FY22 TECHNOLOGY TRANSFER REPORT
Rocky Mountain Research Station

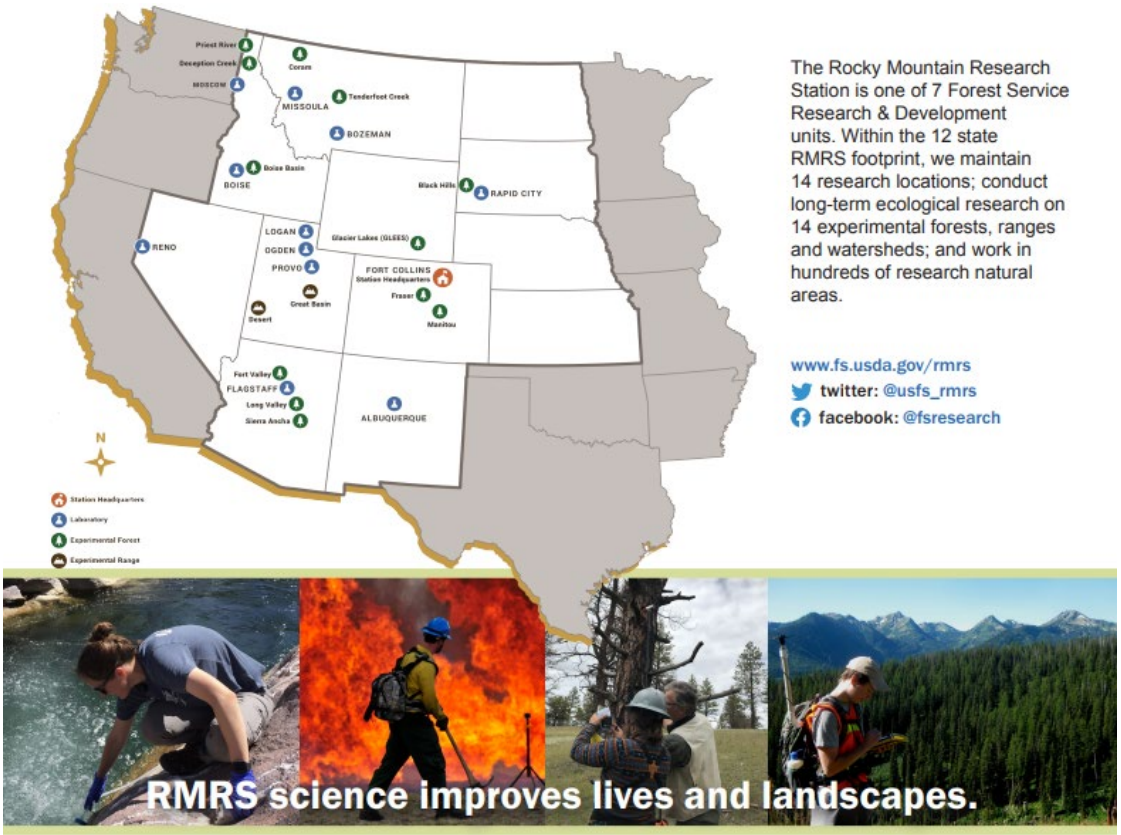
USDA Forest Service Research & Development

January 2023

RMRS scientist Kasten Dumroese at the Coeur d'Alene, ID nursery. USDA Forest Service photo by Alexis Neukirch.

About the Rocky Mountain Research Station

Rocky Mountain Research Station scientists work in a range of biological, physical and social science fields to promote sustainable management of the Nation's diverse forests and rangelands. The Station develops and delivers scientific knowledge and innovation technologies with a focus on informing policy and land management decisions. Our researchers work in collaboration with a range of partners, including other agencies, academia, nonprofit groups and industry. The Rocky Mountain Research Station serves the Forest Service as well as other federal and state agencies, international organizations, Tribes, academia and the public. Our chartered science programs include Water and Watersheds, Fire, Fuels and Smoke, Forest and Woodland Ecosystems, Maintaining Resilient Dryland Ecosystems, Human Dimensions, Inventory and Monitoring, Wildlife and Terrestrial Ecosystems and the Aldo Leopold Wilderness Research Institute. Some of the Station's research dates back over a century and offers invaluable insight into forests are changing over time, particularly in the face of a changing climate and new disturbance regimes.



