydrological information available – represent an ideal site for monitoring and evaluating the effects of possible climatic changes in the region (Gottfried et al. 2014, 2012). This information might also be combined with similar

information obtained from other sites within the region to provide a more holistic view of the potential impacts of climatic changes on people and natural resources in the greater Southwestern Borderlands Region.

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Spatial and Temporal Distribution of Bacteria Indicators and Microbial Source Tracking Markers within Tumacácori National Historical Park and the Santa Cruz River Watershed

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One of the management objectives of Tumacácori National Historical Park (TUMA) is to protect and improve the riparian habitat of the reach of the effluent-dependent Santa Cruz River located within the park. In 2015, the U.S. Geological Survey (USGS) Arizona Water Science Center in cooperation with TUMA initiated a 3-year study as part of the National Parks Service-USGS Water Quality Partnership Program to better understand the spatial and temporal distribution of bacteria indicators and microbial source tracking markers within the park and the upper watershed. Data collected by government agencies and volunteer groups were compiled and analyzed along with an additional two years of high resolution data collection of *Escherichia coli* (*E. coli*), suspended sediment, and water-stage data that were collected at targeted locations in the upper watershed. Results indicate for most of the period of study, water quality in TUMA was primarily a function of the treated-effluent discharged by the Nogales International Wastewater Treatment Plant, but for about 20 percent of the year TUMA is affected by water quality in the upper watershed, specifically flood waters from Nogales Wash that frequently exceed water quality criteria. Changes in *E. coli* concentrations and loads varied by as much as an order of magnitude during both base flow and flooding conditions. Bacteria sources coming from Nogales wash were predominantly human and canine whereas the upper Santa Cruz River and tributaries showed more of a ruminant signature. Overall, the *E.coli* concentrations and sources are dependent on, and vary with, season and flooding.

Distribución espacial y temporal de indicadores de bacterias y marcadores de seguimiento de fuentes microbianas dentro del Parque Histórico Nacional Tumacácori y la cuenca del río Santa Cruz

Uno de los objetivos de gestión del Parque Histórico Nacional Tumacácori (TUMA) es proteger y mejorar el hábitat ribereño del alcance del río Santa Cruz dependiente de efluentes ubicado dentro del parque. En 2015, el Centro de Ciencias del Agua de Arizona (USGS) en cooperación con TUMA inició un estudio de 3 años como parte del Programa de Asociación de Calidad del Agua del Servicio de Parques Nacionales de USGS para comprender mejor la distribución espacial y temporal de indicadores bacterianos y microbianos marcadores de seguimiento de la fuente dentro del parque y la cuenca superior. Los datos recopilados por agencias gubernamentales y grupos de voluntarios se compilaron y analizaron junto con otros dos años de recolección de datos de alta resolución de Escherichia coli (E. coli), sedimentos suspendidos y datos de etapas de agua que se recolectaron en lugares seleccionados en la cuenca superior. Los resultados indican que la calidad del agua en TUMA fue principalmente una función del efluente tratado descargado por la Planta Internacional de Tratamiento de Aguas Residuales de Nogales, pero alrededor del 20 por ciento del año TUMA se ve afectado por la calidad del agua en la cuenca superior, específicamente las aguas de inundación de Nogales Wash que frecuentemente exceden los criterios de calidad del agua. Los cambios en las concentraciones y cargas de E. coli variaron tanto como un orden de magnitud durante el flujo de base y las condiciones de inundación. Las fuentes de bacterias provenientes del lavado de Nogales fueron predominantemente humanas y caninas, mientras que el alto río Santa Cruz y los afluentes mostraron una mayor cantidad de rumiantes. En general, las concentraciones y fuentes de E. coli dependen de, y varían con, las condiciones de la temporada y las inundaciones.

NOTE: A manuscript was not submitted to accompany this presentation.

Using Isotopes and Solute Tracers to Infer Groundwater Recharge and Flow in the Cienega Creek Watershed, SE Arizona

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The Cienega Creek watershed (CCW) of southern Arizona contains two registered "Outstanding Arizona Waters" reaches and wetlands (cienegas) that support several threatened and endangered species. The lack of baseline hydrologic studies in the CCW leave important land management questions unanswered, such as how increases in urbanization, ranching, agriculture, or possible mining could impact groundwater resources? To help address this question, this study investigates the hydrologic connection between recharge in the Santa Rita mountain block and basin groundwater, which is contained in alluvial and Cretaceous aquifers, and wetlands in the basin. Groundwater samples were collected from springs and wells completed in Cretaceous sediments, basin-fill, and shallow alluvial aquifers along a broad transect from the Santa Rita Mountains eastward across the basin to Cienega Creek. Samples were analyzed for major ion chemistry, stable isotopes ($\delta^{18}O$, δD, $\delta^{13}C$, $\delta^{34}S$) and age tracers (^{3}H, ^{14}C). Initial results indicate springs are dominantly sourced year-round from basin groundwater and δ18O values and sulfate to chloride ratios indicate little influence of summer monsoon floodwaters. Most of the groundwater samples analyzed for tritium are below modern precipitation values for the region, and ^{14}C values are low (3.33-77.09 pMC), which indicates most recharge occurred prior to the 1950's. The low sulfate concentrations and $\delta^{34}S$ values of basin groundwater and springs are typical of local rain water values consistent with the lack of sulfate sources in basin sediments. The lack of recent recharge in shallow alluvial aquifers beneath the washes and near Cienega Creek suggests that groundwater throughout the basin is a relatively old resource, and future increase in groundwater pumping may impact surface waters, including cienegas.

Uso de Isótopos y Trazadores de Solutos para Inferir Recarga y Flujo de Aguas Subterráneas en la Cuenca de Ciénega Creek, SE Arizona

La cuenca hidrográfica Cienega Creek (CCW por sus siglas en inglés) del sur de Arizona contiene dos zonas conocidas como "Aguas sobresalientes de Arizona" y humedales (cienegas) que sustentan varias especies amenazadas y en peligro de extinción. La falta de estudios hidrológicos de referencia en la CCW deja sin responder preguntas importantes sobre la gestión de la tierra, por ejemplo, cómo los aumentos en la urbanización, la ganadería, la agricultura o la posible minería podrían afectar los recursos de agua subterránea. Para ayudar a abordar esta cuestión, este estudio investiga la conexión hidrológica entre la recarga en el bloque de montaña Santa Rita y el agua subterránea de la cuenca, que está contenida en los acuíferos aluviales y cretáceos, y los humedales en la cuenca. Se tomaron muestras de agua subterránea de manantiales y pozos completados en sedimentos del Cretácico, relleno de cuencas y acuíferos aluviales poco profundos a lo largo de un amplio transecto desde las montañas de Santa Rita hacia el este a través de la cuenca hasta el arroyo Cienega. Las muestras se analizaron para la química principal de iones, isótopos estables (δ18O, δD, δ13C, δ34S) y trazadores de edad (3H, 14C). Los resultados iniciales indican que los manantiales provienen predominantemente durante todo el año del agua subterránea de la cuenca y los valores de δ18O y las relaciones de sulfato a cloruro indican poca influencia de las aguas del monzón de verano. La mayoría de las muestras de agua subterránea analizadas para tritio están por debajo de los valores modernos de precipitación para la región, y los valores de 14C son bajos (3.33-77.09 pMC), lo que indica que la mayor parte de la recarga se produjo antes de los años 50. Las bajas concentraciones de sulfato y los valores de δ34S del agua subterránea de la cuenca y los manantiales son típicos de los valores de agua de lluvia locales consistentes con la falta de fuentes de sulfato en los sedimentos de la cuenca. La falta de recarga reciente en acuíferos aluviales poco profundos debajo de los lavaderos y cerca de Cienega Creek sugiere que el agua subterránea en toda la cuenca es un recurso relativamente antiguo, y el futuro aumento del bombeo de aguas subterráneas puede afectar las aguas superficiales, incluidas las ciénegas.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 53: Connecting and Sustaining the Flow of Transboundary Environmental Goods and Services

Cascabel Prescribed Fire, Peloncillo Mountains, Coronado National Forest.
(Photo by Gerald Gottfried, USDA Forest Service, Rocky Mountain Research Station, retired).

Abstracts and Papers
Leon
Lien
Villareal
Wilson

A multi-method analysis of rancher attitudes toward endangered species conservation in the southwestern United States

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In March 2014, the United States Fish and Wildlife Service (USFWS) designated “critical habitat” for jaguars (panthera onca) in southeastern Arizona and southwestern New Mexico. Critical habitat is a legal designation under the Endangered Species Act. Federal agencies are required to consult with the USFWS before conducting or funding any project within critical habitat in order to prevent adverse modification or destruction of habitat. The primary land use in the area designated for jaguars is ranching. Most ranchers in this region rely on a combination of private and public lands for grazing, with federal grazing permits making up the majority of many ranches. During the public comment phase of the critical habitat rulemaking process, some ranchers expressed concerns that the designation of critical habitat could limit or end public lands grazing. We conducted a multi-method study to understand the attitudes of ranchers in the region toward the jaguar critical habitat designation, endangered species regulations generally, and incentive-based approaches to endangered species management in the region. Data was developed through in-depth interviews, a written survey, and extension workshops that included focus groups. We found participants in our study are more concerned about how endangered species regulations may impact their operations than they are about depredation impacts from increased jaguar presence; many respondents are interested in incentive-based conservation approaches, depending on regulatory assurances and funding sources; and an overall commitment to wildlife conservation and range management. We present the results of our study and discuss implications for endangered species management.

Un análisis de múltiples métodos de las actitudes de los rancheros hacia la conservación de especies en peligro en el suroeste de los Estados Unidos.

En marzo de 2014, el Servicio de Pesca y Vida Silvestre de los Estados Unidos (USFWS) designó el "hábitat crítico" para los jaguares (panthera onca) en el sudeste de Arizona y el suroeste de Nuevo México. El hábitat crítico es una designación legal bajo la Ley de Especies en Peligro de Extinción. Se requiere que las agencias federales consulten con el USFWS antes de conducir o financiar cualquier proyecto dentro de un hábitat crítico a fin de evitar modificaciones adversas o la destrucción del hábitat. El uso principal de la tierra en el área designada para los jaguares es la ganadería. La mayoría de los ganaderos en esta región dependen de una combinación de tierras privadas y públicas para el pastoreo, y los permisos federales de pastoreo constituyen la mayoría de los ranchos. Durante la fase de comentarios públicos sobre el proceso de reglamentación del hábitat crítico, algunos rancheros expresaron su preocupación de que la designación de hábitat crítico podría limitar o poner fin al pastoreo de tierras públicas. Llevamos a cabo un estudio de múltiples métodos para comprender las actitudes de los rancheros en la región hacia la designación de hábitats críticos del jaguar, las reglamentaciones de especies en peligro en general y los enfoques basados en incentivos para el manejo de especies en peligro en la región. Los datos se desarrollaron a través de entrevistas en profundidad, una encuesta escrita y talleres de extensión que incluyeron grupos focales. Descubrimos que los participantes de nuestro estudio están más preocupados por cómo las reglamentaciones de especies en peligro pueden afectar sus operaciones que por el impacto de la depredación por el aumento de la presencia de jaguares; muchos encuestados están interesados en los enfoques de conservación basados en incentivos, dependiendo de las garantías reglamentarias y las fuentes de financiación; y un compromiso general con la conservación de la vida silvestre y la gestión de pastizales. Presentamos los resultados de nuestro estudio y discutimos las implicaciones para el manejo de especies en peligro de extinción.

NOTE: A manuscript was not submitted to accompany this presentation.

Evaluating Ecosystem Services in Arid Riparian Habitats: a Landscape Perspective

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Riparian ecosystems in arid environments are considered key habitats, since their ecological and economical influence extends well beyond the boundaries of geographical distributions. As key biodiversity hotspots, these ecosystems present unique characteristics in terms of fauna, flora, and processes. Moreover, since most economic, cultural and social activities on these landscapes are highly dependent of the riparian habitats, they are often considered Ecosystem Services (ES) "Hotspots", in the regional and local context. In the present work, we evaluate the change and current state of 1) carbon contained by vegetation type and 2) water "produced" by micro-watershed, in two sub-watersheds of the Sonoran River (Northwestern Mexico). To assess the previous, we used remote sensing and spatial analysis approaches (land cover classification, photosynthetic analysis, and the mapping of ES), coupled with filed sampling and historical data analysis (carbon storage analysis and water availability-use assessment). Our results suggest that carbon storage per area in riparian habitat (93,147 tC/ha), is significantly higher than the next vegetation type with the higher biomass density (oak forest 65,048 tC/ha). Also, we found a steady decrease in basal productivity in riparian vegetation and other land cover types in the watershed. Finally, we report that even when total water recharge is treated at the subwatershed level, there is an uneven extraction occurring among the micro-watersheds within our study area. The loss or conversion of riparian vegetation will significantly decrease the quality and quantity of ES over these arid landscapes.

La evaluación de los servicios ecosistémicos en hábitats ribereños áridos: una perspectiva del paisaje

Los ecosistemas ribereños en ambientes áridos se consideran hábitats clave, ya que su influencia ecológica y económica se extiende mucho más allá de los límites de las distribuciones geográficas. Como puntos críticos de biodiversidad, estos ecosistemas presentan características únicas en términos de fauna, flora y procesos. Además, dado que la mayoría de las actividades económicas, culturales y sociales en estos paisajes dependen en gran medida de los hábitats ribereños, a menudo se los considera "puntos críticos" de los Servicios Ecosistémicos (SE), en el contexto regional y local. En el presente trabajo, evaluamos el cambio y el estado actual de 1) carbono contenido por tipo de vegetación y 2) agua "producida" por microcuenca, en dos subcuencas del río Sonora (noroeste de México). Para evaluar lo anterior, utilizamos enfoques de teledetección y análisis espacial (clasificación de cobertura terrestre, análisis fotosintético y mapeo de ES), junto con muestreo archivado y análisis de datos históricos (análisis de almacenamiento de carbono y evaluación de disponibilidad de agua). Nuestros resultados sugieren que el almacenamiento de carbono por área en el hábitat ribereño (93,147 tC / ha) es significativamente mayor que el siguiente tipo de vegetación con mayor densidad de biomasa (bosque de encino 65,048 tC / ha). Además, encontramos una disminución constante en la productividad basal en la vegetación ribereña y otros tipos de cubierta terrestre en la cuenca. Finalmente, informamos que incluso cuando la recarga total de agua se trata a nivel de subcuenca, se produce una extracción desigual entre las microcuencas en nuestra área de estudio. La pérdida o conversión de vegetación ribereña, disminuirá significativamente la calidad y la cantidad de SE sobre estos paisajes áridos.

NOTE: A manuscript was not submitted to accompany this presentation.

Changing fire regimes in the Madrean Archipelago: Implications for sustainability of transboundary ecosystem services

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The Madrean Ecoregion of US and Mexico provides a unique setting to explore relationships between humans, ecosystems, and wildfire; mountains in the ecoregion are biogeographically similar, but different land uses and fire management approaches have developed over time in the two countries. Human influence encompasses a range of types and intensities across the region; in all cases, fire plays an important role in maintaining landscape heterogeneity that supports many integrated, transboundary ecosystem services that sustain humans and wildlife. Using the anthropogenic biome framework we investigated how fire regimes vary in relation to a diversity of types of human interactions, and to what extent current ecosystems and ecosystem services may be affected, given expected changes in climate and attendant shifts in seasons of burning, fire size, and severity. We developed boosted regression tree models to determine the relative degree to which the spatial gradient in fire severity of recent (1985-2011) wildfires was correlated with bioclimatic variables for contemporary climate (1981-2010 normals) and applied the models to climate projections (RCP 4.5). Fire severity was generally higher in remote forest and rangeland biomes corresponding with higher elevation and shorter growing season; these patterns are expected to continue under future climate. Lower severity fires, more common in residential and populated biomes were predicted to become more severe in places, potentially compromising sustainable livelihoods. On the other hand, some places with current low severity regimes may experience future climates not suitable for anthropogenic burning for agricultural ecosystem services or for restoration of wildlife habitat.

Cambios en los regímenes de incendios en el Archipiélago Madrense: Implicaciones para la sostenibilidad de los servicios ecosistémicos transfronterizos

La Ecoregión Madrense de EE. UU. y México ofrece un entorno único para explorar las relaciones entre los humanos, los ecosistemas y los incendios forestales; las montañas en la ecorregión son biogeográficamente similares, pero diferentes usos de la tierra y enfoques de manejo de incendios se han desarrollado a lo largo del tiempo en los dos países. La influencia humana abarca una variedad de tipos e intensidades en toda la región; en todos los casos, el fuego juega un papel importante en el mantenimiento de la heterogeneidad del paisaje que respalda muchos servicios ecosistémicos transfronterizos integrados que sostienen a los humanos y la vida silvestre. Utilizando el marco del bioma antropogénico, investigamos cómo varían los regímenes de fuego en relación con una diversidad de tipos de interacciones humanas y hasta qué punto los ecosistemas actuales y los servicios del ecosistema pueden verse afectados, dados los cambios climáticos previstos y los cambios correspondientes en las estaciones de quema, tamaño del incendio y severidad. Desarrollamos modelos de árboles de regresión potenciados para determinar el grado relativo en que el gradiente espacial en la severidad del fuego de incendios forestales recientes (1985-2011) se correlacionó con variables bioclimáticas para el clima contemporáneo (normales 1981-2010) y aplicamos los modelos a proyecciones climáticas (RCP 4.5). La severidad del fuego fue generalmente más alta en bosques remotos y biomas de pastizales que corresponden a una elevación más alta y una temporada de crecimiento más corta; Se espera que estos patrones continúen bajo clima futuro. Se pronostica que los incendios de menor gravedad, más comunes en los biomas residenciales y poblados, serán más severos en algunos lugares, lo que podría comprometer los medios de vida sostenibles. Por otro lado, algunos lugares con regímenes de baja severidad actuales pueden experimentar climas futuros no adecuados para la quema antropogénica de servicios de ecosistemas agrícolas o para la restauración del hábitat de vida silvestre.

NOTE: A manuscript was not submitted to accompany this presentation.

Assessing Vegetation Response to Watershed Restoration in Southeastern Arizona using Remote Sensing and Field Methods

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Land managers are installing watershed restoration structures (i.e. gabions, check dams) to increase native vegetation and improve habitat in locations throughout the world. This presentation will describe research exploring the relationship between restoration structures and their influence on vegetation and water availability in riparian areas of the Madrean Archipelago Ecoregion. Specifically, we examine vegetation greenness, species composition and abundance at restoration sites compared with control areas. Remote sensing techniques provide information on trends in overall vegetation health, using greenness as a proxy, while field work is used to quantify species composition and abundance. Using a multi-decadal and US-Mexico transboundary Landsat satellite imagery archive, we calculated NDVI and NDII spectral indices and applied statistical analyses to identify trends in vegetation greenness and detect the spatial extent of those trends both downstream and upstream of restoration. To evaluate the short-term effect of restoration structures and to document the presence of new species such as wetland species or non-natives, field data was collected for 3 growing seasons (August – September) from 2015 to 2017. Our initial remote sensing analysis showed that vegetation greenness increased at restoration sites, which was supported by our field studies that showed a higher frequency of perennial vegetation. Additional remote sensing efforts extended our analyses downstream from restoration sites and suggest that watershed restoration structures can increase vegetation greenness up to 5 km downstream from installation. Collectively, this research suggests that watershed restoration does increase perennial vegetation at restoration sites while increasing vegetation greenness at restoration sites and downstream.

Evaluación de la respuesta de la vegetación a la restauración de cuencas hidrográficas en el sudeste de Arizona mediante detección remota y métodos de campo

Los administradores de la tierra están instalando estructuras de restauración de cuencas (es decir, gaviones, represas de control) para aumentar la vegetación nativa y mejorar el hábitat en lugares de todo el mundo. Esta presentación describirá la investigación que explora la relación entre las estructuras de restauración y su influencia en la vegetación y la disponibilidad de agua en las áreas ribereñas de la Ecorregión del Archipiélago Madrense. Específicamente, examinamos el verdor de la vegetación, la composición de las especies y la abundancia en los sitios de restauración en comparación con las áreas de control. Las técnicas de teledetección proporcionan información sobre las tendencias en la salud general de la vegetación, utilizando el verdor como proxy, mientras que el trabajo de campo se utiliza para cuantificar la composición y abundancia de las especies. Utilizando un archivo de imágenes satelitales Landsat multidecadal y transfronterizo de US-México, calculamos índices espectrales NDVI y NDII y aplicamos análisis estadísticos para identificar tendencias en el verdor de la vegetación y detectar la extensión espacial de esas tendencias aguas abajo y aguas arriba de la restauración. Para evaluar el efecto a corto plazo de las estructuras de restauración y documentar la presencia de nuevas especies como especies de humedales o no nativos, se recopilaron datos de campo durante 3 temporadas de cultivo (agosto - septiembre) de 2015 a 2017. Nuestro análisis inicial de teledetección mostró que el verdor de la vegetación aumentó en los sitios de restauración, lo que fue respaldado por nuestros estudios de campo que mostraron una mayor frecuencia de vegetación perenne. Los esfuerzos adicionales de teledetección ampliaron nuestros análisis aguas abajo de los sitios de restauración y sugieren que las estructuras de restauración de cuencas hidrográficas pueden aumentar el verdor de la vegetación hasta 5 km aguas abajo de la instalación. Colectivamente, esta investigación sugiere que la restauración de cuencas hidrográficas sí aumenta la vegetación perenne en los sitios de restauración al tiempo que aumenta el verdor de la vegetación en los sitios de restauración y río abajo.

NOTE: A manuscript was not submitted to accompany this presentation.

Session 54: Springs

Monitoring spring flow and quality in Sonora, Mexico.
(Photo courtesy of Sky Island Alliance).

Abstracts and Papers
Hammer
Ibarra
Penalba
Stevens
Wilbor

Developing tools to secure water for springs in the Sky Islands

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Sky Island Alliance, the University of Arizona Water Resources Research Center, and AMP Insights launched the Sky Island Waters initiative with the goal of assisting efforts to secure water for natural areas. We are developing a cross-jurisdictional tool for managers interested in protecting spring ecosystems in southeastern Arizona. Emerging conservation interest in spring ecosystems has highlighted the concern that springs are offered limited protection relative to their ecological significance. To address this, we are developing a prioritization tool for springs protection that integrates information biophysical elements of individual springs with management and watershed context. The tool is being developed in partnership with agency personnel, land managers, tribal members, and interested stakeholders who are stewarding springs. Outcomes of tool development include 1) an analysis of existing springs sites and watersheds and 2) an exploratory multi-criteria tool for managers to evaluate landscape-scale and site-specific attributes. Sky Island Alliance has been leading efforts to document the biophysical elements of springs in the region through ground surveys and data collection. Of the 1,592 springs in the region, 293 have been surveyed for biophysical characteristics. This includes cataloguing information on site geomorphology, habitat and microhabitat, biota, and water quality and quantity. The Springs Stewardship Institute has aggregated spring surveys into a central database. The tool has four focal areas for characterizing spring systems and the surrounding landscape: biophysical attributes; management context; cultural values of the spring and surrounding landscape; and resilience to potential climate change impacts.

Desarrollo de herramientas para asegurar agua en manantiales de las Islas Serranas

Sky Island Alliance, el Centro de Investigación de Recursos Hídricos de la Universidad de Arizona y AMP Insights lanzaron la iniciativa Sky Island Waters con el objetivo de ayudar a los esfuerzos para asegurar el agua para las áreas naturales. Estamos desarrollando una herramienta interjurisdiccional para gerentes interesados en proteger los ecosistemas de primavera en el sureste de Arizona. El interés emergente por la conservación en los ecosistemas de primavera ha resaltado la preocupación de que a los manantiales se les ofrezca protección limitada en relación con su importancia ecológica. Para abordar esto, estamos desarrollando una herramienta de priorización para la protección de manantiales que integra elementos biofísicos de información de resortes individuales con la gestión y el contexto de la cuenca. La herramienta se está desarrollando en asociación con el personal de la agencia, los gerentes de la tierra, los miembros de la tribu y las partes interesadas que están administrando los resortes. Los resultados del desarrollo de herramientas incluyen 1) un análisis de los sitios existentes de manantiales y cuencas hidrográficas y 2) una herramienta exploratoria de criterios múltiples para que los gerentes evalúen los atributos de escala de paisaje y específicos del sitio. Sky Island Alliance ha estado liderando los esfuerzos para documentar los elementos biofísicos de los manantiales de la región a través de levantamientos de terreno y recolección de datos. De los 1.592 manantiales de la región, 293 han sido estudiados por sus características biofísicas. Esto incluye información de catalogación sobre la geomorfología del sitio, el hábitat y el microhábitat, la biota y la calidad y cantidad del agua. The Springs Stewardship Institute ha agregado encuestas de primavera en una base de datos central. La herramienta tiene cuatro áreas focales para caracterizar los sistemas de primavera y el paisaje circundante: atributos biofísicos; contexto de gestión; valores culturales del manantial y el paisaje circundante; y resiliencia a los posibles impactos del cambio climático.

NOTE: A manuscript was not submitted to accompany this presentation.

Springs Ecosystems Inventory in the Sky Islands

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Since 2012, Sky Island Alliance has worked to inventory and assess springs in the Sky Island region, also called the Madrean Archipelago. The need for spring ecosystem inventory and restoration was identified at regional climate change adaptation workshops SIA developed with numerous partners and convened in 2010 and 2011. A key strategy identified to address this was to inventory springs in priority watersheds to gather basic information on condition, species presence, and management status. To date, we have assessed over 300 springs in 18 mountain ranges in Arizona and Sonora with the help of thousands of hours donated by volunteers. Most recently, we have focused on how fire affects springs, collecting water rights information, and surveying for spring snails. I will share some of what we have learned from these assessments, updates on what we have accomplished, and discuss areas that still lack data.

Inventario de Ecosistemas de Manantiales en las Islas Serranas

Desde 2012, Sky Island Alliance (SIA) ha trabajado para inventariar y evaluar manantiales en la región de las Islas Serranas, también llamada Archipiélago Madrense. La necesidad de inventario y restauración de ecosistemas primaverales fue identificada en talleres regionales de adaptación al cambio climático que SIA desarrolló con varios socios y convocados en 2010 y 2011. Una estrategia clave identificada para abordar esto fue inventariar manantiales en cuencas prioritarias para recopilar información básica sobre la condición, presencia de especies presencia y estado de gestión. Hasta la fecha, hemos evaluado más de 300 manantiales en 18 cadenas montañosas en Arizona y Sonora con la ayuda de miles de horas donadas por voluntarios. Más recientemente, nos hemos centrado en cómo el fuego afecta a los manantiales, en la recopilación de información sobre los derechos de agua y en la topografía de los caracoles de primavera. Compartiré algo de lo que hemos aprendido de estas evaluaciones, actualizaciones sobre lo que hemos logrado y discutiremos las áreas que aún carecen de datos.

NOTE: A manuscript was not submitted to accompany this presentation.

Springs of Sonora

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The Manantiales de Sonora group, formed by a group of student volunteers belonging to the degree in Biology at the University of Sonora, in collaboration with the Sky Island Alliance, emerged as an initiative to create and obtain information to help us assess the state of ecosystems of the state of Sonora, of which there are no records. Sonora shares a desert with the state of Arizona, which is known to host the largest number of springs in the United States. In addition, most of the state is made up of desert, being the places with fresh water, of great importance for the survival of the plants and animals of the region. The purpose of the group is to evaluate, monitor and restore the areas with springs in the State of Sonora, as well as to educate the community about its importance, in order to preserve and protect these places. The group began work in November of 2017, so far 7 springs have been evaluated in the state. The information

obtained is submitted to the Springs Stewardship Institute database, with the purpose of expanding and keeping the information accessible for further studies in favor of the conservation of aquatic ecosystems.

Manantiales de Sonora

El grupo Manantiales de Sonora, formado por un grupo de estudiantes voluntarios pertenecientes al grado de Biología de la Universidad de Sonora, en colaboración con Sky Island Alliance, surgió como una iniciativa para crear y obtener información que nos ayude a evaluar el estado de los ecosistemas del estado de Sonora, del cual no hay registros. Sonora comparte un desierto con el estado de Arizona, que es conocido por albergar la mayor cantidad de manantiales en los Estados Unidos. Además, la mayor parte del estado se compone de desierto, siendo los lugares con agua dulce, de gran importancia para la supervivencia de las plantas y animales de la región. El propósito del grupo es evaluar, monitorear y restaurar las áreas con manantiales en el Estado de Sonora, así como educar a la comunidad sobre su importancia, a fin de preservar y proteger estos lugares. El grupo comenzó a trabajar en noviembre de 2017, hasta ahora se han evaluado 7 manantiales en el estado. La información obtenida se envía a la base de datos Springs Stewardship Institute, con el propósito de ampliar y mantener la información accesible para futuros estudios a favor de la conservación de los ecosistemas acuáticos.

NOTE: A manuscript was not submitted to accompany this presentation.

Ciénegas: past biodiversity archives

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Due to the permanent presence of water, a limiting factor for living beings, ciénegas retain high biodiversity levels. Moreover, waterlogged sediments favor the conservation of surrounding plant and animal remains, accumulated over millennia. In this work, we estimate the age of ciénegas (end of the Pleistocene and Holocene) located in the southern Madrean archipelago and adjacent Sierra Madre Occidental, and their potential as records of past regional biodiversity, through pollen and molecular markers analyses in sediments. The sedimentary record is often interrupted by hiatuses, linked to arid conditions. Pollen assemblages show, for the last glacial period, a wider geographic distribution of cold and temperate mountain forest taxa (*Pinus, Abies, Picea, Pseudotsuga, Juniperus, Quercus, Ostrya, Tilia*), as well as water-related taxa (*Juglans, Salix, Pteridophyta*). In the Sky Islands, altitudinal decreases of hundreds of meters suggest the possibility of temperate forest corridors between different sierras. Ciénegas represent biodiversity refuges for temperate and tropical taxa, linked to climate change migrations.

Ciénegas: archivos pasados de biodiversidad

Debido a la presencia permanente de agua, un factor limitante para los seres vivos, las ciénegas conservan altos niveles de biodiversidad. Además, los sedimentos saturados de agua favorecen la conservación de los restos vegetales y animales circundantes, acumulados durante milenios. En este trabajo, estimamos la edad de las ciénegas (finales del Pleistoceno y el Holoceno) ubicadas en el sur del archipiélago Madrense y adyacentes a la Sierra Madre Occidental, y su potencial como registros de la biodiversidad regional pasada, a través de análisis de polen y marcadores moleculares en sedimentos. El registro sedimentario a menudo se interrumpe por hiatos, vinculados a condiciones áridas. Los ensambles de polen muestran, para el último período glacial, una distribución geográfica más amplia de taxones de bosques montañosos fríos y templados (Pinus, Abies, Picea, Pseudotsuga, Juniperus, Quercus, Ostrya, Tilia), así como taxones relacionados con

el agua (Juglans, Salix, Pteridophyta). En las Islas Serranas, las disminuciones altitudinales de cientos de metros sugieren la posibilidad de corredores de bosques templados entre diferentes sierras. Ciénegas representa refugios de biodiversidad para taxones templados y tropicales, vinculados a las migraciones del cambio climático.

NOTE: A manuscript was not submitted to accompany this presentation.

Springs Ecosystem Inventory and Assessment Workshops: Lessons Learned in the Southwestern USA and Mexico

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Since 2002 Springs Stewardship Institute (SSI) staff held nearly 50 springs ecosystem inventory and assessment workshops to citizens and non-governmental, Tribal, and national and international governmental organizations. Workshops were designed to assist advocates and environmental managers improve ecosystem stewardship by presenting springs ecosystem ecology as a multi-disciplinary scientific discipline. SSI recognizes that springs owners are entitled to resource use; however, we encourage recognition of the extraordinary importance of springs as sustainable ecosystems, and the benefits of well-considered management across political jurisdictions. Here we share some of many lessons learned in conducting natural resources stewardship trainings:

1) Direct, personal communication with the audience is essential, and information should be communicated in an interactive and engaging fashion that meets the needs of the audience.

2) Hands on experience for two days is sufficient for communicating basic concepts, but is insufficient for teaching more complex skills. Subsequent training often is needed in water quality and flow measurement, field equipment use, plant and animal identification, and in specimen collection and curation, measurements that best serve management needs.

3) Effective information management requires additional practice.

4) Students need to be urged to explore unfamiliar topics to gain oversight, familiarity, and proficiency.

5) Translation requires considering language- and culture-specific precepts.

6) Agency ownership of data is strongly engrained, but thwarts collaboration among watershed neighbors.

7) Gratitude and community communication are essential for long-term learning and continued collaboration.

Talleres de inventario y evaluación de ecosistemas de Manantiales: lecciones aprendidas en el suroeste de los Estados Unidos y México

Desde el 2002, el personal del Springs Stewardship Institute (SSI) llevó a cabo cerca de 50 talleres de evaluación e inventario de ecosistemas de manantiales para ciudadanos, organizaciones no gubernamentales, tribales, y organizaciones gubernamentales nacionales e internaciones. Los talleres se diseñaron para ayudar a los defensores y gerentes ambientales a mejorar la administración de los ecosistemas presentando la ecología de los ecosistemas de

manantiales como una disciplina científica multidisciplinaria. SSI reconoce que los propietarios de manantiales tienen derecho a usar los recursos; sin embargo, alentamos el reconocimiento de la extraordinaria importancia de los manantiales como ecosistemas sostenibles, y los beneficios de un manejo bien considerado en todas las jurisdicciones políticas. Aquí compartimos algunas de las muchas lecciones aprendidas en la conducción de entrenamientos de administración de recursos naturales:

1) *La comunicación directa y personal con el público es esencial, y la información debe comunicarse de una manera interactiva y atractiva que satisfaga las necesidades del público.*

2) *La experiencia práctica durante dos días es suficiente para comunicar conceptos básicos, pero es insuficiente para enseñar habilidades más complejas. Con frecuencia se necesita capacitación posterior en calidad del agua y medición del flujo, uso del equipo de campo, identificación de plantas y animales, y en la recolección y conservación de especímenes, mediciones que mejor sirvan a las necesidades de gestión.*

3) *El manejo efectivo de la información requiere práctica adicional.*

4) *Se debe instar a los estudiantes a explorar temas desconocidos para obtener supervisión, familiaridad y competencia.*

5) *La traducción requiere considerar los preceptos específicos del idioma y la cultura.*

6) *La propiedad de los datos por parte de la agencia está fuertemente arraigada, pero impide la colaboración entre los vecinos de la cuenca.*

7) *La gratitud y la comunicación comunitaria son esenciales para el aprendizaje a largo plazo y la colaboración continua.*

NOTE: A manuscript was not submitted to accompany this presentation.

Exploring Springs Value to Wildlife in Madrean Landscape Linkages and other Focal Areas

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Sky Island Alliance (SIA), a bi-national Madrean Archipelago conservation organization has focused it conservation work on springs since 2012. Springs are critical water and habitat resource for regional biodiversity and wide-ranging wildlife. In order to better understand wildlife use of spring water sources and habitat within the Madrean Archipelago and to guide conservation management of these resources by our public land management agencies SIA developed a citizen-science monitoring program beginning in 2014 (SIA's Adopt-A-Spring Program, volunteer-led spring-specific repeat surveys). Beginning in 2016 we evolved our program to integrate citizen-science monitoring of springs and their wildlife values. With a limited volunteer corps capacity and a desire to fulfill an unmet knowledge need, we have recently focused both our spring and wildlife monitoring on springs within threatened landscape-level wildlife linkages of the region, beginning on the US side of the border, as well as a suite of springs that may show the range of climate-change impacts over time. As a basis for focusing our efforts on linkages, we have use existing regional linkage models. Major threats to linkages include recent proposals for increased border infrastructure and development and human-use near still viable highway crossings. This presentation will outline our new integrated citizen-science projects, based on springs and

wildlife linkages. We provide results of wildlife use through cameras and wildlife track surveys, and biodiversity value at monitored spring sites. We also provide a set of ecosystem condition indicators that consulted managers and researchers believe will be best able to track trends in springs conditions of these exceptional landscape resources.

Explorando el valor de los manantiales para la vida silvestre en los enlaces del paisaje Madrense y otras áreas focales

Sky Island Alliance (SIA), una organización binacional de conservación del Archipiélago Madrense, ha centrado su trabajo de conservación en los manantiales desde 2012. Los manantiales son recursos críticos de agua y hábitat para la biodiversidad regional y la amplia vida silvestre. Para comprender mejor el uso de las fuentes de agua de manantial y el hábitat en el Archipiélago Madrense y para guiar el manejo de conservación de estos recursos por nuestras agencias públicas de gestión de tierras, SIA desarrolló un programa de monitoreo de ciencia ciudadana a partir de 2014 (Programa Adopt-A-Spring de SIA, encuestas repetidas específicas de primavera dirigidas por voluntarios). A partir de 2016, desarrollamos nuestro programa para integrar el monitoreo de la ciencia ciudadana de los manantiales y sus valores de vida silvestre. Con una capacidad limitada de cuerpo voluntario y un deseo de satisfacer una necesidad de conocimiento no satisfecha, recientemente hemos enfocado nuestro monitoreo de primavera y vida silvestre en manantiales dentro de los vínculos de vida silvestre a nivel de paisaje de la región, comenzando también en el lado estadounidense de la frontera, como un conjunto de manantiales que pueden mostrar el rango de los impactos del cambio climático a lo largo del tiempo. Como base para enfocar nuestros esfuerzos en los vínculos, hemos utilizado los modelos de vinculación regional existentes. Las principales amenazas a los vínculos incluyen propuestas recientes para aumentar la infraestructura fronteriza y el desarrollo y el uso humano cerca de cruces viales aún viables. Esta presentación delineará nuestros nuevos proyectos integrados de ciencia ciudadana, basados en resortes y enlaces de vida silvestre. Proporcionamos los resultados del uso de la vida silvestre a través de cámaras y estudios de seguimiento de la vida silvestre, y el valor de la biodiversidad en los sitios de primavera monitoreados. También proporcionamos un conjunto de indicadores de condición del ecosistema que consultó a los gerentes e investigadores que creen que serán los más capaces de rastrear las tendencias en las condiciones de los manantiales de estos recursos paisajísticos excepcionales.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Session 55: Large Landscape Planning

Chiricahua National Monument, US National Park Service, Arizona
(Photo courtesy of the US National Park Service)

Abstracts and Papers
Enquist
Grabau
Radke
Robertson
Wilbor

New Information on Potential Futures Informs Large-Scale Conservation Planning

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Decision-makers and managers are increasingly being asked to make decisions in the context of uncertainty, with climate change adding new sources of complexity. Scenario planning is being used as means of providing managers with insights into planning for near- and long-term changes in the resources they manage. Preliminary feedback from managers highlights the need for a variety of information formats to better address concerns from a range of stakeholders so that the process can more readily help practitioners and managers identify strategies to inform decision-making and support on-the-ground action. Ultimately, scenario planning encourages participants to think more systematically about the critical uncertainties of future change, while enhancing opportunities for innovation and effective partner collaboration. This presentation will provide a brief overview and update on the scenario planning work for the Transboundary Madrean Watersheds, including a re-cap of what we know, don't know, and what remains to be seen about climate impacts on ecosystems and people living in the region.

La nueva información sobre futuros potenciales informa la planificación de la conservación a gran escala

Se está pidiendo cada vez más a los responsables de la toma de decisiones y gerentes que tomen decisiones en el contexto de la incertidumbre, y el cambio climático agrega nuevas fuentes de complejidad. La planificación de escenarios se usa como medio para proporcionar a los gerentes ideas sobre la planificación de cambios a corto y largo plazo en los recursos que administran. Los comentarios preliminares de los gerentes resaltan la necesidad de una variedad de formatos de información para abordar mejor las inquietudes de una variedad de partes interesadas, de modo que el proceso pueda ayudar más fácilmente a los profesionales y gerentes a identificar estrategias para informar la toma de decisiones y apoyar la acción sobre el terreno. En última instancia, la planificación de escenarios alienta a los participantes a pensar más sistemáticamente sobre las incertidumbres críticas de los cambios futuros, al tiempo que mejora las oportunidades de innovación y la colaboración efectiva de los socios. Esta presentación proporcionará una breve descripción y actualización sobre el trabajo de planificación de escenarios para las Cuencas Hidrográficas Madre Transfronterizas, incluyendo una recapitalización de lo que sabemos, no sabemos y lo que queda por ver sobre los impactos del clima en los ecosistemas y las personas que viven en ellas.

NOTE: A manuscript was not submitted to accompany this presentation.

Large-Landscape Conservation Planning in the Transboundary Madrean Watersheds

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The Desert Landscape Conservation Cooperative (Desert LCC) was established to foster collaboration that results in

resilient landscapes capable of responding to environmental challenges while supporting natural and cultural values for current and future generations. The Desert LCC worked with diverse partners to initiate a Landscape Conservation Design for the Transboundary Madrean Watersheds. This presentation will provide an overview of the Landscape Conservation Design process and discuss the vision for this collaborative effort—moving from "just another planning process" to a conservation blueprint that effectively informs where and how to implement conservation or restoration on the ground. Another key component of the Landscape Conservation Design process is determining which conservation actions are likely to be successful. The presentation will show early examples of a collaborative case study sharing platform that facilitates intra and inter-organizational communication to both highlight successful strategies and share lessons learned from unsuccessful projects.

Planificación de conservación de paisajes grandes en las cuencas hidrográficas transfronterizas Madrenses

La Cooperativa para la Conservación del Paisaje del Desierto (Desert LCC) se estableció para fomentar la colaboración que resulta en paisajes resilientes capaces de responder a los desafíos ambientales mientras se apoyan los valores naturales y culturales para las generaciones actuales y futuras. La DLCC trabajó con diversos socios para iniciar un Diseño de Conservación del Paisaje para las Cuencas Hidrográficas Transfronterizas. Esta presentación proporcionará una descripción general del proceso de Diseño de Conservación del Paisaje y discutirá la visión de este esfuerzo de colaboración, pasando de "solo otro proceso de planificación" a un plan de conservación que informa de manera efectiva dónde y cómo implementar la conservación o restauración en el terreno. Otro componente clave del proceso de Diseño de Conservación del Paisaje es determinar qué acciones de conservación serán exitosas. La presentación mostrará ejemplos preliminares de una plataforma colaborativa de intercambio de estudios de caso que facilita la comunicación intra e interorganizacional para resaltar estrategias exitosas y compartir lecciones aprendidas de proyectos no exitosos.

NOTE: A manuscript was not submitted to accompany this presentation.

Conservation Success on a Landscape Scale – Leslie Canyon National Wildlife Refuge

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There are a multitude of innovative strategies available to land managers that can help facilitate landscape-level conservation in the face of expected changes in population growth, increasing temperature, shifting rainfall patterns, and weather extremes. A good example involves Leslie Canyon National Wildlife Refuge (refuge) in Cochise County, Arizona. Here, the U.S. Fish and Wildlife Service (Service) has worked effectively with others to expand protection, conservation, and species recovery activities beyond the 2,765-acre refuge owned by the Service and extending those efforts onto an additional 25,298-acres of privately owned land. Strategies included a combination of: Originally delineating a sizable refuge acquisition boundary to provide ample opportunities for conservation efforts; Monitoring and assessing the impacts of potential groundwater withdrawal within the watershed upstream from the refuge; Acquiring, holding, and maintaining conservation easements on lands within that acquisition boundary; Formalizing a Safe Harbor Agreement with the pertinent landowners to help implement recovery activities for six federally-listed threatened and endangered species; and Seeking and providing funding opportunities that help enable landscape enhancement activities such as erosion control, grassland and wetland restoration, and fish and wildlife reintroductions. The apparent success of this cost-effective effort can be used as a model by those who desire to work together in conserving similarly situated landscapes.

Éxito de conservación en una escala de paisaje - Refugio Nacional de Vida Silvestre Leslie Canyon

Hay una multitud de estrategias innovadoras disponibles para los administradores de la tierra que pueden ayudar a facilitar la conservación a nivel del paisaje frente a los cambios esperados en el crecimiento de la población, el aumento de la temperatura, el cambio de los patrones de lluvia y las condiciones meteorológicas extremas. Un buen ejemplo es el Refugio Nacional de Vida Silvestre Leslie Canyon (refugio) en el condado de Cochise, Arizona. Aquí, el Servicio (Servicio) de Pesca y Vida Silvestre de los EE. UU. ha trabajado eficazmente con otros para expandir las actividades de protección, conservación y recuperación de especies más allá de la propiedad de 2,765 acres del Servicio y extender esos esfuerzos a otros 25,298 acres de tierras de propiedad privada. Las estrategias incluyeron una combinación de: Originalmente delinear un límite considerable de adquisición de refugio para proporcionar amplias oportunidades para los esfuerzos de conservación; Monitorear y evaluar los impactos de la posible extracción de agua subterránea dentro de la cuenca aguas arriba del refugio; Adquirir, y mantener servidumbres de conservación en tierras dentro de ese límite de adquisición; Formalizar un Acuerdo de Puerto Seguro con los propietarios pertinentes para ayudar a implementar actividades de recuperación para seis especies amenazadas y en peligro de extinción incluidas en la lista federal; y Buscar y proporcionar oportunidades de financiación que permitan actividades de mejora del paisaje como el control de la erosión, la restauración de pastizales y humedales, y la reintroducción de peces y vida silvestre. El éxito aparente de este esfuerzo rentable puede ser utilizado como modelo por aquellos que desean trabajar juntos en la conservación de paisajes situados de forma similar.

Note: Full Paper Follows

Conservation Success on a Landscape Scale: Leslie Canyon National Wildlife Refuge.

William R. Radke

U.S. Fish and Wildlife Service; Buenos Aires, Leslie Canyon, and San Bernardino National Wildlife Refuges, Arizona

Abstract- -*There are a multitude of innovative strategies available to land managers that can help facilitate landscape-level conservation in the face of expected changes in human population growth, increasing temperature, shifting rainfall patterns, and weather extremes. A good example involves Leslie Canyon National Wildlife Refuge in Cochise County, Arizona. Here, the U.S. Fish and Wildlife Service (Service) has worked effectively with others to expand protection, conservation, and species recovery activities beyond the 2,765 ac (1,119 ha) Refuge owned by the Service, extending those efforts onto an additional 20,471ac (8,284 ha) of privately owned land. Strategies included a combination of: 1) originally delineating an adequate Refuge acquisition boundary to provide for conservation opportunities at a watershed scale; 2) monitoring and assessing the impacts of potential groundwater withdrawal within the watershed upstream from the Refuge; 3) acquiring, holding, and maintaining conservation easements on lands within that acquisition boundary; 4) formalizing a Safe Harbor Agreement with the neighboring landowners to help implement recovery activities for six federally-listed threatened and endangered species; and 5) seeking and providing funding opportunities that help enable landscape enhancement activities such as erosion control, grassland and wetland restoration, and fish and wildlife reintroductions. The success of these cost-effective efforts serves as a model by those who desire to collaborate in conserving similarly situated landscapes.*

INTRODUCTION

The Rio Yaqui Basin is a large riverine system, which drains portions of southeastern Arizona and southwestern New Mexico in the United States (U.S.), and eastern Sonora and western Chihuahua in Mexico. These rivers flow southwesterly where they eventually join and empty into the Sea of Cortez near Ciudad Obregon, Sonora. The entire basin is approximately 28,185 mi^2 (73,000 km^2), and less than 2% of the entire basin is in the U.S. Dynamic geological events have played a major role in shaping these areas of southeast Arizona, catching and storing crucial water, and helping determine the biological diversity present. The portion of the Rio Yaqui headwaters in Arizona supported unique fish and wildlife, including eight native fish species (USFWS 1994). These are the Mexican longfin dace (*Agosia sp*.), Mexican stoneroller (*Campostoma ornatum*), beautiful shiner (*Cyprinella formosa*), Mexican roundtail chub (*Gila minacae*), Yaqui chub (*Gila purpurea*), Yaqui sucker (*Catostomus bernardini*), Yaqui catfish (*Ictalurus pricei*), and Yaqui topminnow (*Poeciliopsis occidentalis sonoriensis*). Six of these species were found nowhere else in the U.S., and five of these are listed as threatened or endangered species in the U.S. and/or Mexico (USFWS 1994). The biological diversity of a minor portion of the Rio Yaqui watershed in Arizona, now protected as National Wildlife Refuges, is further demonstrated by the documentation of at least 416 species of plants (NPS 2016), 343 birds, 67 mammals, 43 reptiles, and 13 amphibians occurring here. Wilson (2016) describes the rugged Madrean mountain chains of Mexico and the Sky Island heights of the southwestern U.S. within which the Refuges lie as one of the best places in the Earth's biosphere due to the diversity of species supported, and identifies the importance of habitat corridors as one way of lessening the impact of climate change on such biodiversity.

The natural diversity within the region has been severely affected by past human uses, including vegetation clearing, unfavorable historic grazing practices, overuse of groundwater by pumping, stream incision and channelization, and other actions (USFWS 1994). Water development and pumping of underground aquifers constitute the greatest threat to survival of Yaqui fishes (USFWS 1994), followed by the negative impacts of non-native species, topsoil erosion, and resulting stream siltation and aggradation. The area continues to be imperiled by numerous influences, including the threats imposed by altered climate resiliency (Halofsky et al. 2018). This paper discusses a suite of strategies that have been successfully used over the past 40 years to conserve natural resources, facilitate transition of diverse ecosystems to a warmer climate, promote partnerships, and enhance and augment collaborative conservation on a broad scale across a portion of the landscape.

Responding to the need to preserve remaining wetland habitats, and to sustain and recover rare fish, Leslie Canyon (Tract 20) was acquired on May 31, 1988 and established as a 1,240 ac (502 ha) unit of the San Bernardino NWR (SBNWR) in Cochise County, Arizona. A Preliminary Project Proposal for designating the Leslie Canyon portion of SBNWR as a separate unit of the National Wildlife Refuge System was approved on August 25, 1992, and Leslie Canyon National Wildlife Refuge (LCNWR) became established during the summer of 1993. In partnership with others, the U.S. Fish and Wildlife Service (Service) administers the Refuge, which is integral to helping maintain a large healthy intact landscape through a combination of several innovative methods. Some of these include acquiring, holding, and maintaining conservation easements totaling about 20,471 ac (8,284 ha), establishment and oversight of the 24,585 ac (9,949 ha) Leslie Canyon Watershed Safe Harbor Agreement, and conducting associated environmental compliance related to endangered species protection and recovery (Figure 1).

CONSERVATION EASEMENTS

Conservation easements are a unique tool to provide environmental protection on private lands, with the goal of tying together existing protected areas, grasslands and riparian areas within a broader working landscape (Rawoot 2017). In general, conservation easements restrict subdivision, building development, and other land uses that would potentially harm the property's value as fish and wildlife habitat. In exchange for giving up certain development rights, the landowner receives a cash payment that reflects the property's appraised development value, which is a significant part of the land's overall value. The Conservation Easement Program administered by the Service is a voluntary program where willing landowners are paid a percentage of their property's fair market value by the Service for the purchase of the property's farming and/or development rights in perpetuity. Easement acquisition typically focuses on the protection of lands having existing habitat conditions that are considered valuable to fish and wildlife (conservation values), and the program is a cost effective way to ensure protection and conservation of landscapes without the federal government actually owning the land. As privately owned land, the property covered by the easement continues to be subject to property taxes and other local regulations.

Service planners recognized the importance of protecting a watershed large enough for protecting, and supporting the purposes of, the proposed Refuge. The Preliminary Project Proposal therefore strategically identified an acquisition boundary for LCNWR that encompassed about 25,000 ac (10,117 ha), including most of the immediate Leslie Creek watershed outside of designated National Forest lands. This relatively large "Refuge acquisition boundary" was visionary in providing the Service opportunities to pursue habitat protection and conservation of fish and wildlife in a broader watershed that maximized connectivity across the gradient of elevations using a variety of methods, including purchase through fee title and purchase of conservation easements within the established boundary. It is important to recognize that the purchase of a conservation easement by the Service follows the same realty process required for a fee title purchase of land, and cannot be pursued unless the desired land is within an approved designated Refuge acquisition boundary.

Leslie Canyon was acquired through fee title by the Service with the help of The Nature Conservancy, a non-governmental conservation organization, that was able to more quickly purchase property from the willing seller and then hold the parcel in trust until fee title purchase by the Service was ultimately accomplished under authority of the Endangered Species Act (ESA) of 1973, as amended. In 1994, another non-governmental organization, The Conservation Fund purchased an additional 1,200 ac (486 ha) within the acquisition boundary and donated the land to the Service as an addition to the Refuge (Tract 21), which eventually totaled 2,765 ac (1,119 ha) with the acquisition of 324.76 ac (131 ha) (Tract 23) as part of a land trade between the Service, J.A. Varela, and the C.J. Bennett Trust. This relatively small portion of the much larger landscape within the Refuge acquisition boundary was particularly valuable to the Service because it encompassed a perennial stream that supported Yaqui chub, Yaqui topminnow, Chiricahua leopard frogs (*Lithobates chiricahuensis*), and a rich riparian corridor that sustained a diversity of plants and animals. Sale of the land to these conservation organizations (for ultimate transfer to the Service) was possible, in part, because the private landowner viewed the federally-listed endangered species that occupied the property as potential liabilities to his ranching operation. He feared the possibility of serious consequences related to the ESA in restoring species at risk, which

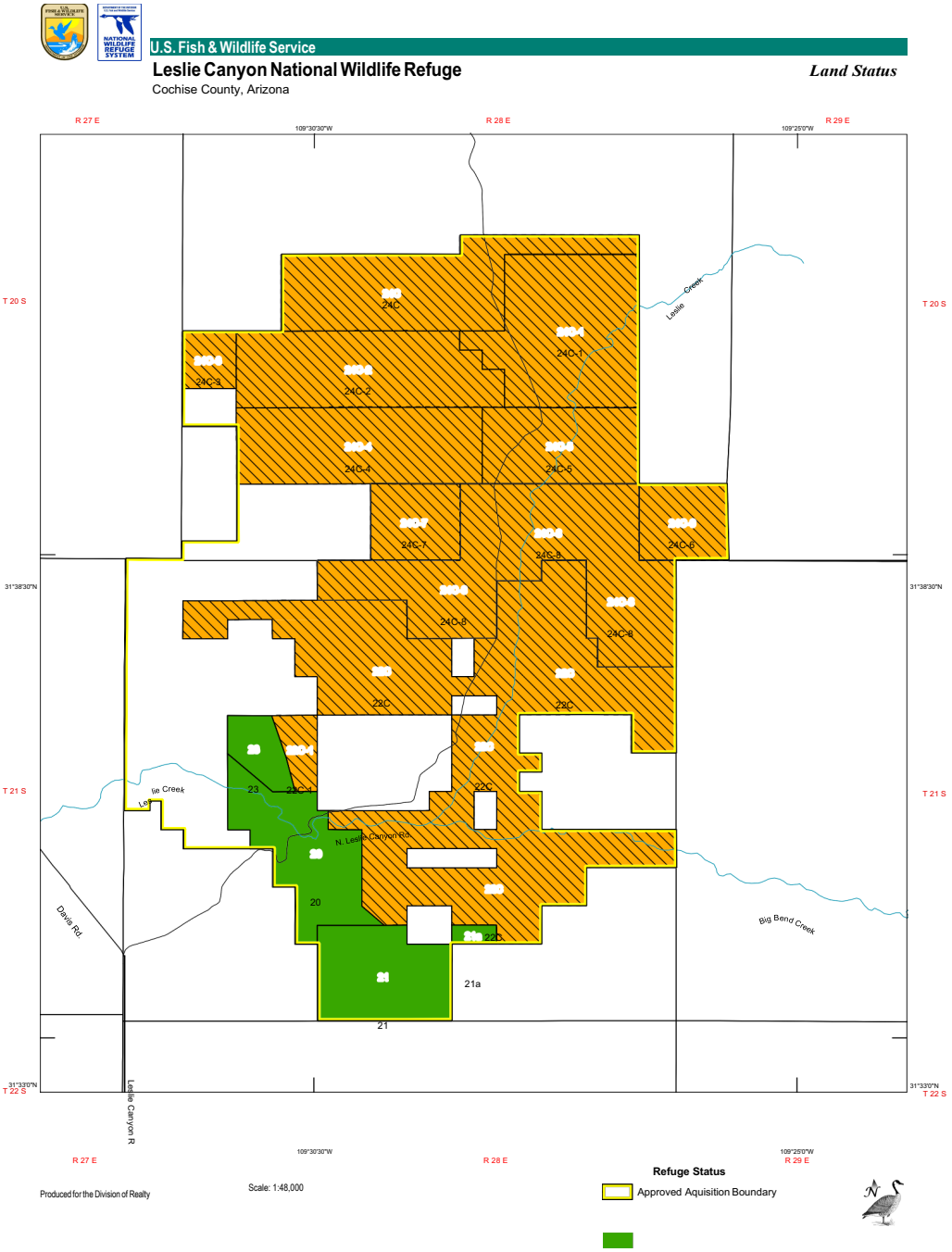

Figure 1. Land Status Map of Leslie Canyon National Wildlife Refuge, Cochise County, Arizona. The 25,000-acre (10,117-ha) approved acquisition boundary was crucial in providing the Service opportunities to pursue habitat protection and conservation on a watershed-based landscape scale that included purchase of 2,765-acres (1,119-ha) through fee title, purchase of 20,471-acres (8,284-ha) of conservation easements, and establish a 24,585-acre (9,949-ha) Safe Harbor Agreement.

might prevent his desired use of the land for ranching. The potential for such restriction was unlikely (Malcom and Li 2015).

Recognizing the conservation values associated with both the 99-Bar Ranch and the Bar-Boot Ranch, the Service contacted the landowners to identify and discuss potential protection strategies for the properties. These conversations were particularly timely and critical because portions of one of the ranches were undergoing a sale at the time and included the risk of possible development by any new landowner. The Malpai Borderlands Group, a local coalition of conservation-minded ranchers having a global reputation for collaborative conservation, stated their support for protecting the ranches using conservation easements if the concept was agreeable to the current landowners or if a conservation-minded buyer could be identified. The Service had already developed a positive trust relationship with the Malpai Borderlands Group, and the group's support for the proposed Refuge acquisition boundary positively influenced local opinion and public acceptance of Service involvement.

The 99-Bar Ranch is located immediately upstream from LCNWR and lies between the Swisshelm Mountains and Pedregosa Mountains at an elevation ranging from about 4,650 – 5,600 ft (1,417-1,707 m). The ranch consists of 11,585ac (4,688 ha), including 7,345 ac (2,972 ha) of deeded lands and 4,240 ac (1,716 ha) of State lease lands. The property is dedicated to livestock production, and it has historically run a 400 head cow herd on State lease and deeded lands. The ranch also has an annual 400 animal unit grazing allotment (for a six-month period) on its USDA Forest Service permit.

Negotiations with the owner of the 99-Bar Ranch to purchase a conservation easement on the property continued for several years. It stalled repeatedly primarily due to the landowner's frustration with the process and his unwillingness to completely trust the federal government. Following the terrorist attacks against the United States on September 11, 2001, the landowner more vigorously pursued the sale of a conservation easement, fearing the country might soon be at war with terrorists and anticipating federal land acquisition funding might quickly become unavailable.
The 99-Bar Ranch Conservation Easement (Tract 22C) was therefore purchased September 26, 2001, with the purpose of assuring the ranch, located immediately upstream and adjacent to LCNWR, would be retained in its current condition to provide for a diversity of wildlife habitat, maintenance, and enhancement of watershed health, education, livestock grazing, and limited residential uses. The conservation easement encumbers about 7,031 ac (2,845 ha) of the deeded lands on the ranch (which excluded some existing developed lands), of which 6,952 ac (2,813 ha) have a non-development restriction. Service funding was available for acquisition of the conservation easement only because the ranch was within the approved LCNWR acquisition boundary (Rawoot 2017).

Following the Service's purchase of the conservation easement on the 99-Bar Ranch, the owners of the adjacent upstream Bar-Boot Ranch observed and evaluated the negotiation and subsequent interactions between the Service and the 99-Bar Ranch landowner and contacted Refuge staff during 2002 to inquire about the possibility of entering into a conservation easement purchase agreement regarding their Bar-Boot Ranch. The Bar-Boot Ranch is located in a high valley lying between the 7,140 ft (2,176 m) elevation Swisshelm Mountains to the west and a southern portion of the 9,854 ft (3,003 m) elevation Chiricahua Mountains to the east. It is located about 15 mi (24 km) upstream from LCNWR, and adjoins portions of the Coronado National Forest on the east, and the 99-Bar Ranch on the south.

The Ranch consists of about 25,940 ac (10,498 ha), originally including about 13,713 ac (5,550 ha) of deeded lands, 640 ac (259 ha) of State Grazing Allotment, 424 ac (172 ha) of Bureau of Land Management grazing allotment, and 11,163 ac (4,518 ha) of U.S. Forest Service grazing allotment. The property is dedicated to livestock production, grassland and wetland habitat restoration, research, and associated activities. The ranch can support up to about 825 cattle on an annual basis.

The Bar-Boot Ranch was owned by conservation-minded philanthropists, whose efforts at ecosystem restoration utilizing headwater erosion control are well known in the Southwest and recognized by many regional conservationists. The ranch is dedicated to maintaining a variety of conservation values of substantial importance to the ranch owners and to the Service. Over several years, the owners have restored this ranch and other properties in the region and made improvements to the watershed and rangelands, both to enhance livestock production and ecosystem health.
Land appraisals for the Bar-Boot Ranch were completed during 2004, and the Bar-Boot Ranch conservation easement, totaling about 14,000 ac (5,666 ha), was ultimately purchased in increments (Tracts 24C and 24C 1-8) as federal funding became available, with acquisition of the final tract occurring during 2011.

Both conservation easements help ensure survival of native fish and wildlife on a landscape scale while providing for normal livestock ranching operations and watershed restoration activities to continue on the ranches. The easements limit division, subdivision, and surface development on the ranches' private fee land in perpetuity while encouraging their traditional ranching and watershed restoration activities to continue. By limiting subdivision and surface development in the upstream reaches of the Leslie Creek watershed, the easements help assure continuation of the water supplies historically available to sustain native fish, wildlife, and plants, including federally-listed threatened and endangered species, found downstream on LCNWR.

Through these two conservation easements, the landowners and the Service agreed to prevent any use of the properties that would significantly impair or interfere with conservation values, and to confine use of the properties to activities consistent with the purpose of the easements. The Service was also granted certain rights, including limited rights to enter upon the ranches each year to monitor compliance with and otherwise enforce the terms of the easements, to prevent any activity or use on the properties that is inconsistent with the purposes of the easements, and to require the restoration of such areas or features of the property that may be damaged by any activity or use which are contrary to the purposes of the easements. While both easements essentially prevented housing development, and protected endangered fish by protecting the ecological integrity of the watershed immediately upstream from LCNWR, they also specifically identified some reserved rights and listed several prohibited uses which are itemized in the deeds. Reserved rights included the right to: carry on ranching, educational, and ecotourism operations on the entire properties; maintain, repair, and construct the agricultural improvements necessary to facilitate livestock grazing operations; continue all manner of identified residential use and enjoyment of the building and grounds within the existing residential zones and within the identified future development zones; expand existing buildings and to construct additional residences within the existing residential zones; construct, maintain, or replace a residence, guesthouse, associated outbuildings, and individual domestic wells within future development zones; engage in recreational uses, such as hunting, that will not negatively impact conservation values; engage in wood-cutting; and other rights.

Prohibited uses included: construction or placing of buildings, permanent camping accommodations, mobile homes, or billboards, except those identified as reserved rights; expanding irrigated pasture; developing commercial enterprises inconsistent with protection of the property's conservation values; altering the ground surface or natural vegetation; dumping environmental contaminants or hazardous waste; introducing invasive non-native species; pumping groundwater for other than on-site residential and agricultural use associated with livestock grazing on the properties; storing and using biocides and chemical fertilizers other than those identified as reserved rights; and utilizing off-road vehicular travel except as reasonably necessary to facilitate ranch operations.

Both ranches are dedicated to livestock production, yet they also inherently support a variety of substantial conservation values. These values include maintaining a healthy watershed characterized by productive bottomland giant sacaton (*Sporobolus Wrightii*) grassland which supports numerous breeding and wintering grassland-dependent birds; maintaining existing riparian vegetation composed of important ash-willow-cottonwood habitats along the southwestern end of Leslie Creek supporting numerous neotropical migratory birds; maintaining free-flowing water at the southwestern end of Leslie Creek which provides habitat for breeding Chiricahua leopard frogs and endemic invertebrates; and maintaining classic Chihuahuan Desert upland slopes of various aspects which support many plant and animal species. The landscape protected by conservation easements supports a large number of mammal species, and recent jaguar (*Panthera onca*) photographs have been captured by remote trail cameras in this geographic area. The portion of Leslie Creek on LCNWR located below the historic rock dam constructed by the Civilian Conservation Corps is largely supported by the watershed on these two ranches and provides perennial aquatic habitat for breeding Mexican longfin dace, Yaqui topminnow, and Yaqui chub.

SAFE HARBOR AGREEMENT

Because many threatened and endangered species occur primarily or exclusively on private land, it is often critical to involve private landowners in conservation and recovery efforts. Many landowners want to help conserve these species on their property, but are concerned about potential land use restrictions they perceive could occur if listed species begin to colonize or expand their numbers as a result of conservation efforts. Due to these concerns, some landowners may limit land and water management practices that would otherwise enhance and maintain habitat for listed species. To address these kinds of concerns and to provide landowners with both management flexibility and regulatory certainty, the Service developed the "Safe Harbor Agreement Program." A Safe Harbor Agreement (SHA) is a voluntary agreement involving private or other non-federal property owners whose actions contribute to the recovery of a species listed as threatened or endangered under the ESA through a net conservation benefit to the covered species. The agreement is between the Service and cooperating non-federal property owners. The regulatory basis for the agreement is codified in the Service's Safe Harbor Agreement final policy (64 FR 32717), final regulations (64 FR 32706), and amendments (69 FR 24084) and implements the intent of the parties to follow the procedural and substantive requirements of section 10(a)(1)(A) of the ESA.

The Service first establishes a "baseline" status for the species on the private property, and then identifies the conservation benefits undertaken by the landowner that will contribute to the recovery of the listed species on non-federal lands. Examples of conservation benefits might include reducing habitat fragmentation; maintaining or restoring existing habitats; increasing the connectivity of otherwise isolated habitats; creating buffers for protected areas; stabilizing or increasing the number or distribution of listed species; and developing or testing new habitat management techniques. The specific conservation measures identified in the Leslie Creek SHA identified the goals of maintaining the integrity of the Leslie Creek Watershed, expanding the geographical distribution of the covered species, and preserving or enhancing the genetic diversity of the covered species (USFWS 2008b). In return for the conservation benefits accomplished by the landowner, the Service issues an "enhancement of survival" permit that provides formal assurances that the Service will not require severe restrictions to current land use and management practices, or require any additional management actions by the landowner without their consent. The enhancement of survival permit allows incidental take of threatened and endangered species that could result from actions taken by the landowner, and allows habitat modifications by the landowner intended to return the property to conditions agreed upon as baseline. Additionally, when the agreement's term ends, the participating landowner may use the property in any otherwise legal manner that ensures that it stays at or above the baseline conditions initially established at the beginning of the agreement. The enhancement of survival permit covers ongoing land use activities, watershed improvement activities, and species related management and monitoring activities.

The Leslie Canyon Watershed Safe Harbor Agreement (Agreement), initiated by Service staff in 2004, was completed and approved during September 2008. Participants of the Agreement include the Service and owners of the 99-Bar Ranch and the Bar-Boot Ranch, and the Agreement encompasses about 24,585 acres (9,949 ha) upstream from LCNWR within the approved Refuge acquisition boundary. Land ownership within the area covered by the Agreement is approximately 15% State Trust Land and about 85% privately held land. A small area of less than 1% consists of small parcels of Federally-owned land administered by the Bureau of Land Management (BLM) and these parcels are not covered by the Agreement (USFWS 2008b). The purpose of the Agreement is to implement recovery activities for six federally-listed species: the federally-listed threatened Chiricahua leopard frog; endangered Yaqui chub; endangered Yaqui topminnow; threatened Yaqui catfish; threatened beautiful shiner; and endangered Huachuca water umbel (*Lilaeopsis schaffneriana* var. *recurva*). The SHA further ensures the continued existence of these species in the Leslie Canyon watershed and provides incentives and assurances to the private landowners during the 50-year duration of the Agreement and associated section 10(a)(1)(A) enhancement of survival permit.

Maintenance of the watershed and connectivity among all the elevations present on the landscape are crucial to the goal of protecting the wetland habitats covered by the Agreement (Halofsky et al. 2018; Taylor et al. 2005). Watershed integrity is maintained through the implementation of various watershed improvement projects, including erosion control activities, restoration of grassland and wetland habitats, and other riparian and hydrologic improvements. An expanded geographic range helps species recovery by increasing the total number of individuals of each covered species

and helps prevent the loss of populations through localized disturbances such as drought, fire, flood, or disease (Beissinger and McCullough 2002). The expanded range also reduces the risk of extinction because species are spread over a larger geographic area, therefore making the overall population less susceptible to risks. Conservation measures help provide for the natural expansion of covered species into habitats in the upper watershed, and have allowed for the introduction of Yaqui chub, Yaqui topminnow, beautiful shiner, and Chiricahua leopard frogs into previously unoccupied habitat on the private properties. Yaqui catfish and Huachuca water umbel have not been introduced onto private lands because suitable habitats do not currently exist for these species within the covered area. Additionally, the introduction of Chiricahua leopard frogs has been complicated by the presence of American bullfrogs, (*Lithobates catesbeiana*), an invasive species and predator to leopard frogs at some otherwise suitable wetland sites in the covered area. Maintenance of genetic diversity is important to preventing the potential for biological compromises (deformities, loss of resistance to pathogens) that can occur through inbreeding (Hedrick and Kalinowski 2000; Leberg and Vrijenhoek 1994; Thornhill 1993). The goal of preserving or enhancing genetic diversity is accomplished through regular population supplementation of Yaqui chub, Yaqui topminnow, and beautiful shiner within the covered area.

The owners of both properties were excellent conservation partners, and they worked together with Refuge staff for several years prior to establishment of the Agreement to coordinate erosion control projects, brush control, groundwater monitoring, and fish and wildlife monitoring on the ranches. Additionally, as described above, the Service had previously established conservation easements on both ranch properties, and with the Agreement in effect, cooperation increased the recovery of native plants, fish, and wildlife. Project activities have included enhanced livestock management (stock tank maintenance), vegetation treatments (using prescribed fire to maintain native grasslands, and using herbicide treatment to control juniper invasion of grasslands), control of invasive wildlife species (American bullfrog removal), enhancing corridors and wildlife movement (replacing existing fences with “wildlife-friendly” fencing), and biological monitoring of groundwater levels and fish and wildlife populations. Annual reporting of management activities, removal of invasive species, and reintroduction of covered species is accomplished through the Refuge’s annual narrative report.

WATER MONITORING

The earliest and most profound effects of a changing climate are expected for water resources, and such changes are expected to reduce fish habitat and negatively affect riparian vegetation and wildlife (Halofsky et al. 2018). Leslie Canyon NWR relies on surface water and ground water to sustain the riparian habitat which supports populations of federally-listed endangered plants, fish, amphibians, and birds, among other species. Ensuring that the Service had in-stream flow water rights on Leslie Creek was deemed essential for the survival and recovery of native fish and critical for the conservation of wetland habitats on the Refuge. Leslie Creek is a flashy, desert fluvial system. Though thunderstorms can create very large flow events, the base flow of the stream is very low. The native fish and surrounding ecosystem rely on the base flow for survival. To guard against anthropogenic depletion of this flow, in 1993 the Service applied for in-stream flow water rights, which received no opposition during the public review and comment period, and were granted by Arizona Department of Water Resources (ADWR). These numbers (Table 1) were derived from a statistical analysis of the mean daily discharge record from a U.S. Geological Survey (USGS) gauge located on Leslie Creek near the upstream end of LCNWR adjacent to the Lewis Monument. This gauge has been operational from 1970-1977 and from 1982-present. A mean of the median monthly daily flow was used to derive the base flow requirements of the Refuge.

Understanding the relationship between stream discharges in Leslie Canyon and groundwater levels within and adjacent to the Refuge is crucial to managing this important habitat. To help determine and document this relationship, groundwater level monitoring has been conducted on the Refuge since 1998, and on the adjacent private lands since 2002, and pressure transducers maintained throughout the watershed provide data to compare to discharge records from the USGS stream gauge on LCNWR. This comparison provides insights into the relationship between surface water and groundwater.