Station-Wide Science Delivery and Technology Transfer Efforts

The Rocky Mountain Research Station *Science You Can Use* (SYCU) publications continue to be highly regarded and sought after by land managers, congressional staff and other scientists. This year we continued to expand our reach and impact. SYCU is directly distributed to a mailing list of over 14,000. We produced a total of 20 SYCU publications in FY22 – 6 *SYCU Bulletins,* 13 *SYCU (in 5 minutes),* and 1 *Connected Science.* We also continued to share RMRS science with the public, media and news outlets, with 19 news releases and 57 media pieces featuring RMRS scientists and publications. And our social media outreach is expanding with a total of 424 social media posts in addition to new Vimeo and Flickr accounts launched.


USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Rocky Mountain Research Station

Science You Can Use *(in 5 minutes)*

SEPTEMBER 2022

Birds & Burns: Can Prescribed Fires Limit Wildfire Severity While Maintaining Fire's Ecological Importance to Bird Species?

Wildfire influences wildlife habitat in ways that benefit some species while degrading habitat for others. Recent wildfire favors several woodpecker species by creating dead trees, or "snags," that are easily excavated for nest cavities and also provide foraging substrate for bark and wood-boring beetles. Within a few years after wildfire, openings in the canopy often stimulate understory vegetation and improve opportunities for species that nest in shrubs or forage on the ground. Yet the same wildfire may reduce habitat for species that nest and forage in live trees. Prescribed fires also can shape bird habitat and diversity directly by changing forest structure and indirectly by modifying subsequent wildfire effects on habitat.

Vicki Saab, scientist emeritus and formerly a research wildlife biologist with the Rocky Mountain Research Station, led a research team examining how prescribed fires affected wildlife populations and habitat. "We wanted to know whether burn severity after wildfire would be lower in locations previously treated with prescribed fire," she explains. "And do birds respond differently to recent wildfires in areas treated for fuels reduction compared to untreated areas?"

Wildfires create snags that woodpecker species like this black-backed woodpecker excavate for nest cavities and use to forage for bark beetles and wood-boring beetles. Courtesy photo by Tom Kogut.

In the early 2000s, Saab designed a study across the Interior West called the Birds and Burns Network to quantify bird responses to prescribed fire. When the 2007 East Zone Complex Fire burned through some of the network plots on the Payette National Forest in Idaho, the team expanded the analysis beyond prescribed fire effects on bird habitat to include wildfire effects.

Bird Responses to Burn Severity

The study confirmed that the prescribed fires limited wildfire burn severity, but the reduction in burn severity didn't change patterns of bird responses to wildfire. Species that normally move into burned areas and those that move away from burned areas were the same whether or not the site was treated with prescribed fire.

Quresh Latif is a member of the research team and a biometrician with the Bird Conservancy of the Rockies, an organization that generates science to advance bird conservation. He says birds responded similarly to burn severity across treated and untreated burn sites.

"Even though prescribed fire limited the severity of subsequent wildfire, the species that favored and avoided severely burned areas were similar regardless of whether the area had or had not been previously treated by prescribed fire," says Latif.

Spring Burns and Breeding Season

One of the big concerns for managers is the timing of spring prescribed burns, which often coincide and potentially interfere with the breeding season of many bird species. Saab says they found no negative

Forest Service Rocky Mountain Research Station

The Rocky Mountain Research Station public-facing website uses a modern Drupal-based platform which has provided a template for modernization for Research and Development. This year the website had over 1.1 million pageviews. The Rocky Mountain Research Station is actively engaged in the R&D web modernization effort which will greatly improve efficiency of IT resources, unify R&D and allow R&D web content to align with USDA web requirements

Biochar Stakeholder Workshops

RMRS research soil scientist Deborah Page-Dumroese co-leads a Targeted Allocation funded project (funding from the Washington Office) to increase production and use of biochar. Her technical expertise is critical to identifying appropriate study sites, choosing feedstocks, and informing/supporting all technical aspects of sample collection, data analysis, long-term data archiving, equipment siting, and interaction with various stakeholders. This multi-pronged effort is intended to redistribute excess forest residues as biochar for improved agriculture, mine, forest nursery, feedlot, and range conditions. Her extensive engagement resulted in two workshops in September and October 2022 focused on supporting the implementation of biochar with stakeholders, land managers, and Forest Service staff. Page-Dumroese also co-authored a publication in a peer-reviewed journal article, *Forest Biomass Policies and Regulations in the United States of America*. Interest in biochar topics is currently high as both houses recently introduced the bipartisan Biochar Research Network Act.

Biochar created from forest residues. USDA Forest Service photo.

Providing Basic and Advanced Training Domestically and Internationally

RMRS scientist Deborah Page-Dumroese was invited by the National Forest System (NFS) soil scientist cadre to develop seven training modules that will be made available through AgLearn and live (recorded) presentation. Her expertise and long-term interactions with land managers was useful to develop content pertinent to soil monitoring, soil impacts from harvest operations, effects assessment, and carbon sequestration.

RMRS research ecologist Samuel Cushman served as the Lead Instructor for the two-week National Advanced Silviculture Program Course in Landscape Ecology in January 2022. The NASP program is a collection of several courses that are required for certification of all Forest Service silviculturists. It provides a strong foundation of perspectives, methods, and tools that are instrumental for successful Agency management. The course also provides a critical opportunity for building important relationships between Forest Service research and National Forest System management, many of which last for many years and grow into extensive, long-term collaborative partnerships between research and management.

RMRS emeritus forester Terrie Jain served as Program Co-Chair for the 2022 National Silviculture Workshop meeting, and proceedings were published as RMRS-P-80. Forest management goals and objectives have vastly expanded in recent decades. Many managers and silviculturists are challenged to produce more than just timber from our nation's forests. Several RMRS scientists, including Justin Crotteau, Jason Reinhardt, and Keith Moser, presented at the Workshop and delivered foundational concepts in silviculture with emphasis on reforestation and early stand improvement through two presentations, *Regenerating and Tending Under the Vision for Resilience and Function in the Free Selection System* and *History of Stand Improvement Practices at the Fort Valley Experimental Forest.* Future forests are expected to deliver complex and often integrated management objectives such as providing a unique sense of place and naturalness, and this Workshop helps land managers make evidence-based decisions.

Forest and Woodland Ecosystems Program scientists contributed to whole of government initiatives, including forest planning and strategic consultations, and requests for assistance on reviews under the *Information Quality Act* and through the Department of State Embassy Science Fellows Program.

Targeting Pinyon-Juniper Management for Sagebrush Birds of Conservation Concern

Jason Reinhardt, RMRS research forester, continued his long-standing collaboration with NRCS, USFWS, and University of Montana scientists on pinyon-juniper management in sagebrush ecosystems. The team completed the analysis for a set of papers which use landscape-scale data derived from population surveys and remote sensing to prioritize the management of pinyon-juniper across the intermountain west while balancing the needs of the greater sage-grouse (sagebrush obligate) and pinyon jay (pinyon-juniper woodland obligate). Two peer-reviewed manuscripts related to this work are under review and are publicly available as preprints on bioRxiv (linked here and here).

Pinyon-juniper stand in Arizona. USDA Forest Service photo.

Development of Silviculture in Temperate Rainforest

RMRS scientists are contributing substantially to knowledge about silvicultural alternatives, including submission of two manuscripts for publication (Prince of Wales Commercial Thinning Study as a GTR and Temperate Rainforest Ecological Silviculture as book chapter), one invited oral presentation (Alaska Society of American Foresters), and one media article (Prince of Wales Commercial Thinning Study in *Western Forester*). Active forest management in southeast Alaska (Region 10) is an important regional and national issue. Recently the President issued an Executive Order to halt all old growth harvesting sales greater than 500 MBF. This means that there is acute pressure for young growth management to deliver forest goods. However, region-specific silviculture has been insufficiently developed and there is little scientific evidence of long-term effects of thinning on growth and ecosystem services. Furthermore, there is additional pressure to shift away from traditional wood-production silviculture and vie toward a newer, ecological forestry approach that is largely undeveloped. With these accomplishments Dr. Justin Crotteau has contributed new substantial knowledge of silvicultural alternatives in the Pacific Northwest.

Application of Adaptive Complexity Thinning Treatments on the Flathead National Forest
RMRS scientists are contributing substantially to knowledge about thinning treatment paradigms, including one poster presentation (Society of American Foresters), one oral presentation (National Silviculture Workshop), one published vignette (National Silviculture Workshop Proceedings, RMRS publication), and efforts to install a replicated block of Adaptive Complexity Thinning (ACT) treatments on the Flathead National Forest. Rocky Mountain forests with simple structure are poorly poised to provide the ecosystem services that society expects in a warming climate. ACT, an ecological approach to precommercial thinning in young stands, has the potential to kick-start development of forest complexity, delay snow melt, and provide hiding cover for snowshoe hares and other wildlife. RMRS scientist Justin Crotteau worked directly with Andy Reed (Flathead NF Tally Lake RD Silviculturist) to identify potential stands for treatment installation and adapt a marking guide for implementation by Forest Service contractors so that the Flathead would be included in this multi-ownership study. This is of great value to the Region, which is often stymied in tending young subalpine stands due to fear that all thinning reduces Canada lynx habitat. This contribution is expected to result in a new silvicultural tool that can improve forest management throughout the subalpine Rocky Mountains.