In general, stream flows resulting from precipitation events measured at the USGS gauge in Leslie Canyon, cannot be correlated to predictable responses at individual wells within the Leslie Creek watershed (USFWS 2008a). In addition,

it appears that large-scale local precipitation events that recharge ground water only in the northern section of the watershed show a muted and delayed response in the lower basin near and within the Refuge, whereas precipitation

Table 1. Monthly In-Stream Flow Water Right (33-96176) for Leslie Creek at Leslie Canyon National Wildlife Refuge. Discharge in cubic feet per second (cfs) and acre feet per month. This water right is essential for the survival and recovery of native fish on the refuge.

	Discharge	
Month	**(cfs)**	**(ac ft/month)**
January	0.62	38.3
February	0.54	33.0
March	0.53	32.6
April	0.52	32.2
May	0.45	27.5
June	0.35	21.8
July	0.34	21.0
August	0.59	36.4
September	0.63	38.7
October	0.74	45.3
November	0.81	49.9
December	0.70	43.3

acre feet/year = 419.90

events that are local to the southern section of the watershed show a quicker response in ground water levels within and near the Refuge. Furthermore, it appears that high magnitude floods of brief duration in the southern watershed result in changes to ground water levels that are small in scale and quickly recede (USFWS 2008a).

Data analysis has suggested that, during times when ground-water levels are less than 10 ft below land surface, the USGS gauge accurately measures ground-water discharge to Leslie Creek during times of no precipitation. However, during times when ground-water levels are greater than 10 ft below land surface, the USGS gauge acts to measure surface water flows from precipitation events that may originate in any portion of the watershed that are of a large enough magnitude to cause flowing water to reach the location of the gauge (USFWS 2008a). The data show that LCNWR does not experience flows through Leslie Canyon that meet the Refuge's State of Arizona Permitted Water Right on a regular basis. Because actual flows are generally less than those permitted to the Refuge, it is important that no new water permits be granted in the watershed that could further deplete the already limited water resources.

WATER RIGHTS

In an effort to learn more about the groundwater conditions and trends within the Leslie Creek watershed, a monitoring well was installed in 1997 at the upstream end of LCNWR. Equipment in this well has allowed constant monitoring and recording of shallow groundwater levels at the site since January 1998. The data (Table 2) provides additional information concerning groundwater and surface water relationships in the watershed, and has increased an understanding of the hydrology of Leslie Creek. Existing data shows tremendous fluctuation of groundwater levels between years, with late 2006 and early 2007 showing a tremendous upsurge in the groundwater level, during which marshland conditions existed at the upstream end of Leslie Canyon. All of 2010, 2011, and 2012 showed dangerously low groundwater levels, threatening the maintenance of riparian vegetation and aquatic habitat. Ground water levels at Leslie Canyon during all of 2012 were the lowest ever recorded, and Leslie Creek did not flow during that year. Fish, frogs, and tadpoles were salvaged and relocated to other wetlands as Leslie Creek became dry, and hundreds of velvet ash (*Fraxinus velutina*), Arizona walnut (*Juglans major*), and Goodding's willow (*Salix gooddingii*) died during this time period after already declining from several years of extended drought. Since 2013, the groundwater level has generally continued to rise

again, but still experiences periodic severe fluctuations, and is influenced primarily by the volume of winter precipitation received in the watershed and by massive precipitation events occurring in the upper watershed during summer months.

Table 2. Leslie Canyon National Wildlife Refuge Groundwater Levels (in feet) 1998-2017. Measured from Top of Casing at Upstream Monitoring Well (ND = no data). Monitoring is Essential in Documenting Hydrologic Trends, Defending In-Stream Flow Water Rights, and Providing Early Warning of Forthcoming Drought Conditions.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						cfs						
1998	7.44	7.25	7.02	ND	7.75	ND	8.92	ND	ND	8.49	8.44	8.37
1999	8.68	9.28	9.71	10.10	10.60	11.4	ND	7.90	8.12	7.35	6.48	5.99
2000	5.74	5.60	5.31	5.44	5.96	6.78	7.00	7.74	8.25	5.90	5.29	4.89
2001	4.48	4.40	4.29	4.31	4.55	4.97	5.11	5.52	5.91	6.12	6.21	6.37
2002	6.85	7.33	7.93	8.74	9.46	10.26	11.32	9.40	9.69	9.19	8.30	7.64
2003	6.95	6.68	6.66	6.93	7.96	9.08	9.86	10.04	10.70	11.08	10.76	10.23
2004	9.72	9.52	9.60	9.90	10.73	11.90	12.82	12.96	14.36	15.44	15.55	15.61
2005	15.03	14.27	14.12	14.26	14.59	15.11	16.69	13.10	10.58	4.91	4.26	4.45
2006	5.25	6.04	7.07	8.12	9.60	10.76	12.83	10.43	4.32	2.90	2.78	2.85
2007	3.11	3.45	3.41	4.08	4.65	5.28	6.54	6.78	7.15	8.17	8.43	8.65
2008	9.42	10.01	10.57	11.01	11.78	12.59	11.75	11.08	6.87	5.19	5.10	5.35
2009	5.66	5.90	6.18	6.65	7.75	9.40	10.37	11.80	13.19	14.10	14.62	15.27
2010	15.94	16.12	16.66	16.75	17.17	17.50	17.77	16.37	17.21	17.91	18.09	17.94
2011	17.47	17.14	17.16	17.02	17.50	17.97	18.25	18.66	19.01	Dry	Dry	Dry
2012	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
2013	ND	14.08	ND	14.07	14.46	14.70	14.93	14.40	13.37	12.76	12.02	11.74
2014	11.08	10.85	10.70	10.58	10.44	10.43	10.32	10.28	10.19	9.83	9.46	9.31
2015	9.13	8.94	8.82	8.74	8.67	8.59	5.57	5.51	8.50	8.48	8.48	8.45
2016	8.53	8.57	8.62	8.67	8.77	8.88	9.02	9.20	9.40	9.66	9.99	10.28
2017	10.63	10.93	11.17	11.40	11.60	11.92	12.13	1.17	2.44	2.87	3.15	3.36

continued to rise again, but still experiences periodic severe fluctuations, and is influenced primarily by the volume of winter precipitation received in the watershed and by massive precipitation events occurring in the upper watershed during summer months.

In addition to the single monitoring well located at the upstream end of LCNWR, pressure transducers were installed in various upstream monitoring wells throughout the watershed on private land during March 2002 and at four monitoring wells along the east Refuge boundary during 2005. Some of the pressure transducers have since been removed from the wells for a variety of reasons, and currently four wells are continuously monitored in the Leslie Creek watershed (Bar-Boot Ranch, LCNWR Upstream, LCNWR Middle, and LCNWR South Well). This long-term well monitoring effort provides important information that helps document groundwater level trends throughout the watershed that supports the perennial portion of Leslie Creek on the Refuge. The well and provides useful early warnings to forthcoming drought conditions. Such warnings allow more timely Service management actions, including fish and tadpole salvage, in anticipation of a pending loss of aquatic habitat.

WATER RIGHT PROTEST AND RESOLUTION

During June 2008 the Service received a Public Notice Summary Notification from ADWR identifying three separate applications filed by the 99-Bar Ranch Ltd. Partnership to appropriate public water (Nos. 33-96794, 33-96795, and 33-

96796) and acquire a total of 465.77 ac-ft of water per year, with a storage capacity of 58.1 ac-ft to irrigate 200 ac (81 ha). Refuge staff had been notified by owners of the ranch nearly two years earlier that they would be applying for asurface water right, which they felt was necessary to support habitat restoration work they were planning on their ranch. The landowners proposed to build earthen berms across badly incised portions of the upper Leslie Creek flood plain to prevent further erosion and force floodwaters to spread out across the flood plain to "irrigate" giant sacaton grassland, as it did historically. As described above, Service staff had been working for several years to investigate the hydrology of the Leslie Creek watershed, and a large amount of information had been collected to identify ground water and surface water relationships in the watershed and to analyze the implications of additional water rights in the basin. This long-term monitoring information became extremely useful in assessing the potential threat of the 99-Bar Ranch water right applications in regard to Refuge objectives for recovering federally-listed threatened and endangered species. Because surface flows in Leslie Creek are generally less that those permitted to the Refuge, it is crucial that any new water permits granted in the watershed do not increase depletion of existing water resources, and cause further injury to endangered fish populations. Therefore, the Service filed a protest to ADWR regarding the 99-Bar Ranch application based on concerns that there was not enough water in the system to support the Refuge water right in addition to the new water right applied for by the 99-Bar Ranch. Increased communication between the parties, facilitated by Refuge staff, helped generate a better understanding of the limited hydrologic resources within the watershed supporting the ranches, and promoted resolution and a greater interest in landscape restoration projects.

Ultimately, following a thorough review of the data collected and published by the USGS regarding daily flow conditions for the Leslie Creek watershed, the Service determined that the total volume of water use requested could impair the United States Permit to appropriate public water for LCNWR. The total annual volumes of water that have been measured at the USGS gauge (#09537200) on the Refuge between 1996 and 2007 showed extremely low values, and it was clear that proposed water diversions by the 99-Bar Ranch in the amounts being requested would exceed the amount of water that has been available in the Leslie Creek watershed in seven of the preceding 12 years. A December 2008 letter from the Service to the ranch owners outlined these concerns and identified a proposed resolution. Based on this analysis, the Service contended that diversions by the 99-Bar Ranch should be limited only to those times when the quantity of water in Leslie Creek was in excess of the Service's water right, in accordance with the doctrine of prior appropriation.

Essentially, 99-Bar Ranch could only divert water during times when the USGS Leslie Creek gauge denoted daily flow values that meet (or exceed) the Refuge's existing water right. Furthermore, the Service recommended that the 99-Bar Ranch water right applications should be adjusted from a request of 465.77 ac-ft to 80 ac-ft per annum, with total storage of 10.8 acre-feet. Once this modification was accepted by the 99-Bar Ranch owners, the Service officially withdrew its protest with ADWR and the permits were modified in accordance with a settlement agreement between the Service and the 99-Bar Ranch Ltd. Partnership. The water right agreement between the Service and the 99-Bar Ranch provided continuing opportunities to enhance wetland habitat on private lands and to manage and protect federally-listed threatened and endangered species throughout the entire watershed rather than the focus being limited to just the Refuge. It provided the impetus for the Service and the landowner to demonstrate and engage in active collaborative conservation efforts previously articulated only in planning documents.

As described above, the Leslie Creek Watershed SHA between the Service and both the 99-Bar Ranch and Bar-Boot Ranch had been approved in September 2008, and the Agreement now provided opportunities to introduce populations of threatened and endangered species into wetlands on private land without any associated ESA risks to the landowners. Habitat work on the 99-Bar Ranch could be used to prevent upland erosion, and could provide additional wetlands for Chiricahua leopard frogs and Yaqui fish species. Both landowners remained interested in such reintroduction efforts, and understood how the conservation easements, multi-species SHA, and habitat restoration work throughout the landscape could benefit their individual ranch properties and livestock operations. Mosquito control by topminnows was of particular interest to the owner of the 99-Bar Ranch, as the threat of West Nile virus spreading from mosquito bites had recently reached Cochise County.

CONSERVATION FUNDING OPPORTUNITIES

The strength of existing partnerships between the Service and private landowners in the Leslie Creek Watershed has helped identify, justify, and enhance opportunities for conservation partners to fund and complete on-the-ground conservation on private lands. The first collaborative funding opportunity within the Leslie Creek Watershed included a 2001 Partners for Fish and Wildlife Project involving $25,000 of cost-shared work ($13,000 Service funding and $12,000 private funding) on the 99-Bar Ranch to enhance grasslands and associated wetland areas. Habitat restoration work involved the repair of old water diversion structures, which help spread water during flood flows, rebuilding dikes, and restoring water holding depressions which act as silt traps. These structures were originally built during the 1940s, but the dikes and holding ponds had eroded and water was no longer infiltrating into the ground as designed. Such infiltration is the key to perennial water flow on the Refuge which is dependent upon the shallow groundwater to supply stream flow in Leslie Creek.

During 2006, a $30,000 Challenge Cost Share Agreement (50:50 match) between the Service and the Bar-Boot Ranch was funded to accomplish watershed restoration activities also focused on repairing and constructing earthen water diversion structures on the property which helped stabilize and restore habitat conditions throughout the larger watershed. Some funding programs are designed specifically to assist species recovery on private lands that influence adjacent national wildlife refuges and federally-listed species. One such federal program is the Service's Cooperative Recovery Initiative (CRI), and during 2014 the Service funded the $330,525 "Cooperative Recovery Initiative Project Associated with Recovery of Federally-listed Species in Southeastern Arizona." This project included $120,000 targeted for habitat conservation projects on the Bar-Boot Ranch, and the landowner contributed additional private funds to help complete projects.

Overall conservation outcomes for this CRI project included improved watershed function that expanded secure habitats for Rio Yaqui fishes and other native aquatic and terrestrial species. Benefits to listed aquatic species included additional, larger, and more secure populations that will prevent extinction and increase recovery potential. Invasive brush control in upland habitat assisted with native grassland restoration throughout the area, and benefitted populations of all grassland dependent species in the watershed by: promoting grasslands and the environmental conditions that existed prior to invasion by mesquite and juniper; helping limit the elevated perches used by predatory species (e.g. ravens) that limit nesting success of grassland birds; encouraging an ecosystem dominated by native grasslands and the associated invertebrate species utilized as food by migratory and resident birds; and by promoting a more natural low flame length fire regime which benefits about 70 grass species utilized by migratory birds and other wildlife in this area. In addition, this landscape-scale watershed enhancement project benefitted all wetland dependent species within the action area by: increasing the availability of seasonal and permanent water; by providing sanctuary areas during drought periods by increasing the overall quality and quantity of groundwater; and by lessening the potential for erosive scouring of flood plain grasslands during extreme runoff events.

CONCLUSIONS

The variety of strategies used to help promote collaborative conservation in the Leslie Creek Watershed have been successful. They are protecting the watershed to ensure adequate flows for Leslie Creek; preserving the natural diversity and abundance of fauna and flora and securing self-sustaining populations; promoting the preservation, restoration, enhancement, and recovery of federally-listed threatened and endangered species; perpetuating the migratory bird resource; and are preserving important cultural resources.

The conservation strategies have helped prevent landscape fragmentation and the drainage and desiccation of wetlands. They and have also protected fish and wildlife habitat from potentially detrimental human disturbances such as concentrated housing and agricultural development, mineral exploration, introduction of non-native species, harmful water diversion, topsoil erosion, grassland deterioration and shrub expansion, and have helped buffer the impacts of a warming climate by maintaining an unobstructed transition of important ecosystem components across a gradient of elevations.

All of this was accomplished through purposeful strategies conducted by willing participants, and these strategies interacted with, and in many ways relied upon, one another for success. Inventory and monitoring of fish, wildlife, and plant populations helped identify an ecologically important landscape. Conservation strategies for protecting that landscape included establishing an appropriately sized acquisition boundary within which multiple options for conservation could be achieved, including purchasing of conservation easements and fee-title Refuge lands. Conservation easements were negotiated and finalized to limit subdivision and surface development on the private property in perpetuity while encouraging traditional ranching and watershed restoration activities to continue. The easements restrict uses that would potentially harm the property's value as fish and wildlife habitat, or potentially impact the downstream Refuge in negative ways. These easements support landscape-scale conservation outcomes, in part, because those engaged in establishing them are prioritizing resources and values with landscape-scale significance (Rawoot 2017). Long-term groundwater monitoring and data analyses provided information that enhanced decision making in perfecting, establishing, and defending water rights to protect conditions necessary to support federally-listed species. A Safe Harbor Agreement further ensures the continued existence of these species in the Leslie Canyon watershed and provides landowner incentives and assurances throughout the duration of the Agreement.
Viewing the region more as a single large landscape rather than as individual parcels within the watershed has helped participants identify, justify, and enhance opportunities to fund and complete on-the-ground conservation within that landscape. Promoting landscape-scale projects that enhance the private ranches and the Refuge provides habitats for a multitude of species and has helped allow the continuance of a working landscape, which is important in this rural setting. Monitoring continues to support informed decision making and compiling, and interpreting historical and current hydrologic data provides recognition of trends and improves the predictability of future conditions upon which managers must be able to favorably respond.

The effectiveness and expense of working on conservation projects in isolation from one another can be prohibitive. All the partners invested in the Leslie Creek watershed are in a better position as a result of their combined accomplishments, and fewer objectives could have been achieved without individuals choosing to work together. The present loss of some active partners can hopefully be remedied through the progressive establishment of additional trust relationships. Many of the conservation strategies implemented here have potential applications to additional settings, and can be integrated by others into regional conservation planning efforts within landscapes that may be similarly situated.

Despite many years of collaborative partnerships, there are risks to long-term conservation inherent to the innovative activities occurring in the Leslie Creek watershed, and some of these threats have already been realized. For example, while the perpetual conservation easements originated with willing landowners, conditions surrounding land ownership, personal interest, and financial security can change conservation partnerships and management cooperation. The 99-Bar Ranch sold during 2014 and the new owners do not appear to be actively interested in landscape-scale conservation. They did not sign into the existing Safe Harbor Agreement, and are not currently engaged with the Service in cooperative conservation projects. Ownership of the Bar-Boot Ranch was impacted during 2016 by personal relationship difficulties between the joint owners, and the ramifications of splitting their interests also potentially jeopardizes the continuation of landscape-level conservation activities due to changes in financial obligations and other reasons.

Finally, even with the innovative actions taken to plan and proactively manage for threats to climate resiliency and implement solutions intended to minimize the anticipated negative effects of a warming climate, continued drought and average temperature increases are impacting the overall water balance, fire regime, and function of the Leslie Creek watershed. These accelerating threats may exceed plans or actions undertaken by the Service or by private landowners. As a result, habitat is being altered beyond the ability of some fish, wildlife, and plants to respond or adapt rapidly enough to survive in the short-term. The reintroductions of some species have not endured lasting success because wetlands are no longer supported by the changing climatic conditions. Active, long-term, management is required to maintain habitats and populations of fish and wildlife that are constantly at risk from accelerated drought, fire effects, and invasive species. The resiliency of the habitats that support unique species is in danger of being altered beyond repair.

Next steps by the Service to help protect and conserve the watershed include continuing to develop strategies to protect threatened and endangered species during prolonged drought periods, and working with private landowners to

encourage the continuity of landscape scale conservation activities within the basin (USFWS 2013). Additionally, it remains crucial for the Service to continue working with the BLM to withdraw the mineral interests on LCNWR fee title lands to preclude any future filing of claims on the mineral estate currently under the administration of that agency.

These cooperative efforts between the Service and environmentally sensitive landowners have provided tremendous opportunities to secure crucial upland and wetland habitats, introduce and maintain self-sustaining fish and wildlife populations, and coordinate the completion of land restoration activities across a greater landscape. Slowly, through these efforts, the land and its associated fish and wildlife are recovering from historic exploitation and inattention.

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A Shared Conservation Approach Built by an Engaged Partnership

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The Transboundary Madrean Watersheds initiative seeks to build collaboration with U.S. and Mexican institutions and stakeholders, and engage partners to work across boundaries on restoration, conservation, stewardship, education and public outreach. The effort seeks to align partners' work to achieve maximum benefits, and capacity to continue work into the future. In order to make regional monitoring and scientific research relevant to managers and decision makers, we seek to better coordinate and to ensure this work is driven by partners' input and needs. This presentation will provide an overview of the shared conservation approach across watersheds in both the current design phase as well as options for ongoing collaboration in the Madrean region as we move forward.

Un enfoque de conservación compartido creado por una asociación comprometida

La iniciativa Transfronterizas de Cuencas Hidrográficas Madrenses busca establecer una colaboración con instituciones y partes interesadas estadounidenses y mexicanas, e involucrar a los socios para que trabajen a través de los límites de restauración, conservación, administración, educación y alcance público. El esfuerzo busca alinear el trabajo de los socios para lograr los máximos beneficios y la capacidad de continuar trabajando en el futuro. En un esfuerzo por hacer que el monitoreo regional y la investigación científica sean relevantes para los gerentes y los responsables de la toma de decisiones, buscamos una mejor coordinación y asegurarnos de que este trabajo sea impulsado por los aportes y las necesidades de los socios. Esta presentación proporcionará una visión general del enfoque de conservación compartido en las cuencas hidrográficas tanto en la fase de diseño actual como en las opciones para la colaboración continua en la región de Madrense a medida que avancemos.

NOTE: A manuscript was not submitted to accompany this presentation.

Developing Indicators and Analysis Methods for Ecosystem Integrity, Connectivity and Biodiversity for Transboundary Madrean Watersheds Landscape Conservation Design

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Landscape Conservation Design combines geospatial data, biological information, models, and expert input to develop a

spatial plan (i.e. conservation blueprint) that will provide for the enduring conservation of biodiversity, habitats, environmental processes and services within the landscape. This type of planning can inform where conservation, and restoration actions may best contribute to maintaining key ecological and social values and functions of the landscape. Over the past several years we worked to develop and analyze these components for select watersheds within the Transboundary Madrean Watersheds area. We will present methods used to select landscape-scale environmental indicators, identify landscape priorities for wildlife movement, and explore spatial data to represent areas of higher biodiversity and species of conservation concern within selected Transboundary Madrean watersheds and sub-watersheds. We will review our research development of these indicators over the last year. We review our selection of select cross-boundary watersheds, analysis unit considerations, and initial testing of these indicators through spatial analysis. Landscape connectivity is key component of our planning and analysis, and conservation of connectivity is crucial climate change adaptation strategy for biodiversity conservation. We will present our approach for defining wildlife habitat "cores" for Madrean forests ("sky islands") and grasslands in connectivity planning as well as our methodology for synthesizing existing connectivity models and adding new core to core connections with a focus on fragmented and high value landscapes. Finally, we introduce plans to encompass spatial biotic and abiotic facet analysis for biodiversity conservation into our Transboundary Madrean Watersheds Conservation Design.

Desarrollo de indicadores y métodos de análisis para la integridad de los ecosistemas, la conectividad y la biodiversidad para las cuencas hidrográficas transfronterizas Diseño de conservación del paisaje

Landscape Conservation Design combina datos geoespaciales, información biológica, modelos y aportaciones de expertos para desarrollar un plan espacial (es decir, un plan de conservación) que proporcionará la conservación duradera de la biodiversidad, hábitats, procesos ambientales y servicios dentro del paisaje. Este tipo de planificación puede informar dónde las acciones de conservación y restauración pueden contribuir mejor a mantener los valores ecológicos y sociales clave y las funciones del paisaje. En los últimos años, trabajamos para desarrollar y analizar estos componentes para cuencas hidrográficas selectas dentro del área de cuencas hidrográficas madre transfronterizas. Presentaremos los métodos utilizados para seleccionar indicadores ambientales a escala de paisaje, identificaremos prioridades de paisaje para el movimiento de vida silvestre y exploraremos datos espaciales para representar áreas de mayor biodiversidad y especies de preocupación de conservación dentro de cuencas hidrográficas y subcuencas hidrográficas transfronterizas seleccionadas. Revisaremos nuestro desarrollo de investigación de estos indicadores durante el último año. Revisamos nuestra selección de determinadas cuencas hidrográficas transfronterizas, consideraciones de unidades de análisis y pruebas iniciales de estos indicadores a través del análisis espacial. La conectividad paisajística es un componente clave de nuestra planificación y análisis, y la conservación de la conectividad es una estrategia crucial de adaptación al cambio climático para la conservación de la biodiversidad. Presentaremos nuestro enfoque para definir "núcleos" de hábitats silvestres para bosques maduros ("islas serranas") y pastizales en la planificación de conectividad, así como nuestra metodología para sintetizar modelos de conectividad existentes y agregar nuevas conexiones núcleo a núcleo con un enfoque fragmentado y alto paisajes de valor. Finalmente, presentamos planes para incluir el análisis facetario biótico espacial y abiótico para la conservación de la biodiversidad en nuestro Diseño de Conservación de Cuencas Madrenses Transfronterizas.

NOTE: A manuscript was not submitted to accompany this presentation.

Tools and Maps

Peloncillo Prescribed Fire thermal imaging
(Photo by Daniel G. Neary, USDA Forest Service, Rocky Mountain Research Station)

Abstracts and Papers
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SEINet: Two Decades of Collaborative Efforts Building a North American Data Network (Tools)

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SEINet has a history that spans nearly two decades. Initially established as an online search engine for a handful of botanical collections curated within Arizona, it has since matured into an information network that incorporates over 300 institutions and 1810 data managers distributed across the United States, Mexico, and Canada. The SEINet database has grown from supplying data to a single southwestern website to supporting 13 regional data portals across North America (http://symbiota.org/docs/seinet/). These portals manage and publish over 12.3 million specimens, 173,000 observations, and 7 million images. Four of the regional portals have a coverage that pertain specifically to the Madrean Archipelago and the Arizona-Sonora borderlands: Madrean Discovery Expeditions, Madrean Assessment Biodiversity Assessment, SEINet – AZ/NM, and Red de Herbarios del Noroeste de México. Initially, SEINet's user interface consisted solely of a read-only specimen search engine. Through many collaborative efforts, it has since matured into a rich biodiversity exploration tool that includes species inventories, interactive identification keys, specimen and field images, taxonomic information, species distribution maps, and species descriptions. The user interface is currently a full-fledged Content Management System specifically designed for managing biodiversity datasets within a web interface. Support from the NSF-ADBC funding initiative has supported the development of a suite of tools and workflows designed to support mass digitation of historical specimens. Support for the SEINet portal network is currently provided by NSF-ADBC, iDigBio, and Arizona State University. The central goal of the network is to promote bio-collaboration, open data, and the inherent value of specimen data.

SEINet: Dos décadas de esfuerzos de colaboración para construir una red de datos de América del Norte (Herramientas)

SEINet tiene una historia que abarca casi dos décadas. Inicialmente establecido como un motor de búsqueda en línea para un pequeño grupo de colecciones botánicas comisariadas en Arizona, ha madurado para convertirse en una red de información que incorpora más de 300 instituciones y 1810 administradores de datos distribuidos en los Estados Unidos, México y Canadá. La base de datos SEINet ha crecido desde el suministro de datos a un único sitio web del sudoeste hasta el apoyo a 13 portales regionales de datos en América del Norte (http://symbiota.org/docs/seinet/). Estos portales administran y publican más de 12.3 millones de especímenes, 173,000 observaciones y 7 millones de imágenes. Cuatro de los portales regionales tienen una cobertura específica para el Archipiélago Madrense y las tierras fronterizas de Arizona y Sonora: Madrean Discovery Expeditions, Madrean Assessment Biodiversity Assessment, SEINet - AZ / NM y Red de Herbarios del Noroeste de México. Inicialmente, la interfaz de usuario de SEINet consistía únicamente en un motor de búsqueda de muestras de solo lectura. A través de muchos esfuerzos de colaboración, ha madurado hasta convertirse en una herramienta de exploración de biodiversidad que incluye inventarios de especies, claves de identificación interactiva, imágenes de especímenes y de campo, información taxonómica, mapas de distribución de especies y descripciones de especies. La interfaz de usuario es actualmente un sistema completo de gestión de contenido específicamente diseñado para gestionar conjuntos de datos de biodiversidad dentro de una interfaz web. El apoyo de la iniciativa de financiación NSF-ADBC ha respaldado el desarrollo de un conjunto de herramientas y flujos de trabajo diseñados para admitir la digitación masiva de especímenes históricos. Actualmente, NSF-ADBC, iDigBio y Arizona State University brindan apoyo para la red del portal SEINet. El objetivo central de la red es promover la colaboración
la biológica, la apertura de datos y el valor inherente de los datos de las muestras.

NOTE: A manuscript was not submitted to accompany this presentation.

Leveraging R Shiny to Create a Web-based Dashboard App for Efficient Processing and Rapid Visualization of Natural Heritage Data (Tools)

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The Arizona Natural Heritage Program (HDMS) receives large quantities of data from many sources, including Scientific Collecting Permits, Citizen Science Projects through iNaturalist, eBird, Audubon, Arizona Breeding Bird Atlas, and our own biologists' work. Processing these datasets into our database for population assessments, conservation, and environmental compliance is a cumbersome task. Some data are new locations while others are updates to existing locations. Even prioritizing what should be processed first can be difficult. Significant challenges for our program are 1) how to make our data flow more efficient, and 2) how to quickly access and visualize the wealth of information at hand. To address these, we have created the "Dashboard," a web-based application that centralizes both our existing data and these multiple, often very large datasets to quickly prioritize data processing and help guide comments for project evaluations with avoidance and mitigation. Through the Dashboard, we can rapidly visualize species distributions and validate models, easily drill-down and filter data, import shapefiles, view species abstracts, and perform quality control such as correcting mapping errors. The Dashboard was developed in R with the Shiny package and utilizes the Leaflet and DataTables libraries. These tools are open-source and extremely flexible to handle the unique needs of any program. We demonstrate the capabilities of the Dashboard and how it has improved our data processing and visualization workflow. We also provide links to an online demo version and share the core Dashboard code in a Github repository.

Aprovechamiento de R Shiny para crear una aplicación de internet para un procesamiento eficiente y una visualización rápida de datos de patrimonio natural (herramientas)

El Programa de Patrimonio Natural de Arizona (HDMS) recibe grandes cantidades de datos de muchas fuentes, incluyendo Permisos de Recolección Científica, Proyectos de Ciencia Ciudadana a través de iNaturalist, eBird, Audubon, Atlas de Aves de Reproducción de Arizona y el trabajo de nuestros propios biólogos. El procesamiento de estos conjuntos de datos en nuestra base de datos para evaluaciones de población, conservación y cumplimiento ambiental es una tarea engorrosa. Algunos datos son ubicaciones nuevas, mientras que otros son actualizaciones de ubicaciones existentes. Incluso priorizar lo que debe procesarse primero puede ser difícil. Los desafíos importantes para nuestro programa son 1) cómo hacer que nuestro flujo de datos sea más eficiente, y 2) cómo acceder rápidamente y visualizar la gran cantidad de información a mano. Para abordar esto, hemos creado el "Tablero", una aplicación web que centraliza tanto nuestros datos existentes como estos conjuntos de datos múltiples, a menudo muy grandes, para priorizar rápidamente el procesamiento de datos y ayudar a guiar los comentarios para las evaluaciones del proyecto con evitación y mitigación. A través del Tablero, podemos visualizar rápidamente distribuciones de especies y validar modelos, desglosar y filtrar datos fácilmente, importar archivos de formas, ver resúmenes de especies y realizar controles de calidad, como corregir errores de mapeo. El Tablero fue desarrollado en R con el paquete Shiny y utiliza las bibliotecas Leaflet y DataTables. Estas herramientas son de código abierto y extremadamente flexibles para manejar las necesidades únicas de cualquier programa. Demostramos las capacidades del Tablero y cómo ha mejorado nuestro flujo de trabajo de procesamiento y visualización de datos. También proporcionamos enlaces a una versión de demostración en línea y compartimos el código central del Tablero en un repositorio de Github.

NOTE: A manuscript was not submitted to accompany this presentation.

Collapsible larval fish light trap using low-power LED light source (Tools)

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Light traps have been shown to be valuable in the conservation and monitoring of endemic desert fishes. In order to use this method sampling in Black Draw, Sonora, Mexico, a trap was developed that is of a robust, power-efficient design. This trap disassembles and nests into itself for safe storage and transport. It can them be easily assembled in the field without tools. Using a single lithium coin cell as a power source, light from a Light Emitting Diode is diffused by the translucent High-Density Polyethylene quatrefoil trap body. Initial field tests indicate this to be an effective design and a possible alternative to more typical quatrefoil light traps of acrylic or polycarbonate construction.

Trampa de luz para peces larvales que se puede colapsar y utiliza una fuente de luz LED de bajo consumo (Herramientas)

Se ha demostrado que las trampas de luz son valiosas en la conservación y el monitoreo de peces endémicos del desierto. Para utilizar este método de muestreo en Black Draw, Sonora, México, se desarrolló una trampa que es de un diseño robusto y de alta eficiencia energética. Esta trampa se desmonta y anida en sí misma para un almacenamiento y transporte seguros, y se puede ensamblar fácilmente en el campo sin herramientas. Usando una sola pila de monedas de litio como fuente de energía, la luz de un Diodo Emisor de Luz se difunde por el cuerpo de trampa translúcido de polietileno de Alta Densidad. Las pruebas de campo iniciales indican que se trata de un diseño eficaz y una posible alternativa a las trampas de luz cuatrifolio más típicas de construcción acrílica o de policarbonato.

Note: Full Paper Follows

Collapsible Larval Fish Light Trap Using Low-power LED Light Source

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***Abstract**--Light traps have been shown to be valuable in the conservation and monitoring of endemic desert fishes. To use this method sampling in Rio San Bernardino, Sonora, Mexico, a trap was developed that is of a robust, power-efficient design. This trap disassembles and nests into itself for safe storage and transport and can be easily assembled in the field without tools. Using two lithium coin cells as a power source, light from a light emitting diode is diffused by the translucent high-density polyethylene quatrefoil trap body. Initial field tests indicate this to be an effective design and a possible alternative to more typical quatrefoil light traps of acrylic or polycarbonate construction.*

INTRODUCTION

The sampling and monitoring of larval and juvenile fishes has been shown to be an effective indicator of abundance and survival and an aid in better understanding a population's structure, as early life stages are often underrepresented using other sampling methods such as electrofishing or seine netting (Murphy and Willis 1996). By analyzing data from early life stages trends in population structure are more rapidly apparent. These methods are widely used in both inland and marine fisheries, and numerous projects have focused specifically on endemic desert fishes. In addition to serving as a tool for population data collection, captured larva of imperiled desert species have been reared under protection and released at significantly larger size as part of ongoing conservation efforts (Marsh et al. 2005).

The use of the light trap as a sampling method takes advantage of the positive phototactic behavior observed in many species of fishes and other organisms. This behavior, where organisms orient themselves and move toward light, likely serves as a response to avoid potential danger or move to more favorable conditions (Barton 2007). Positive phototaxis has been experimentally demonstrated in razorback sucker (Snyder and Meismer 1997) and bonytail chub (Massure et al. 2015). The behavior is believed to be present in other desert fish species (Massure et al. 2015; Minckley et al. 2003; Snyder and Meismer 1997). To evaluate whether this behavior may be present in Yaqui chub (*Gila purpurea*), and as part of ongoing monitoring in the Rio San Bernardino of Sonora, Mexico (Figure 1), the light trap discussed in this paper was developed.

DESIGN

Various designs of light traps have been used to sample phototactic fish larvae. One common design used in inland waters is the quatrefoil light trap, initially designed by Floyd et al. (1984). This trap features four three-quarter sections of acrylic cylinders arranged in a circular array around a central light source. Larval fish, attracted by either a chemical light stick or a waterproof battery powered lamp, enter through narrow gaps between the acrylic cylinders. These cylinders are typically bonded to a top and bottom plate. Foam floats are affixed to the top plate and the light traps may or may not include a collection pan attached to the bottom plate. (Killgore 1994; Secor et al. 1992).

The design described herein is a variation of that original configuration (Figure 2). The primary departure from previous designs is the use of high-density polyethylene tube in place of acrylic. By utilizing this durable material, the overall cost per trap was reduced and the construction process simplified. Use of this translucent material gave the added benefit of significantly diffusing light emitted by the attracting light source.

Another modification is the use of inexpensive commercially available waterproof LED modules as the primary light source. Previous efforts have made effective use of LED lighting as the attractant for light traps, however, these light sources have been specially constructed (Gyekis et al. 2006). Intended for decorative use, the compact modules used in this design are sold as submersible LED tea lights and are available in a wide variety of colors (Figure 3). These inexpensive

modules are powered by two CR2032 lithium coin cells and have a run time of over 12 hours of continuous operation before a battery change is required.