Adaptive Silviculture for Climate Change
Michael Battaglia, RMRS research forester, contributed to the Taylor Park Adaptive Silviculture for Climate Change Workshop in July 2022. Battaglia presented and helped develop climate change adaptation strategies for an installation of the Adaptive Silviculture for Climate Change lodgepole pine site on the Gunnison National Forest. The Adaptive Silviculture for Climate Change (ASCC) is a collaborative research project to integrate climate change adaptation into silvicultural planning and on-the-ground actions. Dr. Battaglia worked with Adaptive Silviculture for Climate Change interns to develop project site webpages for the Colorado State Forest, San Juan National Forest, and Taylor Park site.

Assessment of Root Disease Occurrence and Severity
RMRS research plant pathologist Patrick Bennett served as lead author on an extensive report providing evidence and guidance to support the use of a climate-based root disease model for the USFS Northern Region (Region 1). Two new climate-based root disease models have been developed for Region 1, outlined in the publication *Assessment of root disease occurrence and severity estimated from climate models with Forest Inventory and Analysis (FIA) data*. One model provides estimates of climatic suitability for root disease and the other provides estimates of potential root disease severity. These models were developed using root disease presence and severity data collected on Forest Inventory and

Analysis (FIA) plots and incorporate climatic and biophysical variables to estimate the spatial distributions of suitable climate for root disease and potential severity where root disease may occur.

Southern Rockies Reforestation Tool (SRRT)

RMRS research ecologist Paula Fornwalt has led the development of the Southern Rockies Reforestation Tool (SRRT), which identifies climatically and topographically suitable sites to plant ponderosa pine and Douglas-fir seedlings after wildfire in the southern Rocky Mountains. Tree planting is a common post-fire management activity that may help to offset forest loss due to high-severity wildfire. A simple tool like SRRT that uses best-available science to identify climatically and topographically suitable sites could help land managers optimize planting efforts by focusing on sites with the greatest chance for success. In August 2022, the month after the tool was first published, SRRT was the most-viewed tool on the RMRS website.

Contract tree planters with some of the 530,500 seedlings that would be planted across 2,536 acres in the Lolo National Forest in Montana. Courtesy photo of Dave Gardner.

Research and Management of High Elevation Five Needle Pines

Anna Schoettle, RMRS research plant ecophysiologist, served on the organizing committee for the Second Conference on the Research and Management of High Elevation Five Needle Pines in Western North America (H5II Conference) in October 2022. She delivered a Keynote Address; prepared and published invited manuscripts for a Special Issue of *Forest Ecology and Management Journal*; prepared and published 2 contributions for the H5II proceedings. These contributions and others continue to demonstrate working with partners to further proactive and restoration efforts to increase the resilience of high-elevation five-needle pines to white pine blister rust (WPBR) and climate change. Anna Schoettle also completed the international Crown of the Continent-wide Restoration Plan for whitebark pine and limber pine. U.S. and Canadian land management jurisdictions are implementing the plan.

Pelletized Inoculation of Fire Mosses in Severely Burned Conifer Forests

Carolyn Sieg, RMRS scientist, published research indicating pelletized inoculation of fire mosses in severely burned conifer forests overcomes initial barriers to *Bryum argenteum* establishment but does not increase cover. As wildfires increase in extent and severity, we need new tools to rehabilitate burned landscapes. We tested the effectiveness of adding fire moss tissue, produced in the greenhouse, as a bio-inoculant to severely burned soils in dry mixed conifer forests. We conducted three sequential experiments using knowledge gained from previous experiments to fine-tune fire moss delivery methods. Ultimately, more testing and refinement is needed on pelletization during non-drought conditions.

Bark Beetles and High Elevation Pine Defenses

RMRS research entomologist Barbara Bentz engaged broadly with stakeholders in relation to bark beetles and high elevation pines. She gave Plenary Presentations at the Second Conference on the Research and Management of High Elevation Five Needle Pines in Western North America and Western Forest Insect Work Conference and shared her work through a presentation for the IUFRO Conference Division 7 for Forest Health Pathology and Entomology. Barbara Bentz published nine papers on the topic in peer-reviewed scientific journals. She also spoke about her work with the L.A. Times, Washington Post, Salt Lake Tribune, and National Geographic.