Figure 1. Light traps in use in Rio San Bernardino, Sonora, Mexico (Photo by A. Livingstone, Oregon State University)

Figure 2. Light traps shown assembled for use and collapsed for transport - lid removed to show nesting of components Photo by A. Livingstone, Oregon State University)

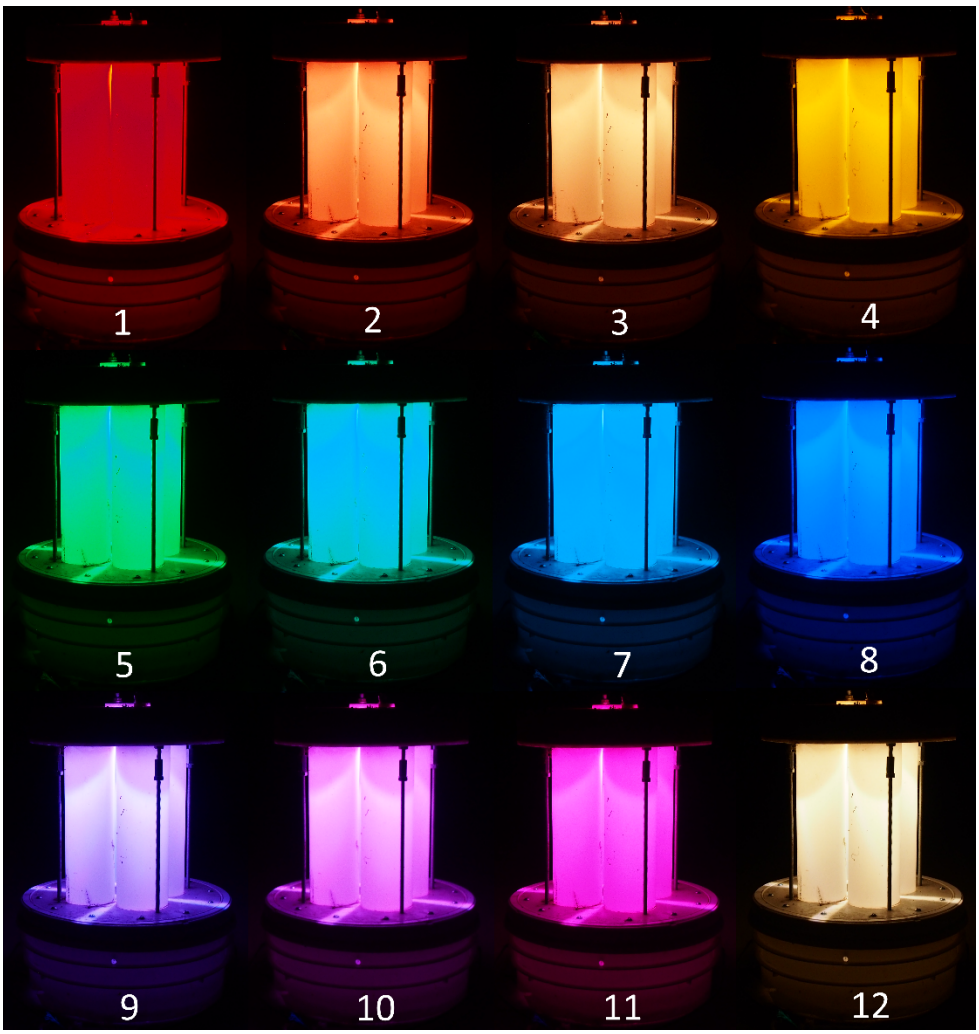

Figure 3. Selection of LED light module colors available – colors 4, 5, 12 were used in Rio San Bernardino tests (Photos by A. Livingstone, Oregon State University)

Additional modifications allow for simplified construction and compact storage. By cutting the top and bottom plates with grooves for the alignment of the cylinders these traps can be easily assembled in the field. The cylinders that make up the trap body are stored within the collection pan for transport. The collection pans are constructed from easily sourced materials. These components include generic 5-gallon (20 L) pails, screw top lids, and bucket strainers commonly available at home improvement stores or from online retailers.

MATERIALS AND METHODS

Much of the fabrication of components to build these traps was performed using a Thermwood Model C67 CNC router. This specific method of fabrication is not critical, and components could be cut using far more commonly available equipment. By carefully creating fixtures and guides, the machined components described could be recreated with a jigsaw and handheld router. The materials sourced were used because of availability as scrap from industrial manufacturing. These materials are available commercially; however, it is the author's opinion that a wide variety of materials with similar properties could be suitably substituted. Material choice for the plates used in making the traps is not critical if machinability and water resistance are considered. For the tubes that make up the trap body, translucent properties are the primary consideration.

The HDPE tubes used for the body of the trap were sourced as scrap. The original intended purpose was as the core tube supplied with rolls of adhesive backed PTFE sheeting. Tubes as sourced were 3.3 in (84 mm) OD and 36 in (914 mm) in length. When the initial cut to remove the quarter-section was made the tubes contracted to an outer diameter of 2.9 in (72.6 mm). Cutting these tubes was found to be most effectively done on the table saw, and fixtures were fabricated for alignment and to index the tube while cutting (Figure 4). After the cuts were made to remove the quarter section, sourced tubes were cut to a final length of 8.9 in (226 mm). Sharp edges were deburred and finished with 400 grit sandpaper.

The cover, top, and bottom plates (Figures 5, 6, and 7, respectively) were machined from 0.18 in (4.5 mm) thick HDPE sheet. These were also obtained as scrap, having originally served as tops and bottoms to 15-gal (56 L) fiber drums. The float was made from 1.5 in (38 mm) extruded polystyrene foam sheet. Using the CAD models designed in SolidWorks, cut paths and cut files were generated in Surfcam. The parts were then cut on a Thermwood C67 5-axis CNC router. After removal, edges of the HDPE parts were deburred and finished with 400 grit sandpaper.

The collection pan was constructed from roughly the upper 4 in (~100 mm) of a 5-gal (20 L) bucket, a modified Gamma Seal Lid, 100-micron EZ-strainer insert, and a section of 1/4 in (6.35 mm) hardware cloth. The 5-gal (20 L) bucket was marked around its circumference and then cut to size. Trial units were initially made by cutting with a razor blade. Despite having a superior cut quality, this method was quickly abandoned in favor of the use of a jigsaw, due to difficulty and safety concerns. To provide protection for the nylon mesh of the strainer, the section of 1/4 in hardware cloth was formed to fit on the inside of the new bottom opening of the section of bucket and fixed in place using high strength hot melt adhesive. A 0.4 in (10 mm) hole was drilled in the bucket section 1.125 in (28.5 mm) below the top to allow for air to escape when the trap is placed in the water. The bucket strainer was then set in the top of the bucket section and sandwiched in place by the adapter for the Gamma Seal Lid, which had the inner gasket removed. To provide a smooth surface and to prevent any fish from getting stuck while the collection pan is emptied, a bead of silicone was run around the inner surface where the Gamma Seal adapter and strainer meet. The Gamma Seal Lid was modified by cutting out the inner portion, and removing the gasket, leaving a male threaded ring with lip. The bottom plate was then set in the recessed upper surface of this ring with the grooves facing away from the threaded portion. By then rotating the bottom plate, the holes were aligned to fall between the gussets found on the underside of the ring. Using a number 7 drill bit (0.201 in, 5.1 mm) in a hand drill, the holes were then match drilled through the threaded ring. The 10-32 hardware was inserted through both components and the nuts were tightened.

The primary components of the float assembly were the cover plate, float, and top plate. Starting with the cover plate, the two 1/4-20 x ¾ in bolts were inserted through the pair of inner ¼ in (6.35 mm) holes. These were affixed in place by a spot of hot melt adhesive on each head. For added protection, the perimeter of the foam float was wrapped with a strip of 2 in (50.8 mm) yellow vinyl tape and the excess was folded over. The cover plate, with the threaded portions of hardware positioned away, was placed on one side of the float. On the other side, the top plate was positioned with the grooves facing out. The four outer ¼ in (6.35 mm) holes were aligned between the three components and the 1/4-20 x 2 in bolts were inserted. Four 1/4-20 in nuts were threaded on and tightened. The LED module of the appropriate color was then affixed to the LED module mount plate using high strength hot melt adhesive. This was then set in place over the studs extending from the cover plate and held in place by two 1/4-20 in wing nuts.

To assemble the trap for use, the HDPE tube sections are placed in the grooves on the base plate assembly. Coupling nuts are threaded to half their depth on four 1/4-20 threaded rods (8 in/203 mm long) and held in place by jam nuts. The threaded rods are then inserted through the ¼ in (6.35 mm) holes in the base plate. The float assembly is then placed on top of the tube sections, which are then aligned to the channels in the top plate. The threaded rods then are attached to the threads extending past the nuts holding the float assembly together. Nuts are then threaded onto the threaded rods from the underside of the baseplate and hand tightened. This entire assembly is then threaded into the collection pan. When the trap is being deployed the upper wingnuts are loosened and the LED module mount twisted and removed. The module is then activated and replaced.

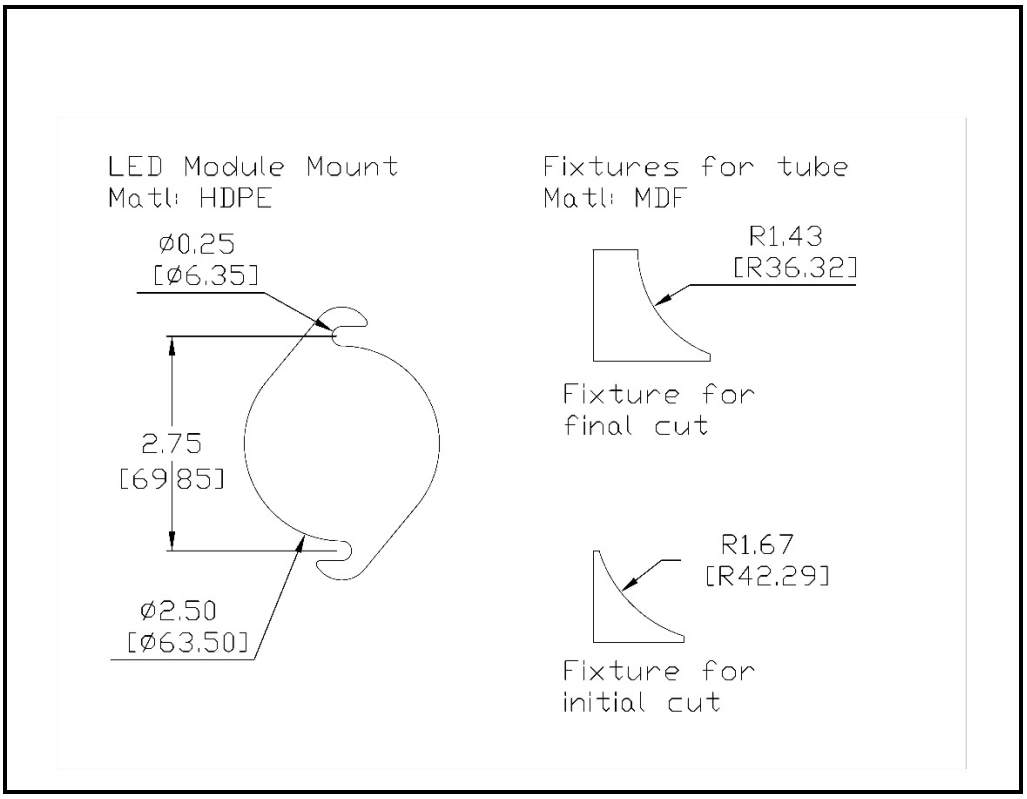

Figure 4. LED light module mount; Fixtures for indexing of tube section cuts. Dimensions: Inches [mm]

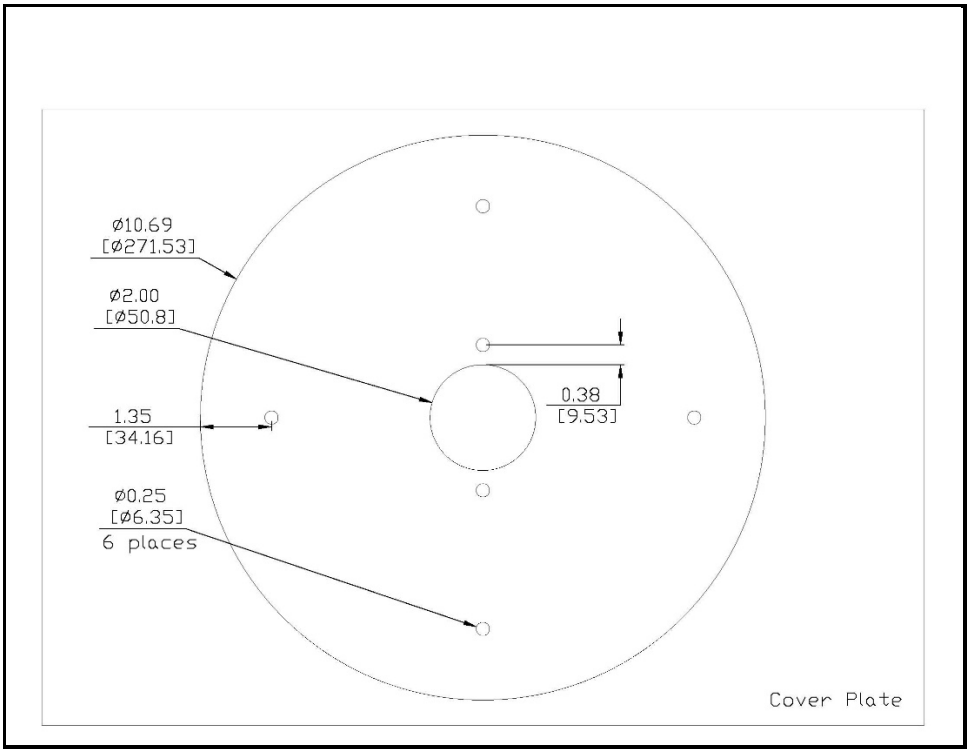

Figure 5. Light trap cover plate – material: 0.18 [4.5] HDPE. Dimensions: Inches [mm]

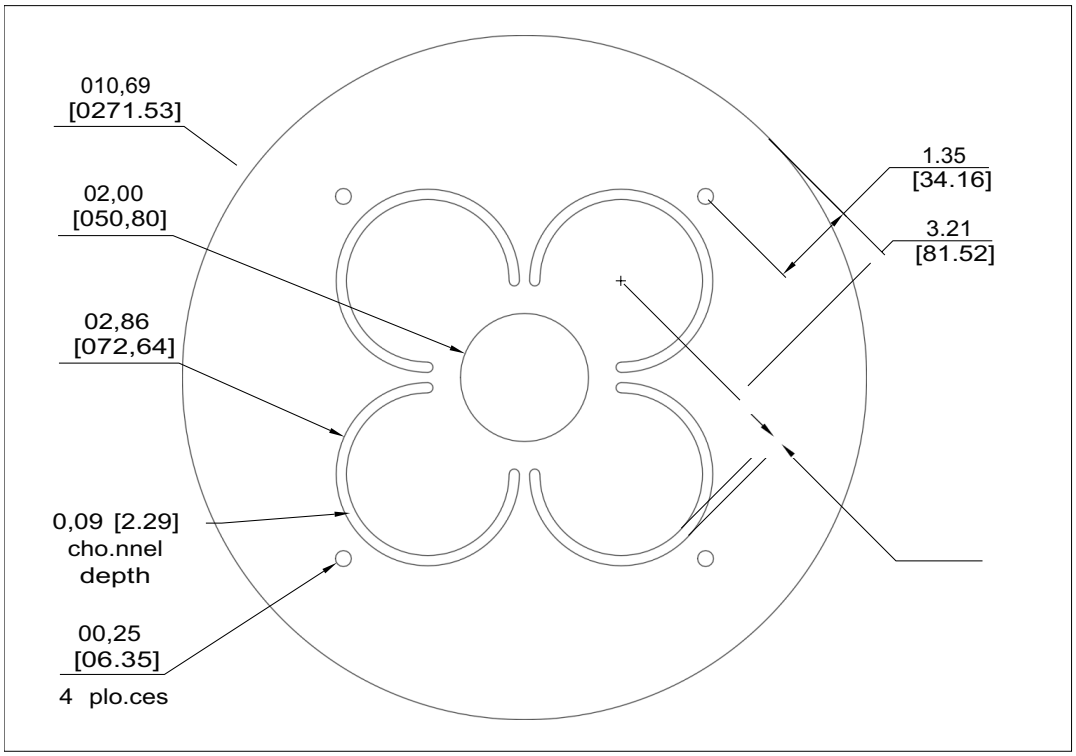

Figure 6. Light trap top plate – material: 0.18 [4.5] HDPE. Dimensions: Inches [mm]

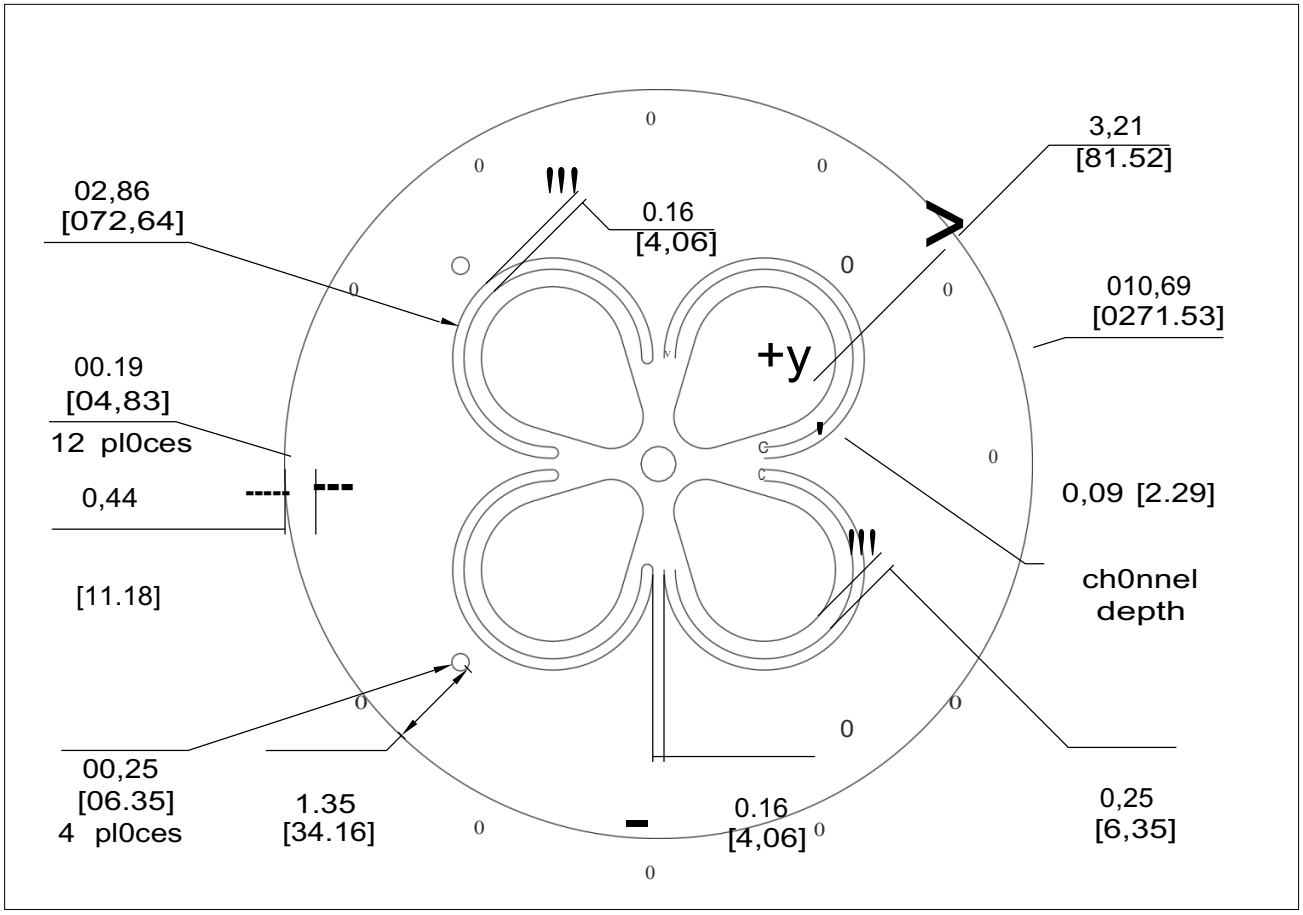

Figure 7. Light trap bottom plate – material: 0.18 [4.5] HDPE. Dimensions: Inches [mm]

For disassembly and storage, the upper assembly is removed from the collection pan. The nuts holding the threaded rods to the base plate are removed and the sections are separated. After removing the threaded rods and coupling nuts from the float assembly, the float assembly is placed on the base plate, aligning the extending bolt threads with the 1/4" (6.35 mm) holes in the base. The nuts are then threaded on and hand tightened from the underside. The threaded rod/coupling nut assemblies and tube sections are then placed in the collection pan and the base plate with attached float assembly is threaded on (Figure 2).

DISCUSSION

At the time of writing no larval fish have been captured using this trap design. In addition, the opportunity to use the trap in a controlled environment and verify its effectiveness with phototactic larval fishes has not yet been available. However, the use of this trap in the Rio San Bernardino has yielded mixed catches of poeciliids (Yaqui topminnow and mosquitofish) and aquatic invertebrates representing several orders (including Odonata, Diptera, and Coleoptera). These sampling efforts have been limited but have co-occurred with other sampling methods (seining and minnow traps). In this same time frame no larval or juvenile Yaqui chub have been captured using any of the methods tried. During initial sampling water conditions were likely out of the range of Yaqui chub spawning conditions (Kline and Bonar 2009) and traps were set to test physical performance characteristics (light intensity and duration, flotation, etc.). Only two sampling events were within possible Yaqui chub spawning conditions. Further sampling efforts will be necessary to observe the possibility of this behavior in Yaqui chub. However, based on performance of capture of non-target species, it is believed that the design is likely to be effective with phototactic larvae.

Additional modifications and alterations are under consideration. Variation of the color of light used as an attractant is one such option. In experiments performed by Gehrke (1994), it is suggested that the color of light used can be optimized for the target species and present water conditions. For the sampling events in the Rio San Bernardino, three different colors have been used – white, yellow, and green (Figure 3). However, initial results between these appear to have been similar. An additional concern that may affect capture rates of larval fishes is predation by poeciliids. Based on results of testing performed by Vilizzi et al. (2008), the addition of an outer mesh may increase trap rate by excluding poeciliids which potentially prey on captured larvae.

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Low-cost Arduino based portable current velocity meter (Tools)

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Measurements of streamflow are crucial to environmental monitoring efforts and development of habitat criteria for aquatic species. Although there are many methods to obtain such measurements, few low-cost options exist that have a minimal learning curve with a relative high level of accuracy. To obtain a unit that meets the above criteria, we developed a portable electronic velocity meter based on an Arduino microcontroller. The fabricated flow transducer makes use of a digital Hall Effect sensor and a modified blade from a CPU cooling fan housed in a section of 3" HDPE plastic tube. Code was written for the unit to allow simple field calibration and scaling of the output. When tested alongside commercially available portable current velocity meters, the accuracy compared favorably. We believe this low-cost flow meter can be a viable alternative for use in citizen science, educational institutions, and other budget constrained projects.

Medidor de velocidad de corriente portátil basado en Arduino y de bajo costo (Herramientas)

Las mediciones de caudal son cruciales para los esfuerzos de monitoreo ambiental y el desarrollo de criterios de hábitat para especies acuáticas. Aunque existen muchos métodos para obtener tales mediciones, existen pocas opciones de bajo costo que tengan una curva de aprendizaje mínima con un relativo alto nivel de precisión. Para obtener una unidad que cumpla con los criterios anteriores, desarrollamos un medidor de velocidad electrónico portátil basado en un microcontrolador Arduino. El transductor de flujo fabricado hace uso de un sensor de efecto Hall digital y una cuchilla modificada de un ventilador de refrigeración de la CPU ubicado en una sección de tubo de plástico HDPE de 3 ". El código fue escrito para la unidad para permitir la calibración de campo simple y la escala de la salida. Cuando se probó junto con los medidores de velocidad de corriente portátiles disponibles comercialmente, la precisión se comparó favorablemente. Creemos que este medidor de flujo de bajo costo puede ser una alternativa viable para su uso en ciencia ciudadana, instituciones educativas y otros proyectos de presupuesto limitado.

NOTE: A manuscript was not submitted to accompany this presentation.

From Contamination to Restoration: Migratory Bird Habitat (Map)

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The U.S. Department of the Interior's Natural Resource Damage Assessment and Restoration Program restores natural resources injured as a result of oil spills or hazardous substances released into the environment. In addition to on-site restoration for migratory birds, monetary settlements from damage assessments have funded nesting and wintering habitat restoration far from contaminated sites. Birds do not recognize geopolitical boundaries when making intercontinental voyages, so ensuring habitat is available where these species frequent is vital to their success. Habitat

restoration for these winged ambassadors is accomplished successfully across the Americas, and beyond, through multiple partnerships with local, state, federal, foreign, indigenous, tribal, and non-governmental organizations.

De la contaminación a la restauración: hábitat de aves migratorias (mapa)

El Programa de Restauración y Evaluación de Daños a los Recursos Naturales del Departamento del Interior de los Estados Unidos restaura los recursos naturales lesionados como resultado de derrames de petróleo o sustancias peligrosas que se liberan al medio ambiente. Además de la restauración en el sitio para las aves migratorias, los asentamientos monetarios de las evaluaciones de daños han financiado la restauración del hábitat de anidación e hibernación lejos de los sitios contaminados. Las aves no reconocen los límites geopolíticos al hacer viajes intercontinentales, por lo que garantizar el hábitat disponible donde estas especies frecuentan es vital para su éxito. La restauración del hábitat para estos embajadores alados se lleva a cabo con éxito en las Américas y más allá, a través de múltiples asociaciones con organizaciones locales, estatales, federales, extranjeras, indígenas, tribales y no gubernamentales.

NOTE: A manuscript was not submitted to accompany this presentation.

The Madrean Discovery Expeditions Database: Documenting Sky Island Biodiversity (Tools)

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The Madrean Archipelago Biodiversity Assessment (MABA) database was created in 2009 to document all plant and animal species in the Sky Islands Region, mostly Sonora and Arizona. In 2015, the Madrean Discovery Expeditions (MDE) database (madreandiscovery.org) was created to continue this effort. The MDE dataset is being managed in a shared database in collaboration with iDigBio, SEINet, and more 280 Universities collections. Biological records are from historical resources, including museum collections, literature, field notes, etc. New observations were generated on fieldtrips, including MDE to the Sierras Buenos Aires, Elenita, Juriquipa, and el Tigre, Mini-Expeditions to the Sierras de la Madera and San José, MDE Education school tours, the lower Río Bavispe Valley Project WILDCAT Predator Protection Program sites, and numerous other areas. All of the records are publicly available online for use in conservation, research, and education. The MDE FLORA is directly linked to the SEINet herbarium databases. The MDE FAUNA is an independent database. The database helps conservation by documenting the diversity of animals and plants in high priority geographic areas. The MDE database currently has 27,844 records (14,486 plants, 13358 animals). Of these records, 18,903 records (9866 plants and 9037 animals) are from Sonora, Mexico. In addition to the MABA and MDE records, the iDigBio and SEINet collaboration has facilitated the integration of 730,000 Arizona/Sonora historic specimen records specimens supplied by more than 300 natural history collections. These databases are the primary sources of biological records for the state of Sonora and the Arizona-Sonora borderlands.

La base de datos de Madrean Discovery Expeditions: documentar la biodiversidad de las Islas Serranas (herramientas)

La base de datos de Evaluación de Biodiversidad del Archipiélago Maduro (MABA por sus siglas en inglés) fue creada en 2009 para documentar todas las especies de plantas y animales en la región de las Islas Serranas, principalmente Sonora y Arizona. En 2015, se creó la base de datos Madrean Discovery Expeditions (MDE) (madreandiscovery.org) para continuar

con este esfuerzo. El conjunto de datos MDE se gestiona en una base de datos compartida en colaboración con iDigBio, SEINet y más de 280 colecciones de Universidades. Los registros biológicos provienen de recursos históricos, incluyendo colecciones de museos, literatura, notas de campo, etc. Se generaron nuevas observaciones en excursiones, incluyendo MDE a las Sierras Buenos Aires, Elenita, Juriquipa y el Tigre, Mini-Expediciones a las Sierras de la Madera y San José, recorridos escolares de Educación MDE, los sitios del Programa de Protección de depredadores WILDCAT del Proyecto del Valle del Bajo Bavispe y muchas otras áreas. Todos los registros están disponibles públicamente en línea para su uso en conservación, investigación y educación. El MDE FLORA está directamente relacionado con las bases de datos del herbario SEINet. MDE FAUNA es una base de datos independiente. La base de datos ayuda a la conservación al documentar la diversidad de animales y plantas en áreas geográficas de alta prioridad. La base de datos MDE actualmente tiene 27,844 registros (14,486 plantas, 13358 animales). De estos registros, 18,903 registros (9866 plantas y 9037 animales) son de Sonora, México. Además de los registros MABA y MDE, la colaboración de iDigBio y SEINet ha facilitado la integración de 730,000 especímenes de especímenes históricos de Arizona / Sonora suministrados por más de 300 colecciones de historia natural. Estas bases de datos son las principales fuentes de registros biológicos para el estado de Sonora y las tierras fronterizas de Arizona y Sonora.

NOTE: A manuscript was not submitted to accompany this presentation.

Climate Landscape Response (CLaRe) metrics: Introducing a new indicator for landscapes and its application to invasive species management. (Tools)

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Invasive buffelgrass (*Pennisetum ciliare*) spreads easily in the Sonoran Desert ecosystem. In affected areas, the grass forms a continuous, flammable layer that carries fire across the landscape, threatening native flora and fauna species. Current management of buffelgrass in Saguaro National Park (SNP) includes the targeted application of herbicide, which is effective when the grass is photosynthetically active. The erratic, localized rain events characteristic of the Sonoran Desert make it difficult to predict when and where buffelgrass will be green and therefore suited to treatment. USGS researchers have developed innovative Climate-Landscape Response (CLaRe) metrics to assist SNP personnel with buffelgrass management efforts (doi:10.3390/rs8070524). CLaRe metrics leverage the correlation between precipitation amounts and satellite-detected vegetation greenness. The presence of buffelgrass can be detected due to its unusually rapid green-up response to precipitation events. Previous studies using CLaRe metrics reveal strategies that allow managers to plan optimal timing of herbicide application, identify nascent populations of invasives and prioritize buffelgrass management activities in their region. Although the metrics were discovered for buffelgrass management, they will transfer readily to other desert invasives, since these typically green-up asynchronous to native vegetation. Moreover, CLaRe metrics have potential to inform other resource management issues, including mapping relative rooting depths of vegetation types as well as mapping the presence, seasonality, and status of understory vegetation in forests that form fine fuels and impact wildfire risk.

Métricas de Climate Landscape Response (CLaRe): introducción de un nuevo indicador de paisajes y su aplicación al manejo de especies invasoras. (Herramientas)

El buffelgrass invasor (Pennisetum ciliare) se disemina fácilmente en el ecosistema del desierto de Sonora. En las áreas afectadas, la hierba forma una capa continua e inflamable que transporta fuego a través del paisaje, amenazando a las especies nativas de flora y fauna. El manejo actual del zacate buffel en el Parque Nacional Saguaro (SNP) incluye la

aplicación específica de herbicida, que es efectiva cuando el pasto es fotosintéticamente activo. Los eventos de lluvia erráticos y localizados característicos del desierto de Sonora hacen que sea difícil predecir cuándo y dónde buffelgrass será verde y, por lo tanto, adecuado para el tratamiento. Los investigadores de USGS han desarrollado métricas innovadoras de Respuesta de clima y paisaje (CLaRe) para ayudar al personal de SNP con los esfuerzos de gestión de pasto buffel (doi: 10.3390 / rs8070524). Las métricas CLaRe aprovechan la correlación entre las cantidades de precipitación y el verdor de vegetación detectado por satélite. La presencia de buffelgrass se puede detectar debido a su inusualmente rápida respuesta verde a los eventos de precipitación. Los estudios previos que utilizan métricas CLaRe revelan estrategias que permiten a los administradores planificar el momento óptimo para la aplicación de herbicidas, identificar las poblaciones incipientes de invasoras y priorizar las actividades de gestión del pasto buffel en su región. Aunque las medidas se descubrieron para el manejo del pasto buffel, se transferirán fácilmente a otras especies invasoras del desierto, ya que estas suelen ser verdes asíncronas a la vegetación nativa. Además, las métricas CLaRe tienen potencial para informar otros problemas de gestión de recursos, incluido el mapeo relativo de las profundidades de enraizamiento de los tipos de vegetación y la presencia, estacionalidad y estado de la vegetación del sotobosque en bosques que forman combustibles finos e impactan el riesgo de incendios forestales.

NOTE: A manuscript was not submitted to accompany this presentation.

Session Abstracts and Papers / *Resúmenes y Articulos*

Posters

Monument Fire, Coronado National Forest
(Photo courtesy of Walnut Creek Experimental Watershed, USDA ARS)

Abstracts and Papers

Alcalá
Becker
Bennett
Blais
Caballero-Reynolds
Calva
Chavez Lincon
Crawford
Duncan
Enquist
Espinosa Encinas
Galaz
Garcia Palafox
Gray
Gray
Hijar
Khosla
King
Li
Lynch
Marshall
McCaughey Espinoza
Nagler
Olivares Rivera
Pate
Petrakis
Rich
Rivera
Salywon
Simpson #1
Simpson #2
Sinclair
Tanori
Verrier
Villanueva-Gutierrez
Villareal

20 Years of Ecosystem Restoration Projects (Poster)

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The Pima County Regional Flood Control District (District) plays a vital role in protecting Pima County residents from flooding and erosion hazards as well as protecting riparian habitat and providing trails. As a regional authority, the District's projects occur within the City of Tucson, Town of Oro Valley, Town of Marana, Town of Sahuarita, and unincorporated Pima County. District projects include bank stabilization, environmental restoration, floodplain mapping, detention and retention basins, bridges, drainage improvements, and river parks. Since inception in 1978, an increasingly important aspect of the District's work includes management of natural resources associated with streams and floodplains. For example, in 1994 the District adopted a series of riparian habitat regulations into the Floodplain Management Ordinance (Ord. 2010-FC5). For the past 20 years, the District has focused on building projects that specifically address local environmental needs. Through biological assessments and collaboration with local experts and other organizations, the District has designed innovative projects to provide sustainable ecosystem functions for special status species present or impaired at specific project sites. Projects are constructed and maintained for public safety and wildlife habitat. Project designs have evolved to include maximization of rainwater harvesting earthworks and utilization of other renewable water supplies. Specifically, noteworthy project elements include native species selection to support the base of the site-specific food web, herpetological salvage and translocation, constructed ephemeral toad breeding habitat, groundwater recharge at the Marana High Plains Effluent Recharge Project, and extensive stormwater harvesting and re-use at the Kino Environmental Restoration Project.

20 años de proyectos de restauración de ecosistemas (Cartel)

El Distrito Regional de Control de Inundaciones del Condado de Pima (Distrito) desempeña un papel vital en la protección de los residentes del Condado de Pima contra inundaciones y peligros de erosión, así como en la protección del hábitat ribereño y la provisión de senderos. Como autoridad regional, los proyectos del Distrito se llevan a cabo dentro de la Ciudad de Tucson, la Ciudad de Oro Valley, la Ciudad de Marana, la Ciudad de Sahuarita y el Condado no incorporado de Pima. Los proyectos del distrito incluyen estabilización bancaria, restauración ambiental, mapeo de llanuras de inundación, cuencas de detención y retención, puentes, mejoras de drenaje y parques fluviales. Desde su inicio en 1978, un aspecto cada vez más importante del trabajo del Distrito incluye el manejo de los recursos naturales asociados con arroyos y llanuras de inundación. Por ejemplo, en 1994 el Distrito adoptó una serie de regulaciones de hábitat ribereño en la Ordenanza de Manejo de Terrenos Inundables (Ord. 2010-FC5). Durante los últimos 20 años, el Distrito se ha enfocado en la construcción de proyectos que abordan específicamente las necesidades ambientales locales. A través de evaluaciones biológicas y colaboración con expertos locales y otras organizaciones, el Distrito ha diseñado proyectos innovadores para proporcionar funciones ecosistémicas sostenibles para especies de estatus especial presentes o deterioradas en sitios de proyectos específicos. Los proyectos se construyen y mantienen para la seguridad pública y el hábitat de la vida silvestre. Los diseños del proyecto han evolucionado para incluir la maximización de los movimientos de tierra para la recolección de agua de lluvia y la utilización de otros suministros de agua renovables. Específicamente, los elementos destacados del proyecto incluyen la selección de especies nativas para apoyar la base de la red trófica específica del sitio, salvamento herpetológico y translocación, hábitat efímero de reproducción del sapo, recarga de aguas subterráneas en el Proyecto de recarga de efluentes de las llanuras altas de Marana y extensas recolecciones.

NOTE: A manuscript was not submitted to accompany this presentation.

Use of sacaton (*Sporobolus wrightii*) in riparian restoration efforts in the Sky Island Region (Poster)

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Sacaton (*Sporobolus wrightii*) and other grasses such as vine mesquite (*Hopia obtusa*) made up a significant portion of the historic understory of many mid-elevation riparian corridors in the Sky Island region. Varied and interacting factors have led to a decline in sacaton-dominated floodplain grasslands over the 20th and 21st centuries, with related effects on floodplain ecosystem function. Case studies and data from restoration projects around the Sky Islands that have used or are utilizing sacaton as a restoration tool will be presented, with the objective of collating and sharing this information to improve restoration efforts along our critical riparian corridors.

Uso de zacatón (Sporobolus wrightii) en los esfuerzos de restauración ribereña en la región de las Islas Serranas (Cartel)

Zacatón (Sporobolus wrightii) y otras hierbas como el mezquite de vid (Hopia obtusa) constituyeron una porción significativa del sotobosque histórico de muchos corredores ribereños de mediana altitud en la región de las Islas Serranas. Los factores variados e interactivos han llevado a una disminución en los pastizales de llanuras de inundación dominados por zacatón durante los siglos 20 y 21, con efectos relacionados en la función del ecosistema de la llanura de inundación. Se presentarán estudios de casos y datos de proyectos de restauración en las Islas Serranas que hayan utilizado o estén utilizando zacatón como herramienta de restauración, con el objetivo de recopilar y compartir esta información para mejorar los esfuerzos de restauración a lo largo de nuestros críticos corredores ribereños.

NOTE: A manuscript was not submitted to accompany this presentation.

Tools of the Trade: Herpetofauna as Models for Conservation (Poster)

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Focused, science-based information about a species' distribution, demography, and systematics can assist wildlife conservation and management strategies with informed actions. Augmentation of novel techniques can reduce environmental impact and costs for stakeholders and wildlife managers, while increasing knowledge bases for understudied taxa and communities. Diverse yet imperiled taxonomic groups, such as herpetofauna (amphibians and reptiles), make excellent models for testing conservation techniques. Herpetofauna are indicators of environmental health, help regulate ecosystem food chains, and are important for human health and medicine. We use herpetofauna models to outline the efficacy of three novel tools for conservation: conservation genomics, non-invasive radio telemetry, and citizen science. We reveal how conservation genetics and genomics have shed light on a grassland-health bioindicator species (Smooth Greensnake - *Opheodrys vernalis*) by identifying population demographics and phylogeographic structure, including geographic expansions and contractions in highly differentiated populations – a focus recommendation for managers. We also show how a non-invasive radio telemetry technique (external attachment) can provide insight into the spatial dynamics, behavior, and microhabitat usage data from a reintroduction of an enigmatic, threatened species (Narrow-headed Gartersnake - *Thamnophis rufipunctatus*). The cumulative results provide

insight into adaptive management conservation measures. Finally, we exemplify how citizen science programs can harvest population dynamic data en masse (e.g. frogs and toads). These novel, non-invasive tools are invaluable to researchers and managers, and subsequent data can inform strategic conservation decisions.

Herramientas del oficio: Herpetofauna como modelos para la conservación (Cartel)

La información enfocada y basada en la ciencia sobre la distribución, demografía y sistemática de una especie puede ayudar a las estrategias de conservación y gestión de la vida silvestre con acciones informadas. El aumento de nuevas técnicas puede reducir el impacto ambiental y los costos para las partes interesadas y los administradores de vida silvestre, al tiempo que aumenta las bases de conocimiento para los taxones y las comunidades poco estudiadas. Diversos grupos taxonómicos amenazados, como la herpetofauna (anfibios y reptiles), son excelentes modelos para probar técnicas de conservación. La herpetofauna es un indicador de la salud ambiental, ayuda a regular las cadenas alimentarias de los ecosistemas y es importante para la salud humana y la medicina. Utilizamos modelos de herpetofauna para delinear la eficacia de tres nuevas herramientas para la conservación: la genómica de la conservación, la radiotelemetría no invasiva y la ciencia ciudadana. Revelamos cómo la genética de la conservación y la genómica han arrojado luz sobre una especie bioindicadora de pastizales de salud (Smooth Greensnake - Opheodrys vernalis) identificando la demografía de la población y la estructura filogeográfica, incluyendo expansiones geográficas y contracciones en poblaciones altamente diferenciadas, una recomendación de enfoque para los administradores. También mostramos cómo una técnica de telemetría no invasiva (conexión externa) puede proporcionar información sobre la dinámica espacial, el comportamiento y los datos de uso de microhábitats de una reintroducción de una especie enigmática amenazada (Gartersnake de cabeza estrecha - Thamnophis rufipunctatus). Los resultados acumulados proporcionan información sobre las medidas de conservación del manejo adaptativo. Finalmente, ejemplificamos cómo los programas de ciencia ciudadana pueden recopilar datos dinámicos de población en masa (por ejemplo, ranas y sapos). Estas herramientas novedosas y no invasivas son invaluables para los investigadores y gerentes, y los datos posteriores pueden informar las decisiones estratégicas de conservación.

NOTE: A manuscript was not submitted to accompany this presentation.

Analysis of elements of visual attraction in conservation themed videos (Poster)

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I looked at the elements of visual attraction in a 7-minute educational video focusing on the critically threatened Gila trout, *Oncorhynchus gilae*, and Apache trout, *Oncorhynchus apache*. Another undergraduate and I produced the video for the Forest Service Ranger District in Safford, AZ. I used the video to understand what elements of visual attraction capture people's attention in conservation themed videos. This information will help the production of future videos in drawing the attention from a broad spectrum of people. I wanted to know specifically what people were looking at during the duration of 7-minutes. The video was placed in a public space for the duration of 2 weeks. In those 2 weeks I observed and collected data on who glanced at the video and what was being watched for more than 5 seconds. Macro, high-variation color, movement, and pattern footage were observed to be the most visually pleasing. Macrography footage allows for the viewer to look at species in high definition and extremely up-close. High-variation color allows the viewer to see the species and surrounding landscape. Species moving continuously throughout their environment attracted people's attention in contrast to still landscapes. Pattern footage attracted people's attention from a further distance due to the repetition in shapes. This information will enable the production of future conservation videos to gain interest from people not necessarily interested in conservation.

Análisis de elementos de atracción visual en videos temáticos de conservación (Cartel)

Observé los elementos de la atracción visual en un video educativo de 7 minutos que se enfoca en la críticamente amenazada trucha Gila, Oncorhynchus gilae, y la trucha Apache, Oncorhynchus apache. Otro estudiante y yo produjimos el video para el Forest Service Ranger District en Safford, AZ. Utilicé el video para comprender qué elementos de la atracción visual captan la atención de las personas en videos con temas de conservación. Esta información ayudará a la producción de videos futuros para llamar la atención de un amplio espectro de personas. Quería saber específicamente lo que las personas estaban mirando durante la duración de 7 minutos. El video fue colocado en un espacio público durante 2 semanas. En esas 2 semanas observé y recolecté datos sobre quién echó un vistazo al video y lo que estaba siendo visto durante más de 5 segundos. Se observó que el macro, la variación de color, el movimiento y el patrón de la variación eran los más visualmente agradables. La filmación de macrografía permite al espectador observar las especies en alta definición y de manera muy cercana. La alta variación de color permite al espectador ver las especies y el paisaje circundante. Las especies que se mueven continuamente a lo largo de su entorno atrajeron la atención de las personas en contraste con los paisajes inmóviles. El metraje del patrón atrajo la atención de las personas desde una distancia mayor debido a la repetición de las formas. Esta información permitirá la producción de videos de conservación futuros para ganar interés de personas que no necesariamente *están interesadas en la conservación.*

NOTE: A manuscript was not submitted to accompany this presentation.

GrottoCenter, searching for natural caves in the Sonoran Desert and beyond (Poster)

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Cave definition is ambiguous, limited and depends of our personal perspective and knowledge about the subterranean environments. Our speleological group focus on several cavities such as caves, caverns, lava tubes and mines, however they are described as caves despite their origin, configuration, scale, substrates, contents and other issues. Classification systems have been proposed even though no single definition has been accepted. Nevertheless, there are basic categories that could guide us on fieldwork. The Pioneering Speleological Group of Sonora (G-PES, in Spanish) is our group dedicated to explore, research and conserve caves and others subterranean environment but searching and exploring cavities in the state of Sonora could be difficult. However, the increase of collaboration between groups and associations and development of new tools and software might support our pursuit for new cavities. For that reason, our objectives are to provide the characteristic of the different subterranean environments and the use of GrottoCenter platform. GrottoCenter is a community database developed for and by cavers on a wiki-like system. This platform works with cavers contributions; however, anyone can use it. The system allows to document and modify any cavities and search the "entries" entered by others. For the moment, we have been recorded 22 cavities in GrottoCenter but we are looking for more. We are seeing great results by explorers of Sonora who are recording the biodiversity of our state in different programs and we believe that their help could be a valuable resource to continue with our goals.

GrottoCenter, en busca de cuevas naturales en el desierto de Sonora y más allá (Cartel)

La definición de cueva es ambigua, limitada y depende de nuestra perspectiva personal y nuestro conocimiento sobre los entornos subterráneos. Nuestro grupo espeleológico se centra en varias cavidades, como cuevas, cavernas, tubos de lava y minas, sin embargo, se describen como cuevas a pesar de su origen, configuración, escala, sustratos, contenidos y otros problemas. Se han propuesto sistemas de clasificación aunque no se haya aceptado una definición única. Sin embargo, hay categorías básicas que podrían guiarnos en el trabajo de campo. El Grupo Espeleológico Pionero de Sonora (G-PES) es nuestro grupo dedicado a explorar, investigar y conservar cuevas y otros ambientes subterráneos, pero la búsqueda y exploración de cavidades en el estado de Sonora podría ser difícil. Sin embargo, el aumento de la colaboración entre grupos y asociaciones y el desarrollo de nuevas herramientas y software podrían respaldar nuestra búsqueda de nuevas cavidades. Por esa razón, nuestros objetivos son proporcionar la característica de los diferentes entornos subterráneos y el uso de la plataforma GrottoCenter. GrottoCenter es una base de datos de la comunidad desarrollada para y por espeleólogos en un sistema tipo wiki. Esta plataforma funciona con contribuciones de espeleólogos; sin embargo, cualquiera puede usarlo. El sistema permite documentar y modificar cavidades y buscar las "entradas" ingresadas por otros. Por el momento, se han registrado 22 cavidades en GrottoCenter, pero estamos buscando más. Estamos viendo excelentes resultados de exploradores de Sonora que registran la biodiversidad de nuestro estado en diferentes programas y creemos que su ayuda podría ser un recurso valioso para continuar con nuestros objetivos.

Note: Full Paper Follows

GrottoCenter, searching for natural caves in the Sonoran Desert and beyond.

Omar Calva and Clément J. M. Ronzon[1,2]

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***Abstract**--Cave definition is ambiguous, limited and depends on our personal perspective and knowledge about the subterranean systems and habitats. Speleological groups focus on several cavities such as caves, caverns, lava tubes and mines, which are all described as caves, despite their diverse origin, dimensions and environmental conditions. Classification systems have been proposed for all the subterranean habitats even though no single definition has been accepted. Nevertheless, there are basic categories that could guide us on fieldwork. The Pioneer Speleological Group of Sonora (G-PES, in Spanish) is a newly group dedicated to explore, study and conserve caves and others subterranean habitats, mainly in Sonora. Finding cavities in Sonora may seem, at first sight, rather difficult; however, the increasing collaboration between groups and associations, and development of new tools and specialized software strongly support the future search for new cavities. our pursuit for new cavities. For that reason, our main objectives are to publicize general characteristics of different subterranean habitats and learn the use including of GrottoCenter platform. GrottoCenter is a recent community database developed for and by cavers on a wiki-like system. This platform works with cavers contributions; however, anyone who has an Internet access can use it. The system allows to document and modify any cavity and search the "entries" entered by others. Until now, 22 cavities have been recorded in GrottoCenter, but we are looking for more. Great results are being provided by Sonoran explorers who are recording the biodiversity by different programs and we believe that their help could be a valuable resource to continue with search of cavities in Sonora.*

INTRODUCTION

Every year, there has been an increasing concern about biodiversity worldwide. Books and publications with a focus on biodiversity have appeared and a rapidly growing up of the amount of information is available (Bribiesca-Contreras and Solís-Marín, 2014; Culver and Sket, 2000; Palacios-Vargas *et al*., 2014). The same can be said about ONG's that provide different volunteer programs or public outreach tools to participate on biological inventories and collaborative conservation (e.g. Buckley, 2015; Girard and Campbell, 2016; Sky Island Alliance, 2017).

Molina-Freaner and Van Devender (2010) published a book about the biological diversity of Sonora, Mexico, identifying topics lacking previous knowledge as in the field of speleology. Speleology means the study of caves and treats the physical and biological aspects of cave environment (Montero-García, 2000; Moore and Sullivan, 1997; Palacios-Vargas, 1993; Palmer, 2012). Nevertheless, caves are not only subterranean environment. There are more subterranean habitats to explore and study (Carabajal *et al*., 1996; Culver and Pipan, 2009; Galán, 1993).

Even though Sonora state is the second biggest in surface in the country, there is a lack of information about many aspects of the speleology. Compared with the current knowledge of cavities of Mexico, Sonora represents 1.2% of the current knowledge (caves and cave dwelling fauna), but the geological evolution and variety of ecosystems that it presents in this state could be an ideal place to research several underground cavities of great biological and cultural value (Calva, 2017; Calva and Castillo-Gámez, 2014; Carabajal *et al*., 1996; Espinasa, 1994; González-León, 2010; Martínez-Hernández, 2004; Martínez-Yrízar, 2010; Moore and Sullivan, 1997; Palmer, 2012). Unfortunately, the understanding of cave definition and the extension of Sonora complicate our objectives about research, exploration and study of all the subterranean environments. However, there are several proposals that might help to understand the complexity of the subterranean habitats and what should we expect in Sonora.

Subterranean Environment

Cave has several definitions, for example, a cave is an empty space of natural origin that is in the underground, large enough to allow human to access. However, this definition excludes a variety of environments that are below the Earth's surface and have the potential to harbor similar physical conditions for living forms (Culver and Pipan, 2009; Montero-García, 2000; Palmer, 2012).

It has been established from the biological perspective that caves as part of the environment or subterranean habitat, which also includes lava tube, fissure system, underground surface, artificial cavities, etc. (Carabajal *et al*., 1996, Culver and Pipan, 2009; Galán, 1993).

The subterranean environment has a characteristic and unique climate, which differentiates it from other habitats. Cavities are much less variable than the surface, being considered as stable environment. The principal factors are absence of light, stable temperature and high levels of water vapor (Carabajal *et al*., 1996; Galán, 1993; Galán and Herrera, 1998; Hoffmann *et al*., 1986; Moore and Sullivan, 1997; Palmer, 2012; Poulson and White, 1969; Rouch, 1986; Trombe, 1952).

Types of Subterranean Habitat

In the speleological literature of subterranean habitats research, the use of morphological terms is indistinct. Therefore, the most accepted definition about subterranean habitats is any cavity, regardless the size, which is a potential habitat for terrestrial, freshwater or marine species, only if there are energetic resources and they exhibit the characteristics of physical conditions. Based on the explorations carried out in the state of Sonora, we agreed with different descriptions from several subterranean habitats based on different authors (Carabajal *et al*.,1996; Culver and Pipan, 2009; Galán, 1993; Medellin *et al*., 2017: Montero-García, 2000; Moore and Sullivan, 1997; Palmer, 2012; Romero, 2009), as we show next:

Cave: Natural or artificial cavities excavated or by dissolutive action of the underground waters when they pass through the pores and fissures of the soluble rocks. It is usually of lesser dimensions without exceeding one kilometer of extension. Present different types of speleothems.

Cavern: Deep natural cavities, subterranean or between rocks. It originates by excavation or dissolution like caves. Its extension is greater than one kilometer and less than 10 km long. Those exceeding 10 km are considered cavern system. Present different types of speleothems.

Lava tube: Occurs in areas where basaltic lava has recently flowed from volcanoes. A tube forms when a tongue of lava, flowing down a marked slope, solidifies on its outer surface while the interior remains molten and continues to flow. When the lava has drained out of the interior of the tongue, a tubular cavity remains. Usually they could have long extension but not much depth.

Mine: Created artificially. Dimensions may vary.

Bat cave: Cavities that are regularly used by bats as roosts. Due to the ecological importance of bats, there is a priority to find their roosts. Special type of cavities could be involved, small space without extension and depth such as rocky coats.

GrottoCenter

The site www.grottocenter.org is an international multi-language database dedicated to speleology and fed by speleologists on the principle of a Wiki. Any natural cavity can be recorded there. This Wiki system is a website on which users collaboratively modify content and structure directly from the web browser.

The site is published by the association Wikicaves which is partner of the UIS (International Union of Speleology) and the FSE (European Federation of Speleology) It has set itself to encourage the development of caving around the world, especially through the collaborative participation, disseminate and share information related to the practice of speleology, facilitate access to information on natural cavities, especially via the Internet to highlight and contribute to the protection of natural cavities and their environment, help the exploration and scientific study of natural cavities.

Wikicaves and GrottoCenter have more than 50,000 cavities documented, more than 86 countries involved and more than 2,800 supporters. However, the project continues progress and need more hands to evolve. Anyone can use the site to share knowledge of the underground world, mark its support by becoming an active member of the association or even join the team of developers to implement innovative web technologies.

CONCLUSIONS

Special attention is required during the description of what is a subterranean habitat such as caves, caverns, grottos, lava tubes, mines or bats caves. Usually, locals have a different understanding of what is a cave, complicated our pursuit to find new cavities. These misunderstanding combined with the dimension of the state of Sonora are the obstacles to overcome. Wiki system such as GrottoCenter are useful tools for conducting inventories of subterranean habitats and will be even more beneficial if we collaborate with the explorers of Sonora to cover more gaps together.

ACKNOWLEDGEMENTS

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Wildlife Tracking Squad (Poster)

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The Wildlife Tracking Squad is a group of young people dedicated to generate information on the movement of wildlife on the Sonoran section of the Western Corridor proposed by the Wildlands Network. It is important to obtain information and dissemination material about wildlife, conservation and species that are in danger of extinction. For that it is necessary to give talks about the importance of these issues, so that people learn to conserve Sonora's fauna, and not only here, but throughout Mexico. In the road ecology methodology on highway 14, the most affected animals were skunks with a total of 9, gray fox with a total of 4, opossum with a total of 3, followed by lagomorphs. The least affected currently was the coyote, in which only one individual was found. Transect Mazocahui: In the search for traces, excreta or any sign of life of the animals, the most found in footprints has been the raccoon, followed by white-tailed deer, few footprints of wild cats and cat excreta have been found. We continue working to find more wild traces.

Escuadrón de Rastreo de Fauna Silvestre (Cartel)

Esta es un grupo de jóvenes dedicados generar información sobre el movimiento de la fauna silvestre sobre la sección Sonorense del Corredor Occidental propuesto por Wildlands Network. Es importante obtener información y material de difusión sobre fauna silvestre, conservación y especies que están en peligro de extinción. Para eso es necesario dar pláticas sobre la importancia de estos temas, para que la gente aprenda a conservar la fauna de Sonora, y no sólo aquí, sino en todo México. En la metodología de ecología de carreteras en la carretera 14, los animales más afectados han sido los zorrillos con un total de 9, zorro gris con un total de 4, tlacuache con un total de 3, seguidos de lagomorfos. El menos afectado por el momento ha sido el coyote, en el cual solo se encontró a un individuo. Transecto Mazocahui: En la búsqueda de huellas, excretas o alguna señal de vida de los animales, el más encontrado en huellas ha sido el mapache, seguido de venado cola blanca, se han encontrado pocas huellas de gato montés y excretas de felinos. Por el momento seguimos trabajando paraencontrar más rastros silvestres.

NOTE: A manuscript was not submitted to accompany this presentation.

How Section 6 of the ESA helps conserve Arizona's rare plants (Poster)

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The Endangered Species Act of 1973 (ESA) seeks to identify, list, and recover all plants and animals in danger of extinction throughout all or a significant portion of their range. Section 6 of the ESA provides the mechanism by which the United States Fish and Wildlife Service (USFWS) works with appropriate state agencies to conduct investigations to determine the status and requirements for survival of plant and animal species. In Arizona, the section 6 program team for plants consists of the USFWS, the Arizona Department of Agriculture, and the University of Arizona Herbarium working cooperatively to fund rare plant studies. Since 2006, the program has supported more than 90 projects, with Federal contributions over $1.3M, and non-Federal matching contributions exceeding $800k. Through the combined efforts of dozens of researchers, we now have information on population size and trend, plant ecology, germination requirements, population genetics, pollinator biology, species delimitation, and habitat assessment on many of Arizona's rare plant

species, as well as methods for improving survey success and development of molecular markers, among other examples. The Madrean Archipelago harbors many plant species of conservation concern, and the Section 6 program is proud to be able to provide resources for furthering our understanding of these species and this unique ecosystem. Our poster provides information on the Section 6 program, as well as examples of 20 current and recent projects from the Madrean Archipelago in both Arizona and northern Mexico.

Cómo la Sección 6 de la ESA ayuda a conservar las plantas raras de Arizona (Cartel)

La Ley de Especies en Peligro de 1973 (ESA, por sus siglas en inglés) busca identificar, enumerar y recuperar todas las plantas y animales en peligro de extinción en la totalidad o una parte importante de su área de distribución. La Sección 6 de la ESA proporciona el mecanismo por el cual el Servicio de Pesca y Vida Silvestre de los Estados Unidos (USFWS) trabaja con las agencias estatales apropiadas para llevar a cabo investigaciones para determinar el estado y los requisitos de supervivencia de las especies de plantas y animales. En Arizona, el equipo del programa de la Sección 6 para plantas está formado por el USFWS, el Departamento de Agricultura de Arizona y el Herbario de la Universidad de Arizona que trabajan en cooperación para financiar estudios de plantas poco comunes. Desde 2006, el programa ha apoyado más de 90 proyectos, con contribuciones federales superiores a $ 1.3 millones y contribuciones de contrapartida no federales que superan los $ 800,000. A través de los esfuerzos combinados de docenas de investigadores, ahora tenemos información sobre tamaño y tendencia de la población, ecología vegetal, requisitos de germinación, genética de poblaciones, biología de polinizadores, delimitación de especies y evaluación de hábitat en muchas de las especies de plantas poco comunes en Arizona, así como métodos para mejorar el éxito de la encuesta y el desarrollo de marcadores moleculares, entre otros ejemplos. El Archipiélago Madrense alberga muchas especies de plantas de interés para la conservación, y el programa de la Sección 6 se enorgullece de poder proporcionar recursos para mejorar nuestra comprensión de estas especies y este ecosistema único. Nuestro póster brinda información sobre el programa de la Sección 6, así como ejemplos de 20 proyectos actuales y recientes del Archipiélago Madrense tanto en Arizona como en el norte de México.

NOTE: A manuscript was not submitted to accompany this presentation.

What is historical range for native fishes? (Poster)

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Determining the historical range for native fishes is important for understanding ecosystem functioning on a broad scale, determining how ecosystems and species have changed in the Anthropocene, and is vitally important when considering and justifying conservation actions. Comparing the current range of a species to its historical range is a major consideration when considering if conservation actions should be taken for the species and is especially important when considering if a species will be listed under the U.S. Endangered Species Act. The Desert Fishes Recovery Team, before it was unceremoniously terminated, and specifically team leader W. L. Minckley, discussed how historical range was viewed for at least the native fishes under the purview of the Recovery Team. I'm sure Dr. Minckley and other Recovery Team members applied that view of how historical range was determined to other native fishes. Basically, the view was that historical range should be considered extensively, and should not be limited to known collection localities, or even only streams with collections. The concept will be discussed as to how it has been applied to the conservation of native fishes in Arizona, and how it has also created some conflicts with the conservation of native non-fish aquatic species. This concept of historical range has been used in: the Arizona Game and Fish Safe Harbor Agreement for Topminnows and Pupfish, the Gila Topminnow revised recovery plan, the Gila River Basin Native Fishes Conservation Program (CAP), and the draft Gila Chub recovery plan.

¿Cuál es el rango histórico para los peces nativos? (Cartel)

La determinación del rango histórico para los peces nativos es importante para comprender el funcionamiento del ecosistema a gran escala, determinar cómo han cambiado los ecosistemas y las especies en el Antropoceno, y es de vital importancia cuando se consideran y justifican las acciones de conservación. Comparar el rango actual de una especie con su rango histórico es una consideración importante al considerar si se deben tomar medidas de conservación para la especie y es especialmente importante cuando se considera si una especie se incluirá en la lista bajo la Ley de Especies en Peligro de los EE. UU. El Equipo de Recuperación de Desert Fishes, antes de que terminara sin ceremonias, y específicamente el líder del equipo W. L. Minckley, discutieron cómo se veía el rango histórico para al menos los peces nativos bajo el control del Equipo de Recuperación. Estoy seguro de que el Dr. Minckley y otros miembros del Equipo de recuperación aplicaron esa visión de cómo se determinó el alcance histórico para otros peces nativos. Básicamente, la opinión era que el rango histórico debe considerarse extensamente, y no debe limitarse a las localidades de recopilación conocidas, o incluso solo las secuencias con colecciones. El concepto será discutido sobre cómo se ha aplicado a la conservación de peces nativos en Arizona, y cómo también ha creado algunos conflictos con la conservación de especies acuáticas nativas que no son peces. Este concepto de rango histórico se ha utilizado en el Acuerdo de Arizona Safe Fish Harbor para Topminnows y Pupfish, el plan de recuperación revisado de Gila Topminnow, el Programa de Conservación de Peces Nativos (CAP) de la cuenca del río Gila y el proyecto de plan de recuperación Gila Chub.

NOTE: A manuscript was not submitted to accompany this presentation.

The Southwest Climate Adaptation Science Center: Toward actionable & decision-relevant science for climate adaptation (Poster)

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The Southwest Climate Adaptation Science Center (SW CASC) is one in a network of eight regional CASCs created by the Department of Interior in 2011. Based in Tucson, the center is hosted by the University of Arizona and is led by seven member institutions from Arizona, California, Nevada, and Utah. The broader CASC network is overseen by the National Climate Adaptation Science Center (formerly the National Climate Change & Wildlife Science Center) based at U.S. U.S. Geological Survey (USGS) headquarters in Reston, VA. On an annual basis, the SW CASC typically provides competitive grants to researchers whose projects align with our mission and goals. These have evolved since our inception, from producing climate science primarily focused on the impacts and vulnerability of natural resources to actionable science for effective climate adaptation. We do this through increasing our investments in translational ecology/science, enhancing capacity building programs, and focusing on knowledge co-production. Each of these concepts has strong links to the foundational social science research that informs many of the most dynamic and highly functional organizations and institutions, such as collaboration, communication, and commitment. In this way, we aim to improve decision-making relative to management of the Nation's natural resources now and into the future.

El Centro de Ciencia de Adaptación Climática del Suroeste de los Estados Unidos: Hacia una ciencia procesable y relevante para la toma de decisiones para la adaptación climática (Cartel)

El Centro de Ciencia de Adaptación Climática del Sudoeste (SW CASC, por sus siglas en ingles) es uno de una red de ocho CASC regionales creadas por el Departamento del Interior en 2011. Con sede en Tucson, el centro está organizado por la Universidad de Arizona y está dirigido por siete instituciones miembros de Arizona, California, Nevada y Utah. La red CASC más amplia es supervisada por el Centro Nacional de Ciencias para la Adaptación al Clima (anteriormente el Centro Nacional de Cambio Climático y Ciencias de la Vida Silvestre) con sede en la sede del Servicio Geológico de EE. UU. (USGS) en Reston, VA. Sobre una base anual, el SW CASC normalmente otorga becas competitivas a los investigadores cuyos proyectos se alinean con nuestra misión y objetivos. Estos han evolucionado desde nuestros comienzos, desde la producción de ciencia del clima centrada principalmente en los impactos y la vulnerabilidad de los recursos naturales hasta la ciencia procesable para una adaptación climática efectiva. Lo hacemos incrementando nuestras inversiones en ecología / ciencia traslacional, mejorando los programas de creación de capacidades y centrándonos en la coproducción de conocimiento. Cada uno de estos conceptos tiene fuertes vínculos con la investigación fundamental de las ciencias sociales que informa a muchas de las organizaciones e instituciones más dinámicas y altamente funcionales, como la colaboración, la comunicación y el compromiso. De esta manera, nuestro objetivo es mejorar la toma de decisiones relativas a la gestión de los recursos naturales de la nación ahora y en el futuro.

NOTE: A manuscript was not submitted to accompany this presentation.

Holocene record of vegetation change at Tonibabi cienega, Sonora, Northwestern Mexico (Poster)

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The Holocene epoch, covering the last 11,700 years, has been characterized by great global climatic variability. In Northwestern Mexico, these changes gave rise to the replacement of mixed conifers forests by pine-oak forests in the Sierra Madre Occidental, and the establishment of the current vegetation in the Sonoran Desert region. However, the response of the vegetation in the Madrean Archipelago region is poorly known. A paleopalynological study was carried out at Tonibabi cienega, a hot spring located in the southern slope of the Sierra La Madera (before Sierra La Oposura), with the aim of reconstructing the plant communities present in the site during the Holocene epoch. The early Holocene record, 9350 years ago, suggests the vegetation around the Tonibabi cienega was dominated by a pine-oak forest. During the middle Holocene, 5220 years ago, the subtropical thorn scrub was established. The late Holocene shows temporal changes, such as 2490 years ago, when the temperate forest briefly returned to the site; finally, the subtropical thorn scrub prevailed the last 920 years. The results allowed us to reconstruct the history of vegetation in the southern slope of the Sierra La Madera. This is one of the first vegetation reconstructions for the southern Sky Island Region, and it shows that vegetation has been modeled through climatic variability during the Holocene.

Registro holocense de cambio de vegetación en la Ciénega de Tonibabi, Sonora, noroeste de México (Cartel)

La época del Holoceno, que abarca los últimos 11,700 años, se ha caracterizado por una gran variabilidad climática global. En el noroeste de México, estos cambios dieron lugar a la sustitución de bosques mixtos de coníferas por bosques de pino-encino en la Sierra Madre Occidental, y al establecimiento de la vegetación actual en la región del Desierto de Sonora. Sin embargo, la respuesta de la vegetación en la región del archipiélago Madrense es poco conocida. Se realizó un estudio paleopalinológico en la ciénaga de Tonibabi, un manantial termal ubicado en la vertiente sur de la Sierra La Madera (antes Sierra La Oposura), con el objetivo de reconstruir las comunidades vegetales presentes en el sitio durante la época del Holoceno. El registro del Holoceno temprano, hace 9350 años, sugiere que la

vegetación alrededor de la ciénaga de Tonibabi estaba dominada por un bosque de pino y roble. Durante el Holoceno medio, hace 5220 años, se estableció el matorral espinoso subtropical. El Holoceno tardío muestra cambios temporales, como hace 2490 años, cuando el bosque templado regresó brevemente al sitio; finalmente, el matorral espinoso subtropical prevaleció durante los últimos 920 años. Los resultados nos permitieron reconstruir la historia de la vegetación en la vertiente sur de la Sierra La Madera. Esta es una de las primeras reconstrucciones de vegetación para la región sur de Sky Island, y muestra que la vegetación ha sido modelada a través de la variabilidad climática durante el Holoceno.

NOTE: A manuscript was not submitted to accompany this presentation.

Vegetation dynamic in the Sierra La Madera, Sonora, Mexico, during the last 1500 years (Poster)

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Paleoecological studies make it possible to infer the functioning and dynamics of changing ecosystems over time, based on the assumption that the factors that currently affect organisms did it in the same way in the past. The present study, carried out in a cienega located in the southern slope of the Sierra La Madera, in the municipality of Moctezuma, Sonora, México, consists of a reconstruction of the vegetation over the last 1500 years. This site was selected due to its susceptibility to climate variations, and to the limited knowledge of the paleoecology of this Sonoran region. For the purpose of this study, a sediment core (49 cm- length) dated ~1300 calibrated years BP (cal yr BP) was extracted from the cienega. High-resolution pollen analysis showed changes in the vegetation in response to climatic changes, although these latter seemed of minor scale. The applied complementary statistical analyses, such as Principal Components Analysis, Detrended Correspondence Analysis and CONISS, allowed to reduce the multivariate data assemblage and showed a constant homogeneity throughout the sedimentary sequence; this information confirms that the vegetation around the study site was a thornscrub all along this period. However, pollen spectra recorded vegetation changes linked to aridity events (1300-1100 cal yr BP) and moisture pulses (~1000 cal yr BP), as well as the Medieval Warm Period, an event recognized at the global level.

Dinámica de la vegetación en Sierra La Madera, Sonora, México, durante los últimos 1500 años (Cartel)

Los estudios paleoecológicos permiten inferir el funcionamiento y la dinámica de los ecosistemas cambiantes a lo largo del tiempo, basándose en la suposición de que los factores que afectan actualmente a los organismos lo hicieron de la misma manera en el pasado. El presente estudio, llevado a cabo en una ciénega ubicada en la ladera sur de la Sierra La Madera, en el municipio de Moctezuma, Sonora, México, consiste en una reconstrucción de la vegetación en los últimos 1500 años. Este sitio fue seleccionado debido a su susceptibilidad a las variaciones climáticas y al conocimiento limitado de la paleoecología de esta región de Sonora. Para el propósito de este estudio, se extrajo un núcleo de sedimento (49 cm de longitud) de ~ 1300 años calibrados BP (cal yr BP) de la ciénega. El análisis de polen de alta resolución mostró cambios en la vegetación en respuesta a los cambios climáticos, aunque estos últimos parecían tener una escala menor. Los análisis estadísticos complementarios aplicados, como el Análisis de Componentes Principales, el Análisis de Correspondencia Desaparecido y CONISS, permitieron reducir el conjunto de datos multivariantes y mostraron una homogeneidad constante a lo largo de la secuencia sedimentaria; esta información confirma que la vegetación alrededor del sitio de estudio fue un espino a lo largo de este período. Sin embargo, los espectros de polen registraron cambios de vegetación relacionados con eventos de aridez (1300-1100 cal año BP) y pulsos de humedad (~ 1000 cal año BP), así como el Período Cálido Medieval, un evento reconocido a nivel mundial.

NOTE: A manuscript was not submitted to accompany this presentation.

Nesting ecology of the desert rattle (*Campylorhynchus brunneicapillus*) in a coastal region of the municipality of Hermosillo, Sonora (Poster)

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The Cactus wren (*Campylorhynchus brunneicapillus*) is a bird characteristic of the Sonoran Desert, which is distributed from southeastern California to central Mexico, occupying a variety of very dry habitats. They build closed nests on cacti, mainly *Cylindropuntia fulgida*, using grasses, branches, fine herbs and some feathers. Its nesting season lasts around 20 days and happens in the months of March to August. The present study aims to document the basic aspects of the nesting ecology of this desert bird by means of data on the physiognomic characteristics and the orientation of its nests, as well as the differences between nests according to their host plants. The average height with respect to the ground was 1.3 m ± 0.27, entrance diameter of 6.46 cm ± 1.72 and average length of 23.94 cm ± 5.86, showing preference for C. fulgida to use as a host plant. The uniformity analysis shows that there is no unidirectionality in the orientation of the nests. Measurements of the microclimates inside the nests are currently carried out using temperature sensors. The importance of the study lies in the need to generate up-to-date information on this desert bird in the remainder of its distribution south of the border, the lack of importance that has been given to the species in recent decades and the lack of research about the ecology of this bird species in Mexico.