A spruce beetle outbreak on the Rio Grande National Forest. USDA Forest Service photo by John Squires.

Vegetation Management Treatments for Enhancing Forest Resiliency

RMRS scientists Jose Negron, Terrie Jain, Michael Battaglia, and collaborators continued their work in *Assessing Vegetation Management Treatments for Mitigating Bark Beetle-Caused Tree Mortality and Enhancing Forest Resiliency*. The study addresses the efficacy of vegetation management to mitigate bark beetle-caused tree mortality and increase resilience in western conifer forests. A variety of silvicultural strategies can be an effective long-term approach to reduce the probability of infestation and the extent of tree mortality caused by bark beetles. However, supporting data typically comes primarily from small (for example <2 acres) and short-term studies. There is a paucity of longer-term information from larger areas with different stand structures. This study will identify ponderosa and lodgepole pine, Douglas-fir, spruce, and mixed conifer forest stands across the West that have been treated in the past and sampled for post-treatment tree mortality caused by various bark beetles. This work has produced a range of research outcomes for public benefit, shared through peer- and informally-reviewed scientific publications, presentations to stakeholders, and broad engagement to support the adoption and enhancement of land management outcomes by partners.

Vegetation Type Conversion in the US Southwest

Ann Lynch, RMRS research entomologist, contributed to the development of a manuscript that distilled case studies provided by workshop participants into a single, informative peer-reviewed publication in the scientific journal *Fire Ecology*. Terrestrial ecosystems of the West are experiencing major transformations in response to land-use change, warming climate, and their interactive effects with wildland fire. Some ecosystems are transitioning to persistent alternative types known as “vegetation type conversion” (VTC). VTC is one of the most pressing forest resource management issues in the southwestern U.S., but their unprecedented nature, spatial extent, and unknown trajectories create difficult management situations. Current strategies to intervene and address change often use trial-and-error approaches developed under great uncertainty in the post-fire environment. This publication is a synthesis of 11 case histories and 61 examples that describe management observations and responses to VTC. It is meant to serve both managers and researchers, but particularly to assist and support

managers' decision processes. This publication will have plenty of impact in the West. It will be well used by the National Forest Service, Park Service, and Bureau of Land Management in preparing project and Forest Plans and associated NEPA documents. It will also serve as a "must read" educational document for southwestern foresters, silviculturists, and forest & woodland resource managers.

Detecting Pathogens in Pacific Islands

Ned Klopfenstein, RMRS research plant pathologist, contributed to work focused on the variety of *Fusarium* species that have been collected and morphologically identified from *Acacia koa* (koa), one of the most iconic forest tree species endemic to Hawai'i. Hawai'i is among the most isolated regions on Earth. Due to this isolation, many of Hawai'i's native plant species are not well adapted to cope with introductions of novel flora, fauna, and pathogens, like *Fusarium*. This study, published in *Forest Pathology*, identified new associations of *Fusarium* spp. with koa root samples and suggests that a complex of *Fusarium* spp. may contribute to disease severity. Potential spread of putative pathogens across the Hawaiian Islands is suggested on the basis of haplotype network analysis. Ned Klopfenstein also contributed to a General Technical Report (PNW-GTR-1006) describing multiple approaches that have been attempted to control the fungus that causes brown root rot disease along with science-based information for consideration when trying to manage the pathogen in the Pacific Islands.

First Report of Armillaria Root Disease in South Carolina

RMRS scientist Ned Klopfenstein led work that examined dieback and mortality of *Celtis laevigata* (sugarberry, southern hackberry). Sugarberry is an important, shade-tolerant, deciduous hardwood tree species that occurs naturally in flood plains, along streams and rivers, and in urban landscapes of the southeastern USA. This research, published in *Plant Disease*, represents the first report associated with Armillaria root disease of sugarberry. Documenting Armillaria distribution is essential for predicting climate-change impacts on Armillaria root diseases in the United States.

Ned Klopfenstein also published new research focused on developing novel approaches to manage Armillaria root disease in coniferous forests of the western U.S. This research was highlighted in a Science Spotlight.