Ecología de la anidación de la matraca del desierto (Campylorhynchus brunneicapillus) en una región costera del municipio de Hermosillo, Sonora (Poster)

La matraca del desierto (Campylorhynchus brunneicapillus) es un ave característica del Desierto Sonorense, la cual se distribuye desde el sureste de California hasta el centro de México, ocupando una variedad de hábitats muy secos. Construyen nidos cerrados sobre cactáceas, principalmente Cylindropuntia fulgida, utilizando pastos, ramas, hierbas finas y algunas plumas. Su temporada de anidamiento dura alrededor de 20 días y sucede en los meses de marzo a agosto. El presente estudio pretende documentar los aspectos básicos de la ecología de la anidación de esta ave desértica mediante datos sobre las características fisionómicas y la orientación de sus nidos, así como de las diferencias entre nidos de acuerdo con sus plantas hospederas. El promedio de altura con respecto al suelo fue de 1.3 m ± 0.27, diámetro de entrada de 6.46 cm ± 1.72 y longitud promedio de 23.94 cm ± 5.86, mostrando preferencia por C. fulgida para utilizar como planta hospedera. El análisis de uniformidad muestra que no hay unidireccionalidad en la orientación de los nidos. Actualmente se llevan a cabo las mediciones de los microclimas al interior de los nidos mediante la utilización de sensores de temperatura. La importancia del estudio recae en la necesidad de generar información actualizada sobre esta ave desértica en lo que resta de su distribución al sur de la frontera, a la poca importancia que se le ha brindado a la especie en las últimas décadas y a la falta de investigaciones sobre la ecología de esta especie de ave en México.

NOTE: A manuscript was not submitted to accompany this presentation.

Characterizing the symbiosis between the dacetine ant *Strumigenys arizonica* and the fungus-growing ant *Trachymyrmex arizonensis* in southwestern North America (Poster)

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Over forty years ago, the dacetine ant *Strumigenys arizonica* was discovered in a nest of the fungus-growing ant *Trachymyrmex arizonensis* at Madera Canyon in the Santa Rita Mountains of the southwestern United States. This discovery suggested that the two species form compound nests, but this hypothesis has not been investigated. Here, we characterize the symbiosis between *S. arizonica* and *T. arizonensis* through the analysis of collection records supplemented by novel field and laboratory observations. Our observations confirm that *S. arizonica* and *T. arizonensis* can form compound nests, and current evidence suggests that these compound nests are a type of commensalistic symbiosis. *Strumigenys arizonica* forage in galleries and tunnels of *T. arizonensis* nests but do not steal fungus or brood from *T. arizonensis*. Instead, workers of *S. arizonica* hunt collembolans in the internal refuse piles of *T. arizonensis* nests. *Strumigenys arizonica* was never found independent of its host *T. arizonensis* and the geographic distribution of *S. arizonica* covered a significant portion of the geographic distribution of *T. arizonensis*. These results suggest a tight but asymmetric association where compound nesting is seemingly obligate for *S. arizonica* and facultative for *T. arizonensis*. Future work will investigate the co-evolutionary history between these two ant partners with a special focus on Madrean sky island populations.

Caracterización de la simbiosis entre la hormiga dacetina Strumigenys arizonica y la hormiga fungicida Trachymyrmex arizonensis en el suroeste de América del Norte (Cartel)

Hace más de cuarenta años, se descubrió la hormiga dacetina Strumigenys arizonica en un nido de la hormiga fungicida Trachymyrmex arizonensis en el Cañon Madera en las montañas Santa Rita, en el suroeste de los Estados Unidos. Este descubrimiento sugirió que las dos especies forman nidos compuestos, pero esta hipótesis no ha sido investigada. Aquí, caracterizamos la simbiosis entre S. arizonica y T. arizonensis a través del análisis de registros de recolección complementados por nuevas observaciones de campo y de laboratorio. Nuestras observaciones confirman que S. arizonica y T. arizonensis pueden formar nidos compuestos, y la evidencia actual sugiere que estos nidos compuestos son un tipo de simbiosis comensalística. El forraje de Strumigenys arizonica en galerías y túneles de T. arizonensis anida pero no roba hongos o crías de T. arizonensis. En cambio, los trabajadores de S. arizonica cazan collembolans en las pilas internas de basura de los nidos de T. arizonensis. Strumigenys arizonica nunca se encontró independiente de su huésped T. arizonensis y la distribución geográfica de S. arizonica cubrió una porción significativa de la distribución geográfica de T. arizonensis. Estos resultados sugieren una asociación estrecha pero asimétrica donde el anidamiento compuesto es aparentemente obligado para S. arizonica y facultativo para T. arizonensis. El trabajo futuro investigará la historia co-evolutiva entre estos dos socios hormonales con un enfoque especial en las poblaciones de las Islas Serranas.

NOTE: A manuscript was not submitted to accompany this presentation.

The increase in the average temperature of the Earth (Poster)

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Expert in renewable energy and energy efficiency shares his passion for the analysis of climate change and especially the effects in the event that the average temperature of the Earth increased from 1 to 6 degrees.

El aumento de la temperatura promedio de la Tierra (Cartel)

Experto en Energias renovables y eficiencia energetica comparte su pasion por el analisis del cambio climatico y sobre todo los efectos en el caso de que aumentara la temperatura promedio de la Tierra de 1 a 6 grados.

NOTE: A manuscript was not submitted to accompany this presentation.

Pixel base Correlation for southern AZ using Prism and MODIS data to identify and monitor buffelgrass. (Poster)

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A major threat to the Sonoran Desert is the persistence and expansion of buffelgrass, an invasive perennial grass that out-competes native vegetation and changes fire regimes. Native desert landscapes are typically composed of widely-space plants that do not carry fire. Buffelgrass introduces a blanket of highly flammable fine fuels into this landscape, carrying fire broadly and killing non-fire adapted cacti and native plants. The impacts of buffelgrass are expected to accelerate given global climate change. The focus of this research project is to promote buffelgrass management in the southwest, specifically the states of Arizona and California. Our research builds on previous work (Wallace et al., 2016) that coupled Moderate-resolution Imaging Spectroradiometer (MODIS) imagery, PRISM precipitation data and ground observations of buffelgrass phenology to map the presence and phenological status of the invasive species. The previous research produced Climate Landscape Response (CLaRe) metrics, which capture the strength of the landscape greenness response to lagged precipitation and expose buffelgrass due to its more rapid green-up following precipitation events when compared to native vegetation. We extend the temporal mapping of CLaRe metrics from 2010 to 2016 regionally across the southwest to identify nascent (new) infestations of invasive buffelgrass by examining the temporal patterns of CLaRe values. If successful, this research will allow managers to treat infestations when they are smaller and prioritize treatment in areas that are spreading most rapidly.

Correlación de la base del píxel para el sur de AZ usando datos Prism y MODIS para identificar y monitorear el zacate buffel. (Cartel)

Una gran amenaza para el Desierto de Sonora es la persistencia y expansión del pasto buffel, un pasto perenne invasor que compite con la vegetación nativa y modifica los regímenes de incendios. Los paisajes nativos del desierto se componen típicamente de plantas de amplio espacio que no portan fuego. Buffelgrass introduce un manto de combustibles finos altamente inflamables en este paisaje, el cual lleva el fuego ampliamente y mata cactus y plantas nativas no adaptadas

al fuego. Se espera que los impactos del buffelgrass se aceleren dado el cambio climático global. El objetivo de este proyecto de investigación es promover el manejo del pasto buffel en el suroeste de los Estados Unidos, específicamente en los estados de Arizona y California. Nuestra investigación se basa en trabajos previos (Wallace et al., 2016) que acoplaron imágenes del espectrorradiómetro de imágenes de resolución moderada (MODIS), datos de precipitación PRISM y observaciones de la fenología del pasto buffel para determinar la presencia y el estado fenológico de las especies invasoras. La investigación anterior produjo métricas de Respuesta del Paisaje Climático (CLaRe), que capturan la fuerza de la respuesta del verdor del paisaje a la precipitación rezagada y exponen el zacate buffel debido a su precipitación más rápida después de los eventos de precipitación en comparación con la vegetación nativa. Extendemos el mapeo temporal de las métricas de CLaRe de 2010 a 2016 a nivel regional en el sudoeste para identificar infestaciones nacientes (nuevas) de pasto buffel invasivo mediante el examen de los patrones temporales de los valores CLaRe. Si tiene éxito, esta investigación permitirá a los gerentes tratar infestaciones cuando son más pequeñas y priorizar el tratamiento en áreas que se propagan más rápidamente.

NOTE: A manuscript was not submitted to accompany this presentation.

Sensitive Species of the Madrean Archipelago in Arizona: An Arizona Natural Heritage Program perspective of Patterns, Knowledge Gaps, and Opportunities. (Poster)

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The Arizona Heritage Data Management System (HDMS) is part of a global network of natural heritage programs that identify and track species of concern, consolidating information about their distribution and status for environmental compliance, research, and conservation actions. HDMS currently tracks over 2200 taxa, among which 447 have special status at the federal, tribal, or state level. In this analysis, we compile the data available for special status taxa in the HDMS for the Madrean Archipelago in Arizona. We find that the region contains 45% of all special status species in the state, including 26 listed taxa on the Endangered Species Act, 8 with candidate conservation agreements, and an additional 70 species of concern. Our motivations for this study are threefold: 1) to explore patterns within the Madrean Archipelago in Arizona that contain high concentrations of sensitive species and high conservation potential; 2) to identify those taxa and areas which lack recent survey efforts; and 3) to bring to light opportunities for research, conservation, and citizen science to remedy these knowledge gaps. We highlight use-cases of how these data have been utilized in decision-making to cultivate future collaborations for conservation and management both in the area and across the state.

Especies Sensibles del Archipiélago Madrense en Arizona: Una perspectiva del Programa de Patrimonio Natural de Arizona sobre Patrones, Brechas de Conocimiento y Oportunidades (Cartel)

El Sistema de Gestión de Datos Patrimoniales de Arizona (HDMS por sus siglas en inglés) es parte de una red mundial de programas de patrimonio natural que identifican y rastrean especies de interés, consolidando información sobre su distribución y estado para cumplimiento medioambiental, investigación y acciones de conservación. HDMS actualmente rastrea más de 2200 taxones, de los cuales 447 tienen un estatus especial a nivel federal, tribal o estatal. En este análisis, compilamos los datos disponibles para taxones de estado especiales en el HDMS para el Archipiélago Madrense en Arizona. Encontramos que la región contiene el 45% de todas las especies de estatus especial en el estado, incluidos 26 taxones listados en la Ley de Especies en Peligro de Extinción, 8 candidatos con acuerdos de conservación y 70 especies

de preocupación adicionales. Nuestras motivaciones para este estudio son triples: 1) explorar patrones dentro del Archipiélago Madrense en Arizona que contienen altas concentraciones de especies sensibles y un alto potencial de conservación; 2) identificar aquellos taxones y áreas que carecen de esfuerzos recientes de encuesta; y 3) sacar a la luz oportunidades de investigación, conservación y ciencia ciudadana para remediar estas lagunas de conocimiento. Destacamos los casos de uso de cómo estos datos se han utilizado en la toma de decisiones para cultivar colaboraciones futuras para la conservación y el manejo, tanto en el área como en todo el estado.

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Manage the invasive Sahara mustard collaboratively through understanding its invasion from microbial to regional scale (Poster)

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Sahara mustard is an invasive species of winter annual plant that threatens native plant diversity in the Sonoran and Mojave Desert. In this talk, I will summarize findings of eight years of work that provides key understanding of its invasion in relation to native plant species. These findings include weak seed banks of Sahara mustard that are likely attacked by soilborne fungi during summer monsoons, large-scale habitat preference of Sahara mustard and the spatial variation of its population abundance in southwestern Arizona, and the expansion history of this species over North America continent since its introduction. I will also summarize the successes and challenges of our inter-agency collaborative efforts to manage its invasion over nearly 1.5 million acres of federal land that includes the Cabeza Prieta National Wildlife Refuge and the Barry M. Goldwater West.

Gestión colaborativa de la invasiva mostaza del Sahara mediante la comprensión de su invasión desde una escala microbiana a regional (Cartel)

La mostaza del Sahara es una especie de planta invasora anual de invierno que amenaza la diversidad de plantas nativas en los desiertos de Sonora y Mojave. Resumiré los hallazgos de ocho años de trabajo que proporcionan una comprensión clave de su invasión en relación con las especies de plantas nativas. Estos resultados incluyen los bancos débiles de semilla que probablemente son atacadas por hongos del suelo durante los monzones de verano, a la gran escala de la preferencia de hábitat y la variación espacial de la abundancia de la población en el suroeste de Arizona, y la historia de la expansión de esta especie a lo largo del continente Americano desde su introducción. También voy a resumir los éxitos y desafíos de nuestros esfuerzos de colaboración entre organismos para gestionar su invasión sobre cerca de 1.5 millones de acres de tierras federales que incluye la Cabeza Prieta National Wildlife Refuge y el Barry M. Goldwater Oeste.

NOTE: A manuscript was not submitted to accompany this presentation.

Spruce-Fir Colonization Following a High-Severity Fire in 1685 in Southern Arizona (Poster)

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The spruce-fir forest of the Pinaleño Mountains in southeast Arizona burned in a high-severity fire in 1685. No fires entered the spruce-fir forest between 1685 and 2004, when it again burned in a high-severity fire. We dendrochronologically reconstructed tree population dynamics over the 300+ years between the two fires from 58 plots on a gridded sample design. Engelmann spruce began recruiting in the burned area within 10 years, and dominated recruitment throughout most of the 300-year period of reconstruction. Corkbark fir began recruiting within 30 years, but did not recruit in large numbers until the late 1810s (120 years post-fire). Both species appear to have recruited from isolated refugial populations in cienegas and steep north-facing canyons. A 900-ha burned area was not fully colonized for 120-180 years. Fire was excluded from the adjacent mixed-conifer forest beginning in the 1870s. Spruce and fir immediately began recruiting rapidly in the mixed-conifer vegetation zone, and doubled their extent within 40 years. Prior to the 2004 fire, spruce occupied 2.5 times the territory it did before fire exclusion.

Colonización de Abeto después de un Incendio de Alta Severidad en 1685 en el sur de Arizona (Cartel)

El bosque de abetos de abeto de las montañas Pinaleño en el sudeste de Arizona se quemó en un incendio de gran intensidad en 1685. No hubo incendios en el bosque de abetos entre 1685 y 2004, cuando volvió a arder en un incendio de gran intensidad. Hemos dendrocronológicamente reconstruido la dinámica de la población de árboles en los más de 300 años entre los dos incendios de 58 parcelas en un diseño de muestra cuadriculada. La pícea de Engelmann comenzó a reclutar en el área quemada en 10 años y dominó el reclutamiento durante la mayor parte del período de reconstrucción de 300 años. El abeto Corkbark comenzó a reclutar en 30 años, pero no reclutaba en grandes cantidades hasta finales de la década de 1810 (120 años después del incendio). Ambas especies parecen haber reclutado poblaciones aisladas de refugio en ciénegas y escarpadas cañadas orientadas al norte. Un área quemada de 900 hectáreas no fue completamente colonizada por 120-180 años. Se excluyó el fuego del bosque adyacente de coníferas mixtas a partir de la década de 1870. Abeto inmediatamente comenzó a reclutar rápidamente en la conífera mixta, y duplicaron su extensión en 40 años. Antes del incendio de 2004, el abeto ocupaba 2.5 veces el territorio que tenía antes de la exclusión del fuego.

NOTE: A manuscript was not submitted to accompany this presentation.

Modeled climate-growth relations and changing tree species distribution in mixed conifer forest across a biophysical gradient (Poster)

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Resilience and the potential for species distribution shifts relating to climate change is a pressing concern for forests. The effects of increasing temperature and changing precipitation patterns are confounded by the legacy of disturbance and altered fire regimes, which gives us the forest present on the landscape today and the potential for future changes. We

consider how climate drivers influence tree ring growth in southwest mixed conifer forests, across a biophysical gradient within one watershed in northern New Mexico, stretching across the elevation range for two dominant mixed conifer species, Pinus ponderosa and Pseudotsuga menziesii. We asked whether species-specific mean tree-ring chronologies grouped by elevation-aspect are modeled better by PRISM-derived temperature or precipitation metrics using AIC model selection, and used GIS to show the areas across the watershed that fit each climate-growth model. We combine this with demography shifts in the relative distribution of the six most common tree species, predicting from the model the potential for upward movement. We found differences in the climate-growth relationship between species at their lower elevational limit, and similarities between lower NE-aspects and higher SW-aspects. We found a general trend upwards in the mean of species distribution between mature trees and seedlings across elevation-aspect groups. Seedling establishment was concentrated in mid-elevation southwest sites, likely reflecting a combination of microclimatic optima and available resources. The growth-climate model informs the potential for species shifts, with patterns of recent seedling establishment indicating the onset of changes, notably increasing dominance of Pinus edulis near its upper elevational limits.

Modelado de las relaciones entre el clima y el crecimiento y la distribución cambiante de las especies arbóreas en el bosque mixto de coníferas a través de un gradiente biofísico (Cartel)

La resiliencia y el potencial de los cambios en la distribución de las especies relacionados con el cambio climático es una preocupación apremiante para los bosques. Los efectos del aumento de la temperatura y los cambios en los patrones de precipitación se confunden con el legado de perturbación y los regímenes de incendios alterados, lo que nos da el bosque presente en el paisaje actual y el potencial de cambios futuros. Consideramos cómo los impulsores del clima influyen en el crecimiento del anillo en bosques de coníferas mixtas del sudoeste, a través de un gradiente biofísico dentro de una cuenca en el norte de Nuevo México, extendiéndose a lo largo del rango de elevación para dos especies dominantes de coníferas mixtas, Pinus ponderosa y Pseudotsuga menziesii. Preguntamos si las cronologías de anillos de árboles de especies específicas agrupadas por aspecto de elevación se modelan mejor mediante mediciones de temperatura o precipitación derivadas de PRISM utilizando la selección de modelos AIC, y utilizamos SIG para mostrar las áreas de la cuenca que se ajustan a cada modelo de crecimiento climático. Combinamos esto con cambios demográficos en la distribución relativa de las seis especies arbóreas más comunes, prediciendo a partir del modelo el potencial de movimiento ascendente. Encontramos diferencias en la relación clima-crecimiento entre las especies en su límite de altitud inferior, y similitudes entre aspectos de NE más bajos y aspectos de SW más elevados. Encontramos una tendencia general hacia arriba en la distribución de especies entre árboles maduros y plántulas en los grupos de elevación y aspecto. El establecimiento de plántulas se concentró en sitios del sudoeste de altura media, probablemente reflejando una combinación de óptimos microclimáticos y recursos disponibles. El modelo de crecimiento-clima informa el potencial de cambios de especies, con patrones de establecimiento reciente de plántulas que indican el inicio de los cambios, notablemente el aumento del predominio de Pinus edulis cerca de sus límites de elevación superiores.

NOTE: A manuscript was not submitted to accompany this presentation.

Native Plants in Quarries of the State of Sonora (Poster)

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The state of Sonora is a semi-desertic region facing severe problems concerning low precipitation, which has led to the

decrease in populations of forge plants, in addition to overgrazing activities and change in the use of land. The aim of this investigation was to allocate native plants in a quarry in the state of Sonora. For this matter, 10 specimens of 4 different species of trees with an average age of 4 months were employed. Transplant survival after 15 days was of 100%, whereas it ranged from 80% to 90% following one month. The recorded average heights were as follows: mesquite (*Prosopis velutina*) was found to be 57.7 cm, palo verde azul (*Parkinsonia florida*) 56.57 cm, palo verde chino (*Parkinsonia microphylla*) 56.27 cm and palo fierro (*Olneya tesota*) 53.4. The crown area for mesquite was in the order of 22.3 cm^2, palo verde azul 20.29 cm^2, palo verde chino 20.22 cm^2 and palo fierro 18.57 cm^2. Regarding the stem area, for mesquite it was found to be 1.58 cm^2, palo verde azul 1.55 cm^2, palo verde chino 1.41 cm^2 and palo fierro 1.35 cm^2. As for the growth index in height percentage, palo verde chino exhibited 13.14%, mesquite 13.02%, palo verde azul 13.01% and palo fierro 6.89%. Palo fierro displayed a crown area of 31.71%, mesquite 24.43%, palo verde chino 24.22% and palo verde azul 22.45%. The stem area in mesquite was 42.08%, palo verde zul 37.24%, palo verde chino 36.32%, and palo fierro 27.21%.

Plantas nativas en Canteras del Estado de Sonora (Cartel)

El estado de Sonora es una región semidesértica que enfrenta severos problemas relacionados con la baja precipitación, lo que ha llevado a la disminución de las poblaciones de plantas de forja, además de actividades de sobrepastoreo y cambio en el uso de la tierra. El objetivo de esta investigación fue asignar plantas nativas en una cantera en el estado de Sonora. Para este caso, se emplearon 10 especímenes de 4 especies diferentes de árboles con una edad promedio de 4 meses. La supervivencia del trasplante después de 15 días fue del 100%, mientras que varió del 80% al 90% después de un mes. La altura promedio registrada fue la siguiente: se encontró mezquite (Prosopis velutina) con 57,7 cm, palo verde azul (Parkinsonia florida) 56,57 cm, palo verde chino (Parkinsonia microphylla) 56,27 cm y palo fierro (Olneya tesota) 53,4. El área de la corona para mezquite fue del orden de 22.3 cm2, palo verde azul 20.29 cm^2, palo verde chino 20.22 cm^2 y palo fierro 18.57 cm^2. En cuanto al área del tallo, para mezquite se encontró que era 1.58 cm^2, palo verde azul 1.55 cm^2, palo verde chino 1.41 cm2 y palo fierro 1.35 cm2. En cuanto al índice de crecimiento en porcentaje de altura, palo verde chino exhibió 13.14%, mezquite 13.02%, palo verde azul 13.01% y palo fierro 6.89%. Palo fierro exhibió un área de corona de 31.71%, mezquite 24.43%, palo verde chino 24.22% y palo verde azul 22.45%. El área del tallo en mezquite fue 42.08%, palo verde zul 37.24%, palo verde chino 36.32% y palo fierro 27.21%.

NOTE: A manuscript was not submitted to accompany this presentation.

Avian response to fire in the lower Sonoran Desert at Kofa National Wildlife Refuge, Arizona (Poster)

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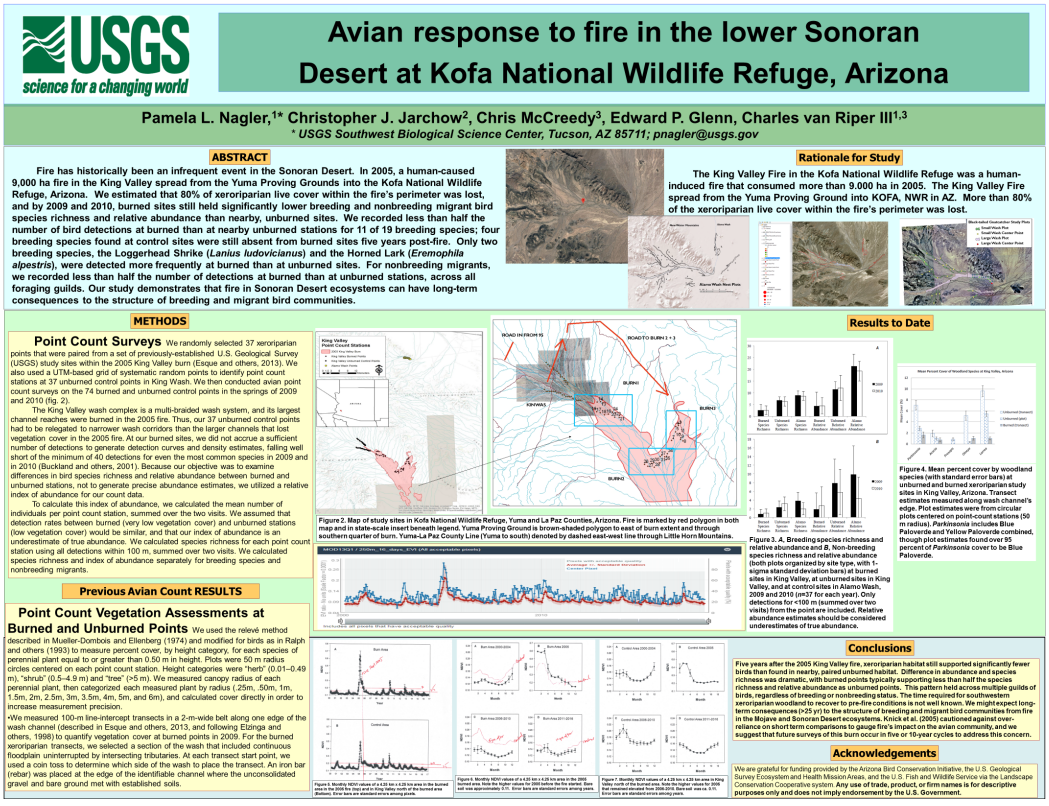
Fire has historically been an infrequent event in the Sonoran Desert. In 2005, a human-caused 9,000 ha fire in the King Valley spread from the Yuma Proving Grounds into the Kofa National Wildlife Refuge, Arizona. Over 80% of xeroriparian live cover within the fire's perimeter was lost, and by 2009 and 2010, burned sites still held significantly lower breeding and nonbreeding migrant bird species richness and relative abundance than nearby, unburned sites. We recorded less than half the number of bird detections at burned than at nearby unburned stations for 11 of 19 breeding species; four breeding species found at control sites were still absent from burned sites five years post-fire. Only two breeding species (Loggerhead Shrike and Horned Lark) were detected more frequently at burned than at unburned sites. For nonbreeding migrants, we recorded less than half the number of detections at burned than at unburned stations, across all foraging guilds. Our study demonstrates that fire in Sonoran Desert ecosystems can have long-term consequences to the structure of breeding and migrant bird communities.

Respuesta aviar al fuego en el desierto de Sonora inferior en Kofa National Wildlife Refuge, Arizona (Cartel)

El fuego ha sido históricamente un evento infrecuente en el desierto de Sonora. En 2005, un incendio de 9,000 hectáreas causado por el hombre en King Valley se extendió desde los terrenos de pruebas de Yuma hasta el Refugio Nacional de Vida Silvestre Kofa, Arizona. Más del 80% de la cobertura de vida xeroribereña dentro del perímetro del incendio se perdió, y en 2009 y 2010, los sitios quemados todavía tenían menor riqueza de especies de aves migratorias reproductoras y no reproductoras al igual que una relativa menor abundancia que los sitios cercanos no quemados. Se registró menos de la mitad del número de detecciones de aves en lugares quemados que en las estaciones colocadas en sitios sin quemar para 11 de las 19 especies reproductoras; cuatro especies reproductoras encontradas en los sitios de control todavía estaban ausentes de los sitios quemados cinco años después del incendio. Solo dos especies reproductoras (Alcaudón bobo y Alondra cornuda) se detectaron con mayor frecuencia en sitios quemados que en sitios no quemados. Para las aves migrantes no reproductivas, registramos menos de la mitad del número de detecciones en las estaciones quemadas que en las no quemadas, en todos los gremios de forrajeo. Nuestro estudio demuestra que los incendios en los ecosistemas del desierto de Sonora pueden tener consecuencias a largo plazo para la estructura de las comunidades de aves reproductoras y migratorias.



NOTE: A manuscript was not submitted to accompany this presentation.

Sand Dunes, Gold Mines & Pronghorn - the "Quitovac" Habitat of endandered Sonoran Pronghorn in Sonora, Mexico (Poster)

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Federal and state agencies in Arizona and Sonora collaborate extensively on conservation of the endangered Sonoran pronghorn. Two of the three distinct population ranges are protected within National Park Service, U.S. Fish & Wildlife, U.S. Air Force, and Mexico Biosphere Reserve boundaries. The third range supports the highest number of pronghorn antelope, yet is largely unprotected. Cattle grazing and mining are the principal land land uses in this remote landscape of granite mountains and stabilized sand dunes. This poster summarizes a research project to model the important habitat characteristics for Sonoran pronghorn in this range using MAXENT, despite limited geospatial environmental data layers. Repeat Landsat imagery was also used to visualize the expansion of gold mines within the heart of important pronghorn habitat.

Dunas de arena, minas de oro y pronghorn - el hábitat "Quitovac" de Berrendo de Sonora en Sonora, México (Cartel)

Las agencias federales y estatales en Arizona y Sonora colaboran ampliamente en la conservación del berrendo de Sonora en peligro de extinción. Dos de los tres rangos de población distintos están protegidos dentro del Servicio de Parques Nacionales, el Servicio Peces y Vida Silvestre de los EE.UU., la Fuerza Aérea de los EE. UU. y los límites de la Reserva de la Biosfera de México. El tercer rango es compatible con el mayor número de berrendos, sin embargo, está ampliamente desprotegido. El pastoreo de ganado y la minería son los principales usos de la tierra en este remoto paisaje de montañas de granito y dunas de arena estabilizadas. Este cartel resume un proyecto de investigación para modelar las características importantes del hábitat del berrendo de Sonora en este rango usando MAXENT, a pesar de las capas limitadas de datos ambientales geoespaciales. Las imágenes repetidas de Landsat también se usaron para visualizar la expansión de las minas de oro en el corazón del importante hábitat de los berrendos.

NOTE: A manuscript was not submitted to accompany this presentation.

Using an Experimental Landscape to Develop a Regional Ecosystem Services Approach to Watershed Restoration (Poster)

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Watersheds within the Madrean Archipelago have been severely degraded by a combination of both anthropogenic and natural processes including unsustainable grazing and timber harvests, long-term droughts, and acute flooding events. We are investigating the effectiveness of various holistic watershed restoration techniques, used by land managers to combat the negative effects of these processes, using an experimental landscape within the Madrean Archipelago. Our study site, Smith Canyon, located in the Nogales Ranger District of the Coronado National Forest, consists of numerous (~125) structurally-similar sub-canyons, each covering approximately 5 to 10 ac. This unique and fairly uniform landscape presents an opportunity for rigorous large-scale experimentation since each sub-canyon can be treated as a replicate

unit. Restoration treatments will focus on the use of check dams and other erosion control methods, varying by both location and size, designed to reduce erosion impacts from single rainfall event runoffs. To assess the effectiveness of the treatments and consider the ecosystem services provided, we will develop a spatial database and hydrological modeling process. We plan to use these research results to provide a protocol for the development of a large-scale, localized spatial database and hydrological modeling network, with the overarching goal of catalyzing a viable payment for ecosystem services in the region. Shifts in the way restoration is approached on the landscape can have major benefits for the quality of watersheds within our region, including improving environmental flows and buffering from changes in natural systems.

Uso de un paisaje experimental para desarrollar un enfoque de servicios ecosistémicos regionales para la restauración de cuencas hidrográficas (Cartel)

Las cuencas hidrográficas dentro del Archipiélago Madrense han sido severamente degradadas por una combinación de procesos antropogénicos y naturales que incluyen pastoreo insostenible y cosechas de madera, sequías a largo plazo e inundaciones agudas. Estamos investigando la efectividad de varias técnicas holísticas de restauración de cuencas hidrográficas, utilizadas por los administradores de la tierra para combatir los efectos negativos de estos procesos, utilizando un paisaje experimental dentro del Archipiélago Madrense. Nuestro sitio de estudio, Smith Canyon, ubicado en el Distrito de Rangers Nogales del Bosque Nacional Coronado, consiste de numerosos (~ 125) sub-cañones estructuralmente similares, cada uno de los cuales cubre aproximadamente de 5 a 10 ac. Este paisaje único y bastante uniforme presenta una oportunidad para la experimentación rigurosa a gran escala ya que cada subcañón se puede tratar como una unidad replicada. Los tratamientos de restauración se centrarán en el uso de represas de retención y otros métodos de control de la erosión, que varían tanto por ubicación como por tamaño, diseñados para reducir el impacto de la erosión a partir de la escorrentía de eventos de lluvia única. Para evaluar la efectividad de los tratamientos y considerar los servicios ecosistémicos provistos, desarrollaremos una base de datos espaciales y un proceso de modelado hidrológico. Planeamos utilizar estos resultados de investigación para proporcionar un protocolo para el desarrollo de una base de datos espaciales y de una base de datos espaciales localizados a gran escala, con el objetivo primordial de catalizar un pago viable para los servicios ecosistémicos en la región. Los cambios en la forma en que se aborda la restauración en el paisaje pueden tener importantes beneficios para la calidad de las cuencas hidrográficas dentro de nuestra región, incluida la mejora de los caudales ambientales y la amortiguación de los cambios en los sistemas naturales.

Note: Full Paper Follows

A Statistical Approach for Watershed Pairing to Inform Semi-Arid Watershed Restoration and Develop a Regional Ecosystem Services Program

Roy E. Petrakis[1], Kurt Vaughn[2], Laura M. Norman[3], Caleb Weaver[2], H. Ron Pulliam[2], and Richard Pritzlaff[4]

Borderlands Restoration Network, Tucson, AZ[1]; Borderlands Restoration Network, Patagonia, AZ[2]; U.S. Geological Survey, Tucson, AZ[3]; Biophilia Foundation, Chester, MD[4]

***Abstract**--Watersheds within the Madrean Archipelago have been severely degraded by a combination of both anthropogenic and natural processes, including unsustainable grazing and timber harvests, long-term droughts, and acute flooding events. We are investigating the effectiveness of various holistic watershed restoration techniques, used by land managers to combat the negative effects of these processes. Our study site, Smith Canyon, located in the Sonoita Creek Watershed and part of the Nogales Ranger District of the Coronado National Forest in Arizona, U.S.A., consists of numerous (~90) structurally-similar sub-basins, each covering approximately 2 to 5 ha. This unique and structurally repetitive landscape presents an opportunity for rigorous large-scale experimentation when considering each sub-basin as a replicate unit. We are using a statistical approach to group subsets of the sub-basins based on structural and biophysical traits. Restoration treatments within the selected sub-basins will focus on the use of check dams and other erosion control methods designed to reduce erosion impacts and reduce nonpoint source pollution downstream. We will monitor the empirical results of water and sediment flows following the treatments to assess the effectiveness and impacts on ecosystem services. We propose these research results be incorporated into a new protocol for large-scale restoration, with the overarching goal to document ecosystem services and a potential payment mechanism for the region.*

INTRODUCTION

A combination of anthropogenic and natural processes, including unsustainable grazing, long-term droughts, and acute flooding events, have degraded the quality of semi-arid and arid watersheds within the Madrean Archipelago and across the Southwest over the past several decades (BLM and USFS, 1994; Denevan, 1967). Watershed restoration structures have been used to combat the negative effects of these processes. Benefits resulting from restoration structures include, but are not limited to: sediment control (Polyakov et al. 2014), aquifer regeneration (Norman et al., 2018), water flow dynamics (Baker et al. 1995; Norman et al. 2010a,b, 2015; Norman and Niraula, 2016), and improving habitat and vegetation conditions (Debano and Schmidt, 1990; Norman et al. 2014; Wilson and Norman, 2018). Much of the knowledge about management effects on the hydrologic cycle and vegetation comes from paired catchment studies, though often it is difficult to match watersheds with good controls (Neary, 2016).

Our overarching goal is to investigate the effectiveness of holistic watershed restoration techniques and the impacts they may have on a suite of ecosystem services, with the aim of possibly developing viable payments, though yet to be determined, for an ecosystem services program in the region. We plan to address these goals through the following research stages. First, we developed a spatial database consisting of structural and biological data to allow for a robust and statistically valid experimental design. Using statistical algorithms with this dataset, we paired groups of sub-basins that are most similar, leaving groups of treatment and control basins. Within the theme of watershed pairing, sub-basins are considered as separate watersheds. Because of funding and time constraints, a portion of these grouped sub-basins will be selected for monitoring based on practitioner input. The amount of sediment and water flow will be monitored prior to the treatments for our selected study sub-basins during the 2018 monsoon season (July – September). In the summer of 2019, erosion-control and water retention restoration structures will be constructed and additional monitoring of sediment and water flows will take place. Finally, based on the quantified impact of these structures on general watershed conditions, we will develop a protocol to improve future restoration efforts and a develop an ecosystem services program. This paper describes this unique methodological approach for statistically paired watersheds and future experimental design.

STUDY AREA

Our study area is Smith Canyon Watershed (SCW), which is located within the Nogales Ranger District of the Coronado National Forest, north of Patagonia, Arizona, U.S.A. (Figure 1). This watershed provides a unique opportunity for rigorous large-scale experimentation due to its feather-like landscape consisting of roughly 90 structurally similar sub-basins (SUB(s)), each approximately 2 to 5 ha. Smith Canyon is a tributary of Sonoita Creek, within the Sonoita Creek 5th Hydrologic Unit Code (HUC). Water flows within SCW are dependent on rainfall events, particularly during the summer monsoon season (Adams and Comrie, 1997).

DATA AND METHODS

Spatial Database Development

We collected a combination of biophysical and structural variables for Smith Canyon Watershed and the surrounding Sonoita Creek Watershed. A sub-3 m Digital Elevation Model (DEM) was used to derived from airborne LiDAR to develop elevation statistics, including: mean, minimum, maximum, and range (Tyson Swetnam, Tucson, AZ, personal communication, January 25, 2018). We also included the following structural input variables: 1) aspect (percent north, south, east, and west facing), and 2) slope (percent gradual, moderate, and steep), derived from the Soil and Water Assessment Tool (SWAT – SWAT Landuse, 2018). Additionally, we collected general structural traits such as area, length, width, and perimeter for each SUB.

To comprise the set of biophysical variables, we included a combination of various land use/land cover classifications for the region, each intended to map certain aspects of the landscape, including: land cover from 2009 (Villarreal et al. 2011), the translated landuse derivatives for Villarreal et al. (2011) created in SWAT (SWAT Landuse, 2018), and existing vegetation designations (Wallace et al. 2011). We also included the Soil Survey Geographic (SSURGO) soil database for southeast Arizona developed by the USDA (Soil Survey Staff). Finally, we produced a five-year mean (2013 – 2017) Normalized Difference Vegetation Index (NDVI – Tucker, 1979) image for the pre-monsoon period of stressed vegetation (mid-June) in Google Earth Engine (GEE – Gorelick et al. 2017). The images GEE used to develop this include Landsat 8 Operational Land Imager (OLI) images from overlapping scenes (Path 35/36; Row 38). Using the resulting NDVI dataset, we quantified various statistics including: minimum, maximum, mean, range, and standard deviation, for each SUB.

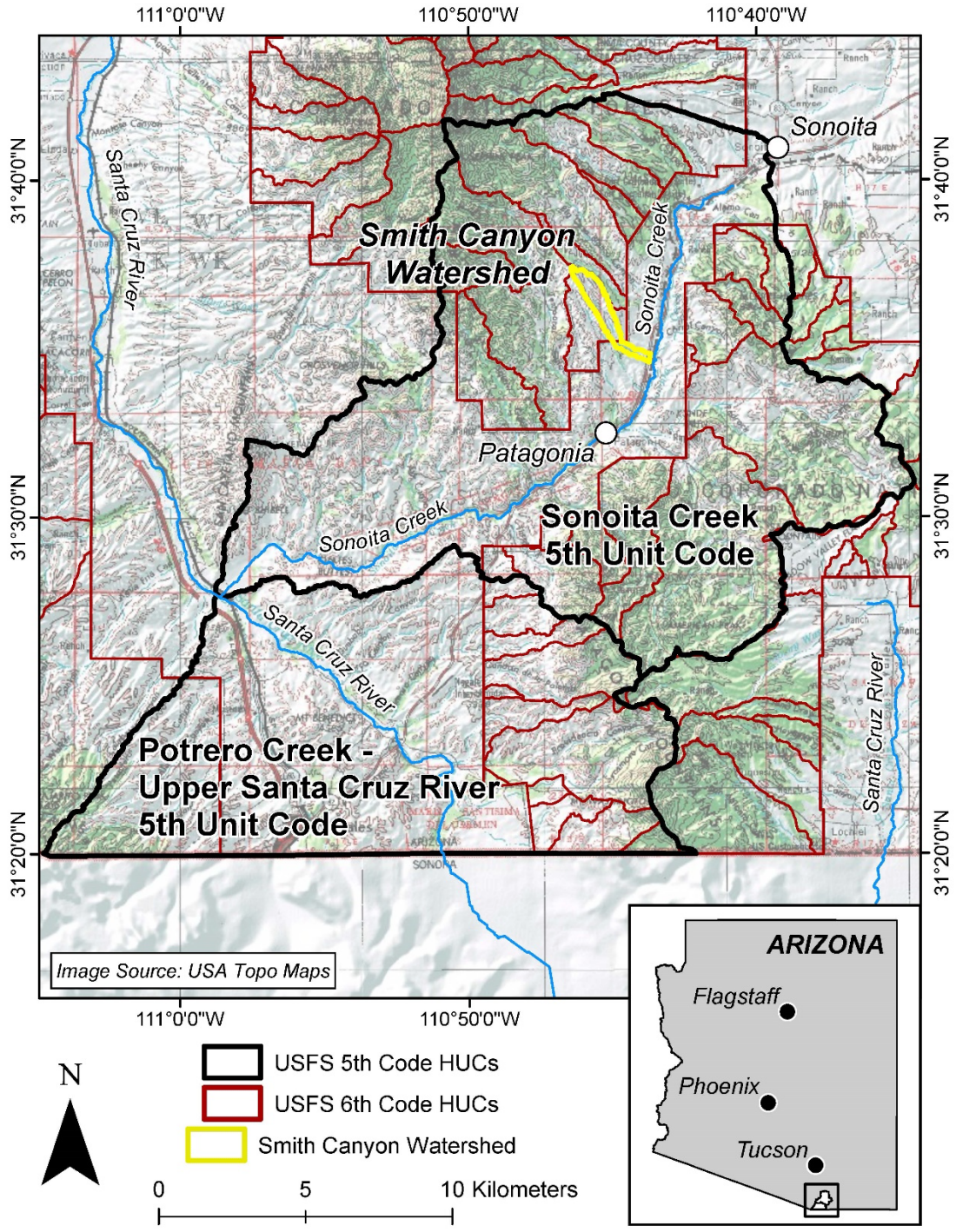

Figure 1--Location of the Smith Canyon Watershed (SCW – in yellow) in relation to the Sonoita Creek 5th Unit Code, approximately 5 km north of Patagonia, AZ.

Clustering Analysis

To pair various SUBs that were most similar based on the input biophysical and structural variables, we used hierarchical clustering techniques in R (Murtagh and Contreras, 2011; R Core Team, 2015). Several processing steps were completed for this analysis. First, we separated both the structural and biophysical variable types quantified for each SUB. For each variable type, we then completed a factor extraction and reduction process using a combination of variable correlations, Maximum Likelihood, and Principal Component Analysis (PCA). We completed this step for each variable type separately to see how the variables interacted. We also shaped our variable selection by considering the real-world impact each variable may have in predicting dynamics of water and sediment flows. For example, gradual and steep slopes were chosen because they will cause increased variability of water flows, whereas moderate slopes will have comparatively less impact on flow dynamics. We then combined the most effective variables for each type and completed the variable reduction analysis with the full suite of variables. Once variable selection was complete, we ran several tests within R to quantify the clustering tendency of the SUBs based on variables included, as well as the optimal number of clusters present for the SUBs. Finally, we built a dendrogram to visualize the SUB clusters. Final selection of study SUBs will use a combination of the dendrogram results and a visual review by local land managers, where tendencies of water flow within the SUBs as well as general characteristics of erosion and flows will be considered.

Restoration Structures

We will develop a protocol for the implementation of restoration structures, ranging from cross-channel check dams to larger-scale head-cut armaments, depending on erosion severity (Heede, 1978). Many of the SUBs have developed large head-cuts. Restoration structures will be designed for erosion-control and water retention – varying by location, size, and construction material. We plan to construct structures using a combination of local dead vegetation and available rocks. Within the defined clusters, 12 SUBs were selected to create three replicates of the four restoration treatment approaches: 1) control (no structures), 2) low (head-cut armament), 3) moderate (head-cut armament; check dams), and 4) high density (head-cut armament; check dams; upland structures).

RESULTS AND DISCUSSION

Factor Extraction, Reduction, and Final Selection

We determined through our statistical analysis approach that a reduced combination of the initial input biophysical and structural variables was optimal for our clustering analysis (Table 1). Each of the final variables can have a unique influence on sediment and water flows within the SUBs. Additionally, the selected variables group SUBs that are most similar within Smith Canyon.

Dendrogram

Our dendrogram consisted of three main clades, or clusters, each with multiple sub-hierarchies (Figure 2). Each of the clades was characterized by unique qualities present within their respective SUBs.

CONCLUSION

We used a statistic-based clustering analysis to group similar sub-basins centered on their biophysical and structural traits, for use as paired control and restoration watersheds. This robust experimental design can improve the validity of statistically valid restoration science. It will form the basis for an analysis of the impacts and effectiveness of restoration structures. This research is intended to stand as an initial step in developing a viable payment program for ecosystem services in the region, including services such as downstream flood insurance rates and carbon sequestration payments.

Improving watershed conditions provides greater flood control and better water quality with indirect benefits to surrounding habitats, and monetization of these ecosystem services could even provide funding for future projects.

Table 1--The final combination of biophysical and structural variables used for the clustering analysis.

Variable	Variable Data Type	Variable Type
Percent steep slope	Slope	Structural
Mean slope	Slope	Structural
Percent North facing	Aspect	Structural
Percent East Facing	Aspect	Structural
Length	Trait	Structural
Area	Trait	Structural
Percent Range Shrubland (RNBG)	SWAT Landuse	Biophysical
Percent moderate slope gravelly sandy loam (1421630)	Soil	Biophysical
Percent steep slope gravelly sandy loam (1421631)	Soil	Biophysical
NDVI Maximum	Vegetation Index	Biophysical
NDVI Minimum	Vegetation Index	Biophysical

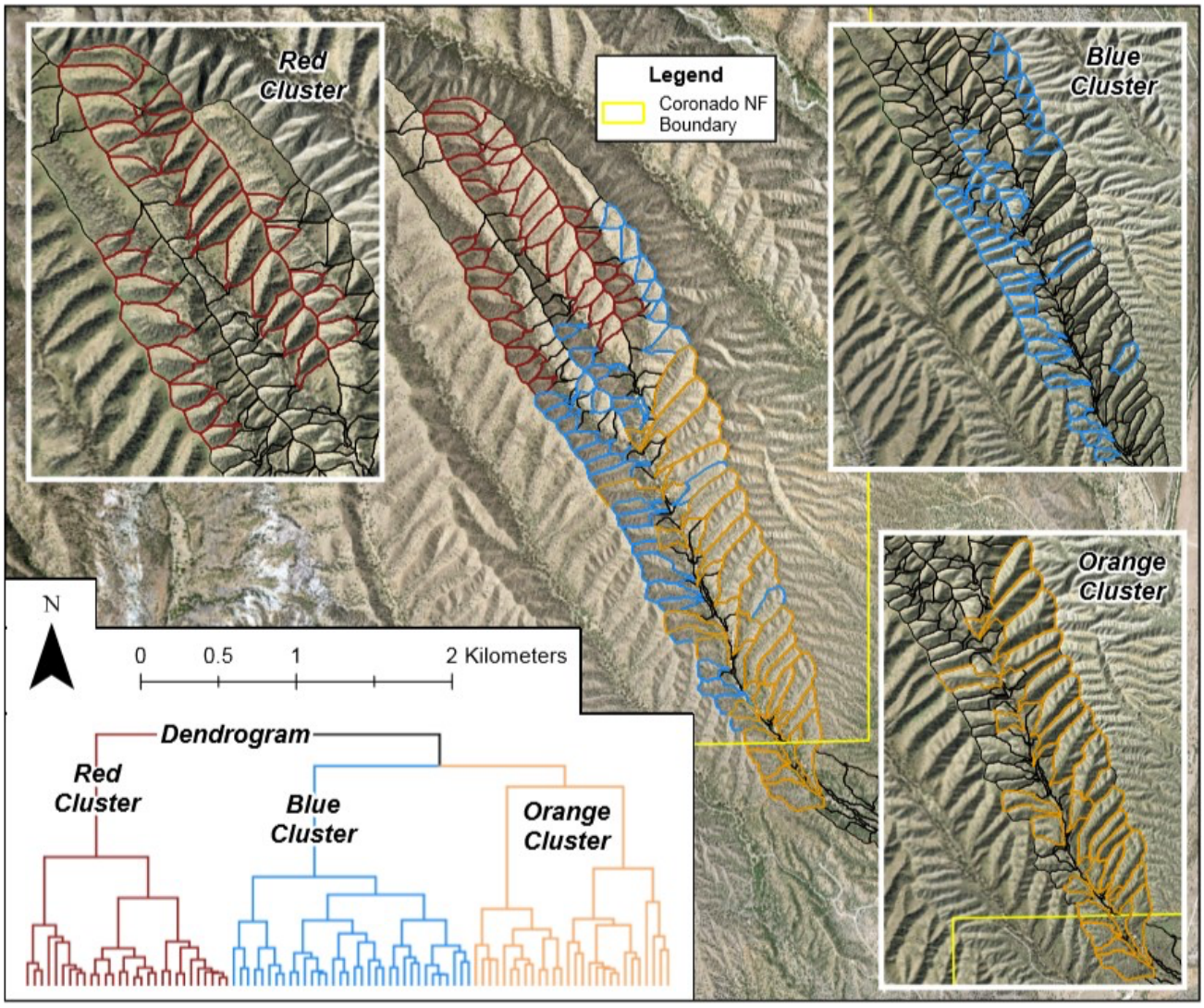

Figure 2--Dendrogram results and the location of clusters within Smith Canyon Watershed.

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Ecomorphs on Sky Islands? Describing sympatry and trait divergence in *Sceloporus* lizards (Poster)

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Sympatry and trait divergence can vary dramatically across the geographic ranges of species, and may also differ between closely-related taxa. Differences in how we describe these patterns may be critical in identifying the microevolutionary processes that produce them. Does it matter whether we consider two species sympatric based on overall species distributions, or do we need to look at a finer scale and delineate specific distances that determine whether or not two species are sympatric with one another? We know that many species of *Sceloporus* have overlapping ranges when viewed at the global scale, but we wanted to determine whether those species were truly sympatric when we looked at the data at a local scale. Here, we used coordinate records compiled from GBIF for 75 species of *Sceloporus* lizards to describe the ways in which patterns of sympatry change at varying geographic distances and to develop metrics for describing a full sympatry profile. Additionally, we used this data set to analyze one of the common consequences of sympatry, divergence of body size. Specifically, we tested whether species were more likely to co-occur with other species of different body sizes than would be expected by chance. Integrating analysis of body size diversity with geographic distributions across multiple species gives us unique insight into the relationship between geography and evolution.

¿Ecomorfos en las Islas Serranas? Describiendo simpatría y divergencia de rasgos en lagartijas Sceloporus (Cartel)

La divergencia de simpatría y rasgo puede variar dramáticamente a través de los rangos geográficos de las especies, y también puede diferir entre taxones estrechamente relacionados. Las diferencias en la forma en que describimos estos patrones pueden ser fundamentales para identificar los procesos microevolutivos que los producen. ¿Importa si consideramos que dos especies son simpátricas en función de las distribuciones globales de especies, o necesitamos mirar a una escala más fina y delinear distancias específicas que determinen si dos especies son simpátricas o no entre sí? Sabemos que muchas especies de Sceloporus tienen rangos superpuestos cuando se ven a escala global, pero queríamos determinar si esas especies eran verdaderamente simpátricas cuando miramos los datos a escala local. Aquí, utilizamos registros de coordenadas compilados de GBIF para 75 especies de lagartijas Sceloporus para describir las formas en que los patrones de simpatría cambian a diferentes distancias geográficas y desarrollar métricas para describir un perfil de simpatría completo. Además, utilizamos este conjunto de datos para analizar una de las consecuencias comunes de la simpatría, la divergencia del tamaño corporal. Específicamente, probamos si era más probable que las especies coexistan con otras especies de diferentes tamaños corporales de lo que cabría esperar por casualidad. La integración del análisis de la diversidad del tamaño del cuerpo con las distribuciones geográficas entre múltiples especies nos proporciona una visión única de la relación entre la geografía y la evolución.

NOTE: A manuscript was not submitted to accompany this presentation.

Integrating geology and climate data to reconstruct the long-term history of *Sceloporus* lizards in Arizona (Poster)

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Recently, scientists can easily access huge amounts of information on species distributions including geographic locations and high-resolution multidimensional climate data. Here, we use phylogenetic comparative and paleontological modeling approaches to reconstruct the diversification of *Sceloporus* lizards in Arizona over very long periods of evolutionary time. Specifically, we model changes in geographic distributions of species over time, integrating information on North American geological events, like the rise of the Madre Mountains, and paleoclimate to identify biological bounds for taxa at different points in time, therefore, limiting ranges so that they exclude unsuitable habitat. We then use detailed morphological measures extracted from CT scans to reconstruct changes to ancestral skull shapes in both space and time. Throughout, we emphasize how our approach may be applied to other organisms or to forecast future changes in geographic distributions, especially in the context of climate change.

Integración de datos geológicos y climáticos para reconstruir la historia a largo plazo de las lagartijas Sceloporus en Arizona (Cartel)

Recientemente, los científicos pueden acceder fácilmente a enormes cantidades de información sobre distribuciones de especies, incluidas ubicaciones geográficas y datos climáticos multidimensionales de alta resolución. Aquí, utilizamos enfoques de modelos filogenéticos comparativos y paleontológicos para reconstruir la diversificación de lagartijas Sceloporus en Arizona durante períodos muy largos de tiempo evolutivo. Específicamente, modelamos los cambios en las distribuciones geográficas de especies a lo largo del tiempo, integrando información sobre eventos geológicos de América del Norte, como el ascenso de las montañas Madre, y paleoclima para identificar límites biológicos para taxones en diferentes momentos, por lo tanto, limitando los rangos para que excluir el hábitat inadecuado. A continuación, utilizamos medidas morfológicas detalladas extraídas de tomografías computarizadas para reconstruir los cambios en las formas ancestrales del cráneo tanto en el espacio como en el tiempo. En todo momento, enfatizamos cómo nuestro enfoque puede aplicarse a otros organismos o pronosticar cambios futuros en las distribuciones geográficas, especialmente en el contexto del cambio climático.

NOTE: A manuscript was not submitted to accompany this presentation.

Current status of the beaver population (*Castor canadensis*) in the upper basin of the San Pedro River, Sonora. (Poster)

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The beaver (*Castor canadensis*) in northeastern Sonora inhabits a riparian ecosystem surrounded by grasslands, desert thickets and mountain ranges in the Sky Islands. In the period from December 2015 to November 2016, monitoring was carried out to determine their presence through the registration of traces, xcretas, gnawed trees, dikes, food reserves

and active burrows, derived from the observations, maps were created with their areas of distribution. Their relative abundance and density were determined by two sampling methods: direct observation and photo-trapping. The correlation between the vegetation and the number of registered asters was analyzed, and the habitat was characterized to determine the plant species that are available to them. Five sites with presence of the species and eight active colonies were identified. The beaver was the third most abundant recorded mammal (IAR = 5.13 reg./dias-camera) after the white-tailed deer (*Odocoileus virginianus*) and the raccoon (*Procyon lotor*). 29 species of plants (herbaceous, shrubs and trees) were recorded in sites with the presence of beaver. The statistical analysis was not significant, so it is considered that the vegetation was not a determining factor in its establishment, although it is possible to find it in the presence of riparian vegetation such as the Poplar (*Populus fremontii*), Willow (*Salix gooddingii*) and Fresno *(Fraxinus velutina*). This work represents a joint effort for beaver conservation among civil society organizations, academia and government agencies, this species is considered endangered in Mexico.

Estado actual de la población de castor (Castor canadensis) en la cuenca alta del río San Pedro, Sonora. (Cartel)

El castor (Castor canadensis) en el noreste de Sonora habita un ecosistema ribereño rodeado de pastizales, matorrales desérticos y cadenas montañosas en las llamadas Islas Serranas. En el periodo comprendido de diciembre de 2015 a noviembre de 2016 se realizaron monitoreos para determinar su presencia mediante el registro de huellas, xcretas, árboles roídos, diques, reservas de alimento y madrigueras activas, derivado de las observaciones se crearon mapas con sus áreas de distribución. Se determinó su abundancia relativa y densidad mediante dos métodos de muestreo: observación directa y foto-trampeo. Se analizó la correlación entre la vegetación y el número de astores registrados, y se caracterizó el hábitat para determinar las especies vegetales que tienen a su disposición. Se identificaron cinco sitios con presencia de la especie y ocho colonias activas. El castor fue el tercer mamífero registrado más abundante (IAR=5.13 reg./días-cámara) después del venado cola blanca (Odocoileus virginianus) y el mapache (Procyon lotor). Se registraron 29 especies de plantas (herbáceas, arbustos y árboles) en sitios con presencia de castor. El análisis estadístico no fue significativo, por lo que se considera que la vegetación no fue un factor determinante en su establecimiento, aunque es posible encontrarlo en presencia de vegetación ribereña como el Álamo (Populus fremontii), Sauce (Salix gooddingii) y Fresno (Fraxinus velutina). Este trabajo representa un esfuerzo conjunto para la conservación del castor entre organizaciones de la sociedad civil, academia y dependencias de gobierno, esta especie es considerada en peligro de extinción en México.

Note: Full Paper Follows

The Beaver Population Status in The Upper San Pedro River Basin, Sonora.

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Universidad de Sonora, Hermosillo, Sonora[1] and Naturalia, A.C., Hermosillo, Sonora[2].

***Abstract**--The beaver (Castor canadensis) inhabits a riparian ecosystem surrounded by grasslands, desert thickets and mountain ranges in the so-called Sky Islands. In the period from december 2015 to november 2016, monitoring was carried out to determine relative abundance by photo trapping and density using the direct observation method. We identified five sites with presence of the species. The first data of relative abundance and density for the area was reported. This work represents a joint effort for beaver conservation among civil society organizations, academics and government agencies; this species is considered endangered in Mexico.*

INTRODUCTION

The beaver (*Castor canadensis*) is considered worldwide a species of least concern by the IUCN list, however, in Mexico it is an endangered species (DOF 2010 NOM-059-SEMARNAT-2010) due mainly to hunting and low availability of habitats among other factors (Ceballos and Oliva 2015, DOF 2010, Cassola 2016). Despite being in this category, the beaver status of the San Pedro River Basin (SPRB) is unknown, but it is presumed that its population persists in small numbers (Ceballos and Oliva, 2015). Beaver populations in northeastern Sonora are located in a region with diverse topography and vegetation, where it is possible to find grasslands and desert thickets that interact with mountain ranges and riparian ecosystems. The beaver is known as the ecosystem engineer for its ability to modify the landscape, since by foraging and building dams is able to create more suitable habitats for the development of aquatic birds, fish, amphibians, reptiles, and invertebrates, as well as the establishment of aquatic and riparian plants; its importance is critical for the regional diversity of riparian species (Browning-Aiken et al. 2004, Jakes et al. 2007, Pelz et al. 2005). Therefore, the purpose of this work was to determine its population status within the San Pedro River Basin.

AREA OF STUDY AND METHODS

Study Area

The San Pedro River Basin is located in northwestern Mexico, in the state of Sonora and southwest of the United States, in Arizona. The Mexican portion is represented by a valley surrounded by mountain ranges, remaining open in its northern portion where it connects with the United States until it joins the Gila River, in Arizona. The present study comprised five observation sites between the municipalities of Cananea and Santa Cruz (Los Fresnos, Las Chivas, Las Nutrias, El Novillo and San Rafael), which encompass a series of continental wetlands, made up of seasonal streams (Figure 1; Juárez 2009).

Materials and Methods

Distribution: The samplings were carried out from December 2015 to November 2016. Two sampling methods were used to determine the presence of the beaver: direct observation using linear transects along the river and the photo-trapping technique. The surveys were carried out monthly in a 1 km linear transect in the five sampling sites. The activity of the beaver was determined by gnawed trees, dams, active burrows and by direct sighting (Nelson and Nielsen 2011, Pelz et al. 2005). The maximum number of beavers seen at the same time was determined (Bau 2001). Additionally, 12 trap cameras were distributed in the sampling sites (Karanth and Nicholson 1998; Table 1). Each camera was placed at 200 linear meters in a 1 km transect, starting from the sites where there was the highest activity, preferably on the river bank. This criterion was based on the semi-aquatic habits of the species (Feldhamer et al. 2003).

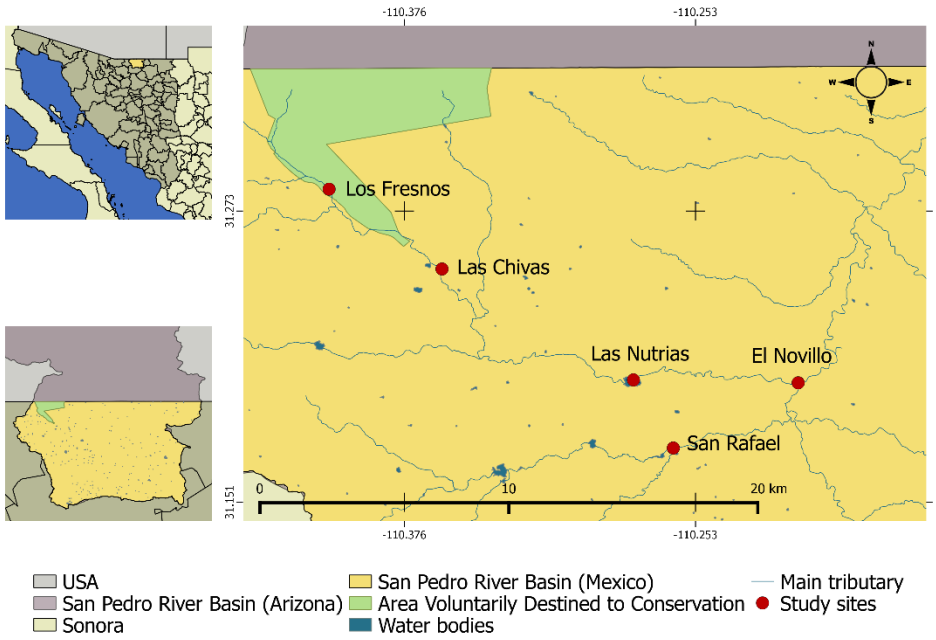

Figure 1. Sampling sites in the San Pedro River Basin, Sonora, Mexico (Map by: Stephanie Olivares).

Relative abundance and density: The photographic records of beaver were separated using the methodology proposed by Kelly et al. (2008). The Relative Abundance Index (RAI = C/MS * 100 trap days) was determined by the capture-recapture method (Chávez et al. 2013). The density was calculated by dividing the estimated abundance by direct observation method between the Effective Sampling Area (ESA), which was 15.02 km^2. This result was reported as individuals per km^2: D = N / A (D = density, N = abundance obtained by direct observation method, A = Effective Sampling Area in km^2).

RESULTS

Distribution

The activities of the beaver extend in 1 km long in a straight line per site. In all the sampling sites, agricultural activities are practiced, such as livestock. Burrows, dams, and recent gnawed trees were recorded throughout the year (Table 2). During the study, 15 beavers were recorded distributed in three of the five sampling sites (Table 3). No beaver could be observed in two sites (Las Chivas and San Rafael), but records of recent traces indicate that their presence is still active in those places, and at least there is one beaver in both sites.

Relative abundance and density

Twelve trapping stations were placed, and the total sampling effort was 1,646 trap days. We obtained a total of 432 photographs of ten species of mammals, of which 169 were of beaver. According to the RAI, the beaver was more abundant during period three (Figure 2). The density obtained by the direct observation method was 1.13 ind/km^2.

Table 1. Number of camera-traps and sampling effort per site in the San Pedro River Basin, Sonora (December 2015 – November 2016).

Site	Camera	Days	
		Dry season (Dec 2015 to Jun 2016	Wet season (Jul to Nov 2016)
Los Fresnos	1	61	43
	2	61	43
	3	28	43
Las Chivas	4	62	99
	5	62	99
Las Nutrias	6	62	17
El Novillo	7	62	100
	8	62	100
	9	62	100
San Rafael	10	61	99
	11	61	99
	12	61	99
	Sampling effort (camera-days)	705	941

Table 2. Traces of beaver (*Castor canadensis*) in each of the five sites sampled within the San Pedro River Basin, Sonora (December 2015 - November 2016).

Site	Gnawed tree	Burrow	Dam
Los Fresnos	37	3	7
Las Chivas	10	5	2
Las Nutrias	42	5	1
El Novillo	33	3	2
San Rafael	20	1	4

Table 3 — Number of beavers sighted within the San Pedro River Basin, Sonora (december 2015 - november 2016).

Site	Number of beavers	Adults	Juveniles
Los Fresnos	6	5	1

Las Chivas	0	0	0
Las Nutrias	7	5	2
El Novillo	2	2	0
San Rafael	0	0	0

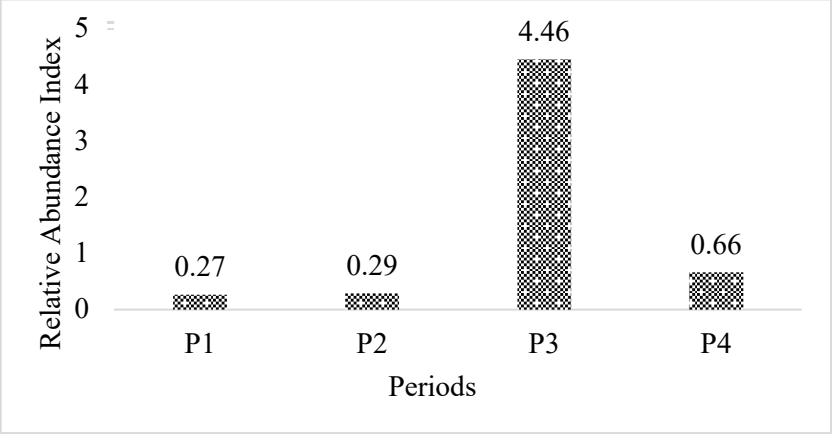

Figure 2. Relative abundance of beaver (*Castor canadensis*) obtained by photo-trapping in the San Pedro River Basin, Sonora (december 2015 – november 2016). *P1: dec 2016-jan 2016; P2: feb-mar 2016; P3: jun-aug 2016; P4: sep-nov 2016.

DISCUSSION

In the five sampling sites the beaver colonies were distributed to no more than one km long in the streams. The home range of the beaver is not documented in Mexico, but there are data reported in the United States and Canada that support these observations: Aleksiuk (1968), and Jenkins and Busher (1979) determined its distribution in 800 m of the river, Müller-Schwarze and Sun (2003) observed traces of beaver at 500 m in Manitoba and Ontario in Canada, while in California it has been observed that they move between 200 and 800 m, reaching 3.4 km in Illinois (Havens et al. 2013). In the San Pedro River Basin (SPRB), the maximum distance travelled in the river was of one km, which coincides with what was previously reported. Regarding beaver abundance, Toyos and Amador (2014) recorded 36 individuals within the SPRB, twice the number of individuals registered in the present study. Mearns (1907) describes beavers as extremely shy and difficult to watch when in contact with potential predators, which is possibly why in two sites no specimen was observed. The density reported in this work is low in contrast to those reported in other regions of its distribution such as: Alberta, Canada (4.6 ind km^{-2}) and New York, United States (4.8 ind km^{-2} (Feldhamer et al. 1982, Novak 1987); but it resembles the results in previous studies in Sierra San Luis, near Aguaprieta, Sonora (Pelz et al. 2005). Nevertheless, the observation of pups tells us that it is possible to recover the numbers that were available in the SPRB in the 19th century (Carrillo et al. 2009). But it must be taken into account that not all currents can withstand high levels of activity by beaver and probably 100 years ago the conditions of the SPRB were different from those currently known. The distance of natural dispersion varies greatly and also depends on the location of the habitat and its quality (Feldhamer et al., 2003). In the literature it is point out that the home range of the beaver depends on many factors: sex, age and family organization; but it mostly depends of water fluctuation and woody material availability (Feldhamer et al. 2003, Fustec et al. 2001, Maringer and Slotta-Bachmayr 2006). In the SPRB there are no records of relative abundance of beaver and the surrounding species using camera-traps, but the species has been intentionally monitored with this technique in some affluents of Mexico and also in different parts of the United States and Scotland to confirm its presence (Campbell-Palmer et al. 2016, Carreón et al. 2016).

CONCLUSIONS AND RECOMMENDATIONS

Among the possible threats, it highlights the overlap with human activities such as livestock; however, the beaver persists in these places, which tells us that it is a species with a plasticity that allows it to coexist within these environments and is not limited due to its crepuscular habits. Even so, it must be considered if the presence of cattle limits population growth due to native vegetation loss, damage of soils and stream banks (contamination of waterways with fecal waste), or if the beaver population has reached its maximum number of members it can hold without depleting the resources. The requirements of the beaver will be different to those registered in other northern regions, because beavers tend to move along the stream depending of the ecological conditions (Pelz et al. 2005). This work shows the first records of relative abundance and density for the beaver within the SPRB, so the continuity of this type of studies is important to understand the dynamism of the population over time. To complement and contrast the indices of abundance, another type of indirect methodologies can be used, such as the registration of traces of footprints and excreta. Although direct observation is the most effective method to document the behavior of the species in its natural environment, it gives us small sample sizes and is much more invasive. It is proposed to continue using both methods as complementary alternatives and not as a substitute for the other.

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Hohokam Lost Crop Found: A New *Agave* (Agavaceae) Species Only Known from Large-scale pre-Columbian Agricultural Fields in Southern Arizona (Poster)

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For over thirty years archaeologists have provided evidence that southern Arizona pre-Columbian Native Americans, the Hohokam, extensively cultivated agave. However, no archeologists reported finding living agaves growing in the rock piled or gridded Hohokam fields, therefore researchers could only speculate about the species cultivated. Our work expands upon a recent publication noting several agaves growing in prehistoric dry-farmed fields on terraces overlooking the San Pedro River. We found these agaves to be extremely rare, reproducing asexually via rhizomatous offsets with no apparent fruit set, relatively uniform intra- and inter-population morphology, growing only with archaeological features and unknown from natural settings – all characteristics expected in a domesticated crop. We propose that this agave is a clonal, relictual crop grown from ca. A.D. 800 – 1450 by the Hohokam, and thus represents a 'lost crop' as sought by archaeologists. The extensive size and wide distribution of Hohokam agave fields that transformed the landscape and are still visible today indicates the crop's importance in the Hohokam economy. The question of where and when this agave originated has implications for North American domestication centers. Our discovery emphasizes the importance of collaborative research between archaeologists and botanists whose distinctive data can provide a richer understanding of how the Hohokam developed and then sustained one of the American Southwest's largest prehistoric populations.

Hohokam encontramos el cultivo perdido: Un nuevo agave (Agavaceae) Especie conocida solo a gran escala en los campos agrícolas precolombinos en el sur de Arizona (Cartel)

Durante más de treinta años, los arqueólogos han proporcionado evidencia de que los nativos americanos precolombinos del sur de Arizona, los Hohokam, cultivaban agave extensamente. Sin embargo, ningún arqueólogo informó haber encontrado agaves vivientes creciendo en los campos de Hohokam apilados o en cuadrículas, por lo tanto, los investigadores solo podían especular acerca de la especie cultivada. Nuestro trabajo se amplía a una publicación reciente que destaca varios agaves que crecen en campos prehistóricos de cultivo seco en terrazas con vista al río San Pedro. Encontramos que estos agaves son extremadamente raros, se reproducen asexualmente a través de desplazamientos rizomatosos sin un conjunto de frutos aparente, tienen una morfología intra e interpoblación relativamente uniforme, creciendo solo en características arqueológicas desconocidas en entornos naturales, todas las características esperadas en un cultivo domesticado. Proponemos que este agave es un cultivo clonal y relictual cultivado a desde ca. 800 AC hasta el 1450 por el Hohokam, y por lo tanto representa una "cosecha perdida" según lo buscado por los arqueólogos. El extenso tamaño y amplia distribución de los campos de agave Hohokam que transformaron el paisaje y aún son visibles hoy en día, indican la importancia del cultivo en la economía Hohokam. La cuestión de dónde y cuándo se originó este agave tiene implicaciones para los centros de domesticación de América del Norte. Nuestro descubrimiento enfatiza la importancia de la investigación colaborativa entre arqueólogos y botánicos cuyos datos distintivos pueden proporcionar una comprensión más rica de cómo el Hohokam desarrolló y luego sostuvo a una de las poblaciones prehistóricas más grandes del suroeste de Estados Unidos.

NOTE: A manuscript was not submitted to accompany this presentation.

Constructing and Operating a Bicycle-Powered Seed Pelletizing Machine for Use in Gardening and Ecological Restoration Projects (Poster)

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Seed balls are an ancient method of sowing seed, especially in areas with compacted or dry soils. This method encapsulates seed in a substrate that will potentially reduce predation by insects and rodents while allowing for increased water retention and seed-soil contact. Seed balls often combine three components: seed, clay, and nutrient-rich organic matter such as compost or humus. Seed balls are strewn in the desired location and remain inactive until heavy rains arrive, washing away the clay and allowing the seeds to germinate. This method of sowing seeds does not require any tilling or soil preparation, desirable aspects for restoration work, urban planting and sustainable farming practices. It is also cheap and relies on a few simple components which can be attained just about anywhere in the world. However, making seed balls by hand is extremely time consuming and often requires a large group of volunteers. To make large amounts of seed balls in a reasonable amount of time, we constructed a bicycle-powered seed pelletizing machine that effectively coats seed in clay and compost materials. The bicycle spins a barrel containing the seeds and coating materials while the operators periodically mist the contents with water. The result is coated seed balls that can be used in a desired area. This poster details how to make and operate the seed pelletizing machine for use in gardening or revegetation projects.

Construir y operar una máquina de peletización de semillas impulsada por icicletas para su uso en proyectos de jardinería y restauración ecológica (Cartel)

Las bolas de semillas son un método antiguo de siembra de semillas, especialmente en áreas con suelos compactos o secos. Este método encapsula semillas en un sustrato que potencialmente reducirá la depredación por insectos y roedores mientras permite una mayor retención de agua y el contacto semilla-suelo. Las bolas de semillas a menudo combinan tres componentes: semilla, arcilla y materia orgánica rica en nutrientes, como compost o humus. Las bolas de semillas se esparcen en la ubicación deseada y permanecen inactivas hasta que llegan las lluvias intensas, lavando la arcilla y permitiendo que las semillas germinen. Este método de siembra de semillas no requiere ninguna labranza o preparación del suelo, aspectos deseables para trabajos de restauración, plantación urbana y prácticas agrícolas sostenibles. También es barato y se basa en unos pocos componentes simples que se pueden obtener en casi cualquier parte del mundo. Sin embargo, hacer bolas de semillas a mano es extremadamente lento y a menudo requiere un gran grupo de voluntarios. Para hacer grandes cantidades de bolas de semillas en un período de tiempo razonable, construimos una máquina de peletización de semillas impulsada por bicicletas que efectivamente recubre las semillas en arcilla y materiales de compost. La bicicleta hace girar un barril que contiene las semillas y los materiales de revestimiento, mientras que los operadores periódicamente rocían el contenido con agua. El resultado es bolas de semillas recubiertas que se pueden usar en un área deseada. Este póster detalla cómo fabricar y operar la máquina de peletización de semillas para su uso en proyectos de jardinería o revegetación.

NOTE: A manuscript was not submitted to accompany this presentation.

Post-fire Seeding Treatment Effectiveness on the Frye Fire: Pinaleno Mountains, Graham County, AZ (Poster)

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The Frye Fire began in June 2017 and burned over 48,000 acres in the Pinaleno Mountains of Graham County in Arizona. The Burn Area Emergency Response (BAER) team aerially seeded an annual grass, common barley (*Hordeum vulgare*) to minimize soil erosion and improve soil productivity. This study assesses the effectiveness of this treatment in minimizing erosion compared to unseeded areas. Monitoring results from fall 2017 suggest seeding did not meet success criteria. Insufficient germination lead to low canopy cover of the seeded species compared to native vegetation. Additionally, seeded sites contain significantly lower cover of native plants overall, suggesting potential suppression of post-burn native plant response. Furthermore, there were no differences observed in soil rill network density between seeded and control sites. Repeat monitoring is scheduled for Spring 2018 to assess for additional recruitment of *H. vulgare* and improve understanding of treatment effects. More long-term quantitative monitoring and study areas are needed to determine the effectiveness of seeding applications in Southern Arizona.

Eficacia del tratamiento de siembra después del incendio en el fuego Frye: montañas de Pinaleno, condado de Graham, AZ (Cartel)

El incendio de Frye comenzó en junio de 2017 y quemó más de 48,000 ac en las montañas Pinaleno del condado de Graham en el sureste de Arizona. El equipo de Respuesta a Emergencias del Área de Quemaduras (BAER, por sus siglas en inglés) sembró aéreamente una hierba anual, cebada común (Hordeum vulgare) para minimizar la erosión del suelo y mejorar la productividad del suelo. Este estudio evalúa la efectividad de este tratamiento para minimizar la erosión en comparación con las áreas no sembradas. Los resultados del monitoreo del otoño de 2017 sugieren que la siembra no cumplió con los criterios de éxito. Una germinación insuficiente conduce a una cubierta del dosel bajo de la especie sembrada en comparación con la vegetación nativa. Además, los sitios sembrados contienen una cobertura significativamente menor de plantas nativas en general, lo que sugiere una posible supresión de la respuesta de la planta nativa después de la quema. Además, no se observaron diferencias en la densidad de la red de arroyos del suelo entre los sitios sembrados y de control. La repetición del monitoreo está programada para la primavera de 2018 para evaluar el reclutamiento adicional de H. vulgare y mejorar la comprensión de los efectos del tratamiento. Se necesitan áreas de estudio y monitoreo cuantitativo a más largo plazo para determinar la efectividad de las aplicaciones de siembra en el sur de Arizona.

NOTE: A manuscript was not submitted to accompany this presentation.

Geomorphology and Floral Diversity at Grand Canyon Ecoregion Springs: A Statistical Analysis (Poster)

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The Grand Canyon Ecoregion (GCE) represents the entire landscape that drains into Grand Canyon. This region

encompasses a wide array of environments and corresponding plant communities of biological interest. Springs are numerous in the GCE and play a multitude of roles in this generally arid land. Springs serve as critical sources of water support many endangered and endemic species with over springs-dependent species identified in the GCE. This study conducted a statistical community analysis of over 352 springs in the Grand Canyon Ecoregion across four spring types – helocrene wet meadows; hanging gardens; rheocrene flowing springs; and hillslope springs – and examined their physical traits and floral communities. All springs types were distinguished by differences in physical site characters which in turn were associated with plant community structure and specific species. An astounding species packing was demonstrated with almost 1000 species recorded across all springs, representing over 45% of the region's entire flora in less than square kilometer of habitat area. Geomorphic microhabitat diversity was positively related to springs diversity. Managers should protect a wide variety of springs to protect the distinct floral communities present across the GCE. While, this study identified key differences between springs types, each spring needs to be understood in an individual context. Stewardship efforts should aim to protect varied microhabitats. Their concentrations of biodiversity warrant further conservation and additional inventory and study will prove useful in furthering understanding of springs of the GCE.

Geomorfología y diversidad floral en Grand Canyon Ecoregion Springs: un análisis estadístico (Cartel)

La Ecorregión del Gran Cañón (GCE por sus siglas en inglés) representa todo el paisaje que desemboca en el Gran Cañón. Esta región abarca una amplia gama de entornos y comunidades vegetales correspondientes de interés biológico. Los manantiales son numerosos en el GCE y juegan una multitud de papeles en esta tierra generalmente árida. Los manantiales sirven como fuentes críticas de agua para el mantenimiento de muchas especies en peligro de extinción y endémicas con especies dependientes de manantiales identificadas en la GCE. Este estudio llevo a cabo un análisis estadístico de la comunidad de más de 352 manantiales en la Ecorregión del Gran Cañón en cuatro tipos de manantiales: prados húmedos helocrenos; Jardines colgantes; manantiales fluoroscentes; manantiales y colinas, y examinó sus rasgos físicos y comunidades florales. Todos los tipos de manantiales se distinguieron por las diferencias en los caracteres físicos del sitio que a su vez estaban asociados con la estructura de la comunidad vegetal y las especies específicas. Se demostró un asombroso empaque de especies con casi 1000 especies registradas en todos los manantiales, que representan más del 45% de toda la flora de la región en menos de un kilómetro cuadrado de área de hábitat. La diversidad geomórfica de microhábitats se relacionó positivamente con la diversidad de manantiales. Los gerentes deben proteger una amplia variedad de manantiales para proteger a las distintas comunidades florales presentes a través de la CME. Si bien, este estudio identificó las principales diferencias entre los tipos de manantiales, cada primavera debe entenderse en un contexto individual. Los esfuerzos de mayordomía deberían apuntar a proteger los microhábitats variados. Sus concentraciones de biodiversidad justifican una mayor conservación y el inventario y el estudio adicionales serán útiles para fomentar la comprensión de los manantiales de la CME.

NOTE: A manuscript was not submitted to accompany this presentation.

Birds that fly over Sierra Huérfana (Poster)

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Aves que sobrevuelas sierra huerfana is an artistic proposal for dissemination and conservation from an environmental education perspective, which aims to disseminate among young people, the diversity of bird species that keeps Sierra Huérfana as "Island of biodiversity" in the State of Sonora. Based on observation records made since August 2014 by specialists led by Thomas R. Van Devender, and the subsequent expeditions carried out until December 2017, MABA identified 123 species, of which two stand out: *Aquila chrysaetos* that is in threatened category and its distribution is

non-endemic; *Buteo albonotatus* is subject to special protection and its distribution is not endemic. The tours to admire the migratory behavior of birds in this region have been highly profitable for scientific dissemination. The methodology for the development of the project is the design of the drawings of the birds in color using paper marquilla and prismacolor; document the creative process in video and digital photography in high definition, in order to be used for the publication of a birdwatching guide in Sierra Huérfana; the design of a fan; the printing of the 2018 calendar; and the exhibition of artistic drawings with their identification cards on the 123 species that fly over this region that is intended to be considered, Protected Natural Area as an area of flora and fauna protection "Sierra Huérfana" Sonora, Mexico.

Aves que sobrevuelan Sierra Huérfana (Cartel)

Aves que sobrevuelan sierra huérfana es una propuesta artística para la divulgación y la conservación desde una perspectiva de la educación ambiental, que tiene como objetivo difundir entre los jóvenes, la diversidad de especies de aves que mantiene Sierra Huérfana como "Isla de biodiversidad" en el Estado de Sonora. Con base en registros de observación realizados desde agosto de 2014 por especialistas dirigidos por Thomas R. Van Devender, y las subsecuentes expediciones efectuadas hasta diciembre de 2017, MABA identificó 123 especies entre las que destacan dos: Aquila chrysaetos que se encuentra en categoría amenazada y su distribución es no endémica; Buteo albonotatus se encuentra sujeta a protección especial y su distribución es no endémica. Los recorridos para admirar el comportamiento migratorio de la avifauna en esta región ha sido altamente provechoso para la divulgación científica. La metodología para el desarrollo del proyecto es el diseño de los dibujos de las aves a color utilizando papel marquilla y prismacolor; documentar el proceso creativo en video y fotografía digital en alta definición, a fin de ser utilizado para la publicación de una guía de observación de aves en Sierra Huérfana; el diseño de un abanico; la impresión del calendario 2018; y la exposición de dibujos artísticos con sus fichas de identificación sobre las 123 especies que sobrevuelan esta región que pretende sea considerada, Área Natural Protegida como área de protección de flora y fauna "Sierra Huérfana" Sonora, México.

NOTE: A manuscript was not submitted to accompany this presentation.

The Status of *Buddleja sessiliflora* (Scrophulariaceae) in Arizona (Poster)

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Butterfly bush reaches its northern range in southeastern Arizona and historic herbarium records document seven localities from Pima and Santa Cruz counties. We visited all populations between 2014 and 2017, except for one on the Tohono O'odham Nation. Five localities were verified to be extant and a total of 18 plants were located during this study. One population is extirpated due to groundwater depletion and all remaining colonies are isolated within areas 6–15 m in diameter. Populations at each *Buddleja* site ranged between one and six individuals. No seedlings were found, and it is unknown if these populations are still capable of sexual reproduction. Foliage of plants at all five localities is heavily impacted by beetle herbivory during flowering, which presumably contributes to decreased seed production. Currently *B. sessiliflora* has no recognized state conservation status and is listed as unranked. This riparian species with southern affinities has been impacted by diminishing water resources, longterm drought and invasive plant species. *Buddleja sessiliflora* may be one of the rarest plants in southern Arizona.

El estado de Buddleja sessiliflora (Scrophulariaceae) en Arizona (Cartel)

El arbusto de mariposa alcanza su rango norteño en el sureste de Arizona y los registros históricos de herbario documentan siete localidades de los condados de Pima y Santa Cruz. Visitamos todas las poblaciones entre 2014 y 2017,

excepto uno en la Nación Tohono O'odham. Se verificaron la existencia de cinco localidades y se localizaron un total de 18 plantas durante este estudio. Una población se extirpa debido al agotamiento del agua subterránea y todas las colonias restantes se aíslan dentro de áreas de 6-15 m de diámetro. Las poblaciones en cada sitio de Buddleja variaron entre uno y seis individuos. No se encontraron plántulas y se desconoce si estas poblaciones todavía son capaces de reproducción sexual. El follaje de las plantas en las cinco localidades se ve muy afectado por la herbivoría del escarabajo durante la floración, lo que presumiblemente contribuye a la disminución de la producción de semillas. Actualmente, B. sessiliflora no tiene un estado de conservación estatal reconocido y está catalogado como no clasificado. Esta especie ribereña con afinidades sureñas se ha visto afectada por la disminución de los recursos hídricos, la sequía a largo plazo y las especies de plantas invasoras. Buddleja sessiliflora puede ser una las plantas más raras en el sur de Arizona.

Note: Full Paper Follows

The Status of *Buddleja sessiliflora* (Scrophulariaceae) in Arizona

James T. Verrier[1] and Iris E. Rodden[2]

University of Arizona Herbarium[1] and University of Arizona[2]

***Abstract**--Butterfly bush (Buddleja sessiliflora) reaches its northern range in southeast Arizona and herbarium records document seven historic localities from Pima and Santa Cruz counties. We visited all populations between 2014 and 2018, except for one reported from the Tohono O'odham Nation to discover that five historic localities were verified to be extant, and an additional locality was discovered in 2018. A total of 22 plants were documented during this study. All surveyed populations are isolated to 6–15 m areas and contained between one and seven plants. No propagules were found, except for a small 30 cm tall plant at the southernmost locality. It is unclear if any of these plants are still capable of reproducing in situ either sexually or vegetatively. Currently B. sessiliflora has no recognized state conservation status and is listed as unranked. Impacts to this riparian species with southern affinities may include climate change, diminishing water resources, invasive plant species and possible genetic bottlenecking due to isolation. Buddleja sessiliflora may be one of the rarest plants in southern Arizona.*

INTRODUCTION

Originally described in 1818, *Buddleja sessiliflora* Kunth occurs from tropical southern Mexico north to southeast Arizona (Shreve and Wiggins 1964). It is found in Mexico in Oaxaca, Coahuila, San Luis Potosí, Sinaloa, Sonora, and Baja California Norte, and in southern Texas and southeast Arizona in the United States. In Sonora, plants are widespread, but somewhat uncommon. The holotype for *B. pringlei* A. Gray was collected from "fields near Tucson, Pima County, Arizona" (*Pringlei 16, 17 May 1883* GH) and was later synonymized with *B. sessiliflora*.

The common name for this genus is 'butterfly bush' due to its role as a strong pollinator attractant. The fragrant flowers emit a robust and pungent aroma which often elicits novel descriptions such as "acridly sweet like carrion or stale urine" (Felger et al 2001, p. 90), or a mixture of vinegar and chocolate. While this type of scent typically attracts flies, a wide assortment of other pollinators also visits the plant including bees, butterflies and ants.

Plants are shrubs but become arborescent at upper elevations in tropical deciduous forest in Sonora, growing to 5 m in height (Felger et al. 2001). Plants require riparian conditions and are always found in moist conditions near springs and along streambeds (Mild 2009) or in areas where water collects to provide subsurface moisture. Mexican populations occur at elevations between 30–1,158 m and Arizona localities were reported to grow up to 914 m (Felger et al 2001; Kearney & Peebles 1960). Hairy, four-petaled, yellowish-green blooms form in the spring between February and May (sometimes into June). Well-watered specimens form massive trunks and branches, creating a somewhat muscular appearance. The specific epitaph refers to the characteristic sessile flower heads; a simple and diagnostic feature that separates it from other regional *Buddleja* species.

This species is not ranked as rare or sensitive by any state organizations. The NatureServe Conservation Status Rank for Arizona is unranked, while Texas populations are listed as 'imperiled' (S2). A NatureServe Conservation Status of S1 is designated for 'critically endangered' (very rare) species with 5 or less localities, or less than 1,000 individuals. S2 listed species occur at less than 20 localities or comprise less than 3,000 individuals. NatureServe state conservation designations are useful management agencies to assist in determining species of concern and conservation priorities.

METHODS

All historic collection localities were visited, except for the Quinlan Mountains site on the Tohono O'odham Nation. Fieldwork took place in 2014, 2016, 2017 and 2018. The presence of *B. sessiliflora* at each site was verified and adjacent areas were searched for additional plants. Additional effort was spent searching nearby Fresno and Coal Mine canyons at the Sonoita Creek site, as these areas appear to support *Buddleja* habitat. Only limited portions of the Santa Cruz River Valley in the Tucson Basin were explored due to highly degraded habitat conditions.

RESULTS

A total of 22 individual plants were found across six sites. All populations were restricted to approximate 6–15 m diameter areas. A single young plant was found at the southernmost locality a few miles from the international border. No plants were found in any downstream adjacent riparian areas although they seemed to provide ideal habitat for propagules. All plants were found between elevations of 858–1,330 m. The herbarium records listed below are all vouchered at the University of Arizona Herbarium (ARIZ), Arizona State University Herbarium (ASU), and University of Sonora Herbarium (USON).

Santa Cruz River Valley, Tucson, Pima County; extirpated; 732 m; river was completely dry by the late 1940s (Glennon 2002). (ARIZ: *Thornber 7571, 23 Mar 1916*)

Gibbon Springs, Santa Catalina Mtns foothills, Pima County; one plant; 858 m site is currently owned by a golf course, the springs are being pumped to support an artificial lake by the clubhouse; springs only support minimal surface flow (ARIZ: *Thornber 5409, 15 Jun 1913 "escaping from cultivated areas"; Thornber 8097, 15 Apr 1915*; *Herndon s.n., 23 Apr 1916*; *Fonseca s.n., 21 Jun 2013*)

Mendoza Canyon, Coyote Mtns, Pima County; two plants; 1030 m; spring site has been invaded by a near monoculture of carrizo (*Arundo donax*) (ARIZ: *Parker 5799, 22 Apr 1945*; *Goodding 456-59, 2 Apr 1959*; *Bohrer 838, 4 Apr 1965*; *Halse s.n., 28 Apr 1973* (*"common"*). ASU: *Butterwick 7776*, *24 Jun 1981* ("*uncommon*").

Sonoita Creek, Santa Cruz County; six plants; 1103 m; located in minor slot canyon with weak spring; growing in shady understory; (ARIZ: *McLaughlin 6842, 20 Apr 1993*)

Rock Corral Canyon, Tumacacori Mtns, Santa Cruz County; seven plants; 1142 m; located at perennial spring site among boulders; all plants clustered within ~9 m area; (ARIZ: *Toolin 2184, 6 Jun 1986*; *Verrier 468, 4 July 2016*)

Grubstake Mine, Pajarito Mtns, Santa Cruz County; four plants; 1186 m; spring has been enclosed in concrete box and adjacent riparian trees have failed; groundwater being pumped at site for upslope livestock tanks; In 2005 P. Jenkins described a plant at this site as over 2.4 m (*pers. comm*. P. Jenkins, 2005); in 2016 largest plant is currently less than 1 m; (ARIZ: *Scholz 351, 9 Jun 2005*; *Verrier 467, 30 May 2016*)

Cumero Mountain, San Luis Mtns, Pima County; two plants; 1330 m; population discovered by A. Flesch and S. Jacobs in 2018; the smaller plant is the only seedling or vegetative propagule located in this study; (ARIZ: *Verrier 1308, 11 Mar 2018*)

Quinlan Mountains, Pima County, Tohono O'odham Nation; site not visited due to lack of access; (USON: *Nichols s.n., 21 Feb 1940*).

DISCUSSSION

This highly riparian species is restricted to a small group of isolated locations in Arizona. None of the six known populations exceed a single 5–16 m area, suggesting that these plants may no longer be capable of producing viable seeds (Baskin and Baskin 2014). It is also surprising that plant material distributed downstream during seasonal flooding events does not produce additional clonal plants, as cuttings of this taxon effortlessly root in horticultural settings. The single 30 cm seedling or vegetative clone found in the San Luis Mountains site represented the only possible reproductively successful plant, suggesting that more plants or populations may occur in the vicinity of this site.

Populations are clustered near the international border, with distances between individual colonies of 18–32 km. This contrasts with the northern two sites that are separated from the others by 56–90 km. Population connectivity is essential to preserve genetic variation, particularly in small populations. Reduced allelic diversity from isolation can induce a genetic bottleneck (Broquet et al. 2010) and may explain the lack of sexual propagation. Butterfly bush has large, soft foliage that are susceptible to desiccation, and the hotter and drier conditions at the northern edge of its range may negatively impact these plants. The two northernmost sites are also at the lowest elevations of all sites surveyed.

Diminishing water resources may be another significant influence in the decline of *B. sessiliflora* in Arizona. All sites have experienced anthropogenic groundwater pumping or diversion, in addition to the lack of water recharge as a consequence of long-term drought and increasing temperatures.

Additional surveys in Sonoita Creek, and in the San Luis and Pajarito mountains are likely to identify a handful of additional localities, but the total number of statewide plants may not exceed 50 individuals. This species is extremely habitat specific and may be one of the rarest species in Arizona. Butterfly bush appears to be retracting to the south and current Arizona populations represent historic climatic conditions from the past.

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Diversity of carnivorous mammals at Rancho La Volanta, Bacoachi, Sonora, Mexico. (Poster)

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The state of Sonora has 126 species of mammals, where 18 species (14.2%) correspond to carnivores. The present study was conducted at Rancho La Volanta, located 18.6 kilometers northeast of Bacoachi, Sonora, in the Sonora River Basin, and abutting Sierra Los Ajos, which is part of APFF Bavispe, a federal protected natural area. This study was carried out under the technique of photo-trapping, with which it was possible to obtain information 24 hours a day and without being invasive for wildlife. 12 trap chambers were installed in 12 sites within the premises for 9 months between 2014 and 2015. The sites where they were placed were sidewalks, drinking fountains for livestock and natural bodies of water. After a total sampling effort of 3,000 trap days, a record of 11,703 photographs was obtained, of which 2,186 were wild mammals in 10 families, 17 genera and 18 species. Of these, 367 photos corresponded to carnivores in five families, 11 genera and 12 species. The species with the highest density was coyote (*Canis latrans*) with 0.01 ind km^{-2}, followed by coati (*Nasua narica*) with 0.81 ind km^{-2}. The black bear (*Ursus americanus*) and the jaguar (*Panthera onca*) were the species of special interest to be found. The records are available in the Bavispe APFF database (http://madreandiscovery.org/fauna/). It is considered that the ecosystem in this region is well preserved thanks to the good management of the range and its proximity to a conservation area.

Diversidad de mamíferos carnívoros en Rancho La Volanta, Bacoachi, Sonora, México. (Cartel)

El estado de Sonora cuenta con 126 especies de mamíferos, en donde, 18 especies (14.2%) corresponden a carnívoros. El presente estudio se efectuó en Rancho La Volanta, ubicado a 18.6 kilómetros al Noreste de Bacoachi, Sonora, en la Cuenca del Río Sonora, y colindando con Sierra Los Ajos, que forma parte del APFF Bavispe, un área natural protegida federal. Este estudio se llevó a cabo bajo la técnica de foto-trampeo, con la cual fue posible obtener información durante las 24 horas del día y sin ser invasiva para la fauna silvestre. Se instalaron 12 cámaras-trampas en 12 sitios dentro del predio durante 9 meses entre 2014 y 2015. Los sitios donde se colocaron fueron veredas, bebederos para ganado y cuerpos de agua naturales. Tras un esfuerzo total de muestreo de 3,000 días-trampa, se obtuvo un registro de 11,703 fotografías, de entre las cuales, 2,186 correspondieron a mamíferos silvestres en 10 familias, 17 géneros y 18 especies. De estas, 367 fotos correspondieron a carnívoros en cinco familias, 11 géneros y 12 especies. La especie con mayor densidad fue coyote (Canis latrans) con 1.01 ind/ km^2*a, seguida por coatí (Nasua narica) con 0.81 ind/* km^2*. El oso negro (Ursus americanus) y el jaguar (Panthera onca) eran las especies de interés especial por encontrar. Los registros están disponibles en la base de datos de Bavispe APFF (http://madreandiscovery.org/fauna/). Se considera que el ecosistema en esta región está bien conservada gracias al buen manejo del agostadero y a su cercanía con una zona de conservación.*

Note: Full Paper Follows

Diversidad de Mamíferos Carnívoros en Rancho “La Volanta”, Sonora, México

Saul Abraham Amador Alcalá

Naturalia Committee for the Conservation of Wild Species AC

***Resumen**--El estado de Sonora cuenta con 126 especies de mamíferos, de las cuales, 18 especies (14.2%) corresponden a carnívoros. El presente estudio se efectuó en Rancho “La Volanta”, ubicado a 18.6 kilómetros al noreste de Bacoachi, Sonora, en la Cuenca del Río Sonora, y colindando con Sierra Los Ajos, que forma parte de la APFF Bavispe, un área natural protegida federal. Este estudio se llevó a cabo bajo la técnica de foto-trampeo, con la cual fue posible obtener información durante las 24 horas del día y sin ser invasiva para la fauna silvestre. Se instalaron 12 cámaras-trampas en 12 sitios dentro del predio durante nueve meses entre 2014 y 2015. Los sitios donde se colocaron fueron veredas, bebederos para ganado y cuerpos de agua naturales. Tras un esfuerzo total de muestreo de 3,000 días-trampa, se obtuvo un registro de 11,703 fotografías, de entre las cuales, 2,186 correspondieron a mamíferos silvestres en 10 familias, 17 géneros y 18 especies. De estas, 367 fotografías correspondieron a carnívoros en cinco familias, 11 géneros y 12 especies. Los carnívoros con mayor densidad fueron el coyote (Canis latrans) con 1.01 ind/km^2, seguida por coatí (Nasua narica) con 0.81 ind/km^2. El oso negro (Ursus americanus) y el jaguar (Panthera onca) eran las especies de interés especial por encontrar. Los registros están disponibles en la base de datos de APFF Bavispe (accesibles en la base de datos Madrean Discovery Expeditions, http://madreandiscovery.org). Se considera que el ecosistema en esta región está bien conservada gracias al buen manejo del agostadero y a su cercanía con una zona de conservación.*

INTRODUCCIÓN

El papel que tienen las áreas naturales protegidas es muy importante, ya que son áreas poco perturbadas por el humano. Estas áreas se sujetan a estrictos regímenes de protección, y conservación, con el fin de proteger la biodiversidad natural y cultural además de los servicios ambientales que nos puede proporcionar a la sociedad. Tal es el caso del Área de Protección de Flora y Fauna (APFF) Bavispe y su zona de influencia ubicada en la formación montañosa conocida como ‘Isla Serrana’ o ’Sky Island’ (CONANP 2001) en el noreste del estado de Sonora. Las cumbres montañosas tienen coronas de encinal y bosque de pino-encino con gran diversidad biológica, separada por matorral desértico, pastizal, matorral espinoso y selva baja caducifolia. Su zonificación altitudinal y sus climas totalmente diferentes las convierten en hábitos únicos y refugio para diferentes especies de flora y fauna.

Los mamíferos carnívoros son especies indicadores que brindan información sobre los cambios en las condiciones ambientales, que pueden provocar perturbaciones antropogénicas en la estructura y composición de las comunidades animales (Morin, 2011). El uso de cámaras trampa es una alternativa adecuada, ya que es posible obtener información sobre aspectos ecológicos como abundancia relativa, aspectos de la reproducción (Lira-Torres y Briones-Salas 2012), evaluación de patrones de actividad (Rumiz et al., 2002; Monroy-Vilchis et al. 2009), uso de hábitat (Bowkett et al. 2007), así como realizar estimaciones de densidad (Karanth et al. 2004; Maffei y Noss 2007; Trolle 2008).

ÁREA DE ESTUDIO

El municipio de Bacoachi, se encuentra entre los paralelos 30.45° y 30.90° de latitud norte; los meridianos 109.73° y 109.83° de longitud oeste; con una altitud aproximadamente entre 950 y 2,400 m (3,116 a 7,872 ft). Ocupa una superficie de 1,260. 65 km^2 (487 mi^2). El territorio de este municipio está representado por zonas montañosas en las Sierras Los Ajos, Buenos Aires y La Púrica al este del Río Sonora (INAFED, 2010).

En la zona de influencia de la fracción IV “Sierra Los Ajos, Buenos Aires y La Púrica” se encuentran los predios “Los Nogales y La Volanta” (Figura 1). De acuerdo con la Carta de Uso de Suelo y Vegetación, Serie V (INEGI, 2011) presenta dos tipos de vegetación predominante, bosque de encino y pastizal. El APFF Bavispe cubre un área importante dentro de las cuencas hidrológicas de la región, incluyendo el Río Sonora, San Pedro, Bavispe y Yaqui los cuales son de vital importancia ya que proveen agua a una gran parte de la población dentro del Estado de Sonora

MATERIALES Y MÉTODOS

Se instalaron 12 cámaras- trampa, modelos WILDVIEW y ScoutGuard en 12 sitos dentro de los predios en un terreno de aproximadamente 16 ha. El trabajo de campo se realizó de septiembre 2014 a mayo del 2015. Los sitios utilizados fueron veredas donde transita la fauna, bebederos para ganado y cuerpos de agua naturales (Chavez et al. 2013). Cabe mencionar que en ningún sitio se utilizó cebo, esto con el fin de no alterar el comportamiento de la mastofauna.

El índice de abundancia relativa (IAR) para foto-trampas se calculó mediante la frecuencia de captura. Para medir diversidad se utilizó el índice de diversidad de Shannon-Wiener y el índice de Simpson (Swindel and Tallie 1994)). Los registros están disponibles en la base de datos de APFF Bavispe (accesible en la base de datos de Madrean Discovery Expeditions, http://madreandiscovery.org).

RESULTADOS

Se obtuvó un esfuerzo total de muestreo de 3,000 días-trampas con 72,000 horas- trampa al instalarse 12 cámaras-trampa, se obtuvo un registro de 11,703 fotografías, de las cuales 2,186 pertenecen a mamíferos y de éstas 367 fotografías corresponden a carnívoros. Respecto al orden Carnivora se obtuvieron cinco familias, 11 géneros y 12 especies. Las abundancia relativa por el método de fototrampeo fue de puma (*Puma concolor*; IAR= 67.43, n= 49,), gato montés (*Lynx Rufus*; IAR= 16.40, n= 12) , coyote (*Canis latrans*; IAR= 108.90, n= 80), zorra gris (*Urocyon cinereoargenteus;* IAR= 14.75, n= 11), oso negro (*Ursus americanus*; IAR= 2.57, n=2), cacomixtle (*Bassariscus astutus*; IAR= 17.76, n= 13), mapache (*Procyon lotor*; IAR= 2.41, n=2), coatí/cholugo (*Nasua narica;* IAR= 89.23, n= 64), zorrillo moteado (*Spilogale gracilis*; IAR=1.36, n= 1), zorrillo rayado (*Mephitis mephitis*; IAR= 18.60, n= 14), zorrillo encapuchado (*Mephitis macroura*; IAR= 11.69, n=9) y zorrillo espalda blanca (*Conepatus leuconotus*; IAR= 5.30, n=4). La diversidad de mamíferos carnívoros estimada con el índice de Shannon- Wiener mediante el método de fototrampeo fue de H´= 1.87, con una diversidad máxima de Hmax= 2.48. Con el índice de Simpson se obtuvo una diversidad de D= 3.311.

DISCUSION

Coronel et al. (2016), menciona que para Sierra Los Ajos se encontraron 11 especies de carnívoros mientras que Lara-Díaz et al. (2011) menciona un total de 10 especies. El presente estudio agrega dos especies que no se encuentran en los estudios anteriormente mencionados, los cuales son *Canis latrans* y *Spilogale gracilis*, por lo cual, se establece la importancia de seguir con este tipo de estudios que aumentan la riqueza de especies de un área. Como se mencionó anteriormente en el presente estudio no se utilizó atrayentes a diferencia del estudio de Coronel et al. (2016) y Lara-Diaz et al. (2010) donde obtuvieron registros de especies de carnívoros de mayor tamaño. Sumando las especies registradas por dichos autores y el presente estudio, se obtuvo un total de 14 especies de mamíferos carnívoros registrados para el estado de Sonora; lo cual indica un sitio con alto grado de conservación, ya que son especie que requieren de hábitats con grandes extensiones de cobertura vegetal, agua y presas abundantes.

La fauna de mamíferos carnívoros de Rancho “La Volanta” representada con 12 especies, es típica de los pastizales desérticos dentro del estado de Sonora. Esta fauna es similar a los mamíferos en matorral espinoso de El Valle del Río Bavispe al sur de Granados (Van Devender et al. Est volumen). Para Rancho “La Volanta” hace falta registros de ardilla (*Otospermophilus variegatus*), ocelote (*Leopardus pardalis*) y el tejón (*Taxidea taxus*). Dichas especies presentan afinidades a sitio templados hacia el norte como la ardilla de Arizona (*Sciurus arizonensis*) y oso negro (*Ursus americanus*). Especies con grandes rangos hacia sitios tropicales son jabalí (*Pecari tajacu*), y jaguar (*Panthera onca*).

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Contemporary fire regimes of the Madrean Sky Islands of US and Mexico (Poster)

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Studies of contemporary fire regimes in the Madrean Sky Islands have previously been limited by a lack of comparable datasets across the international border. In an effort to address this need, we developed a database of fire occurrence and severity for 30 Sky Islands in the United States and Mexico for large (404 ha) wildfires that occurred from 1985-2011. A total of 254 fires were identified across the region: 99 fires in México (mean fire size = 3,901 ha, SD = 5,066 ha) and 155 in the U.S. (mean fire size = 3,808 ha, SD = 8,368 ha). The Animas, Chiricahua, Huachuca-Patagonia, and Santa Catalina mountains in the U.S., and El Pinito in México had the highest proportion of total area burned (50%) relative to Sky Island size. Across all islands, variations in fire shape and size were observed in both wetter and drier years, contributing to landscape heterogeneity across the region. Changes in fire patterns fluctuated with climate; the five largest (25,000 ha) fires all occurred during 21st century droughts (2002-2003 and 2011), and many of the most severe fires occurred during drought years (1996-1997, 2002-2003, and 2007). However, human interactions with ecosystems also play a role in shaping fire regimes. Analysis of fire severity relative to anthropogenic biomes alluded to legacies of human influence including fire suppression, fuel accumulation, and human-caused ignitions.

Los regímenes de fuego contemporáneos de las Islas Serranas Madrenses de los Estados Unidos y México (Cartel)

Los estudios de los regímenes de fuego contemporáneos en las Islas Serranas Madrenses han sido previamente limitados por la falta de conjuntos de datos comparables a través de la frontera internacional. En un esfuerzo por abordar esta necesidad, desarrollamos una base de datos de ocurrencia y severidad de incendios para 30 Islas Serranas en los Estados Unidos y México para grandes incendios forestales (404 ha) que ocurrieron entre 1985-2011. Se identificaron un total de 254 incendios en la región: 99 incendios en México (tamaño medio de fuego = 3,901 ha, SD = 5,066 ha) y 155 en los EE. UU. (Tamaño medio de fuego = 3,808 ha, SD = 8,368 ha). Las montañas Animas, Chiricahua, Huachuca-Patagonia y Santa Catalina en los Estados Unidos, y El Pinito en México tenían la proporción más alta del área total quemada (50%) en relación con el tamaño de la Isla Serrana. En todas las islas, se observaron variaciones en la forma y el tamaño del fuego en los años más húmedos y secos, lo que contribuye a la heterogeneidad del paisaje en toda la región. Los cambios en los patrones de fuego fluctuaron con el clima; los cinco incendios más grandes (25,000 ha) ocurrieron durante las sequías del siglo XXI (2002-2003 y 2011), y muchos de los incendios más severos ocurrieron durante los años de sequía (1996-1997, 2002-2003 y 2007). Sin embargo, las interacciones humanas con los ecosistemas también juegan un papel en la configuración de los regímenes de fuego. El análisis de la severidad del fuego en relación con los biomas antropogénicos aludió a los legados de la influencia humana, incluida la supresión de incendios, la acumulación de combustible y las igniciones causadas por el hombre.

NOTE: A manuscript was not submitted to accompany this presentation.