Effectiveness of Fuel Treatments at the Landscape Scale

Terrie Jain, RMRS emeritus forester, led the development of the *Effectiveness of fuel treatments at the landscape scale: State of understanding and key research gaps* project. Maximizing the effectiveness of fuel treatments at the landscape scale is a key research and management need given the inability to treat all areas at risk from wildfire, and there is a growing body of scientific literature assessing this need. The interdisciplinary team concluded that existing literature contains useful information that can inform future fuel treatment planning, but that additional research is needed in underrepresented ecosystems and underdeveloped topics including cost-benefit analysis, fuel treatment longevity, and interactions among fuel, topography, and climate that contribute toward influencing fuel treatment effectiveness. As of August 2022, this was the most-viewed publication in the financial year for the Rocky Mountain Research Station.

Identifying Conifer Mortality Induced by Armillaria Root Disease Using Airborne Lidar

Andrew Hudak, RMRS research forester, helped develop a method for identifying conifer mortality using LIDAR, which was published in the scientific journal *Forest Ecology and Management*. Armillaria root disease causes tree stress and mortality worldwide, including in conifer forests of western North America. Armillaria-induced tree mortality is slower than other disturbances, such as fire, but persistent over time, and therefore difficult to detect across large areas. Hence methods to detect Armillaria-affected trees and identify infested stands are of great value to forest managers. The team used high-

density light detection and ranging (lidar), high-resolution aerial orthoimagery, and associated field observations to map individual tree health across an Armillaria-affected forest dominated by Abies in south central Oregon. This research approach was highlighted in a *Science You Can Use Bulletin*.

Fire Ecology and Management: Past, Present, and Future of US Forested Ecosystems

RMRS scientists Paula Fornwalt and Mike Battaglia published a book chapter focused on fire ecology and management in forested ecosystems in the United States. Fire shapes forest structure, composition, and biodiversity. Driven by climate change and a history of fire exclusion, wildfires are growing more frequent and severe, reshaping forest ecosystems and creating new management challenges. Land managers need comprehensive syntheses of fire ecology to help reduce wildfire risk while supporting healthy forests. A new book meets this challenge by examining the driving forces, historical patterns, and future management challenges of fire in a variety of forested ecosystems across the United States. The book covers fire ecology of every major forest type in the United States, including fire regimes, land use history, ecosystem restoration, and the impacts of fire suppression and climate. It provides accessible information to help understand how fire histories, behavior, and impacts differ between major ecosystems and future directions for forest management. This research is highlighted in an associated Science Spotlight.

Fire scientists surveying ground-level fuels. USDA Forest Service photo by Sharon Hood.

Influence of UAS Flight Altitude and Speed on Aboveground Biomass Prediction

Wade Tinkham and Andrew Hudak, RMRS scientists, published research indicating a strong positive relationship between flight altitude and plot-based aboveground biomass modeling accuracy. The management of low-density savannah and woodland forests for carbon storage presents a mechanism to offset the expense of ecologically informed forest management strategies. However, existing carbon monitoring systems draw on vast amounts of either field observations or aerial light detection and ranging (LiDAR) collections, making them financially prohibitive in low productivity systems where forest management focuses on promoting resilience to disturbance and multiple uses. The imagery was acquired across a range of UAS altitudes and flight speeds that influence the efficiency of data collection. Results show a strong positive relationship between flight altitude and plot-based aboveground biomass modeling accuracy. UAS predictions increasingly outperformed (2-24% increased variance explained) commercial airborne LiDAR strategies as acquisition altitude increased from 80-120 m. The reduced cost of UAS data collection and processing and improved biomass modeling accuracy over airborne LiDAR approaches could make carbon monitoring viable in low productivity forest systems.

Entity Guidelines for Greenhouse Gas Quantification in Agriculture and Forestry Updated

Update the *2014 Entity Guidelines for Greenhouse Gas Quantification in Agriculture and Forestry*: Shawn Urbanski and Karin Riley took a lead role in the USDA effort to update the *2014 Entity Guidelines for Greenhouse Gas Quantification in Agriculture and Forestry*. Shawn and Karin were the conceptual architects and lead authors of the fire subchapter, which focused on immediate fire effects on greenhouse gas emissions and carbon pools.

Fire Effects Information System

Fire crews monitor a prescribed burn on the Caribou-Targhee National Forest. USDA Forest Service photo by the Caribou-Targhee National Forest.

Thousands of scientific articles and reports are published each year about wildland fire, making it difficult for managers and planners to find, read, and use the best available science. Fire Effects Information System (FEIS) is a team of ecologists within the Fire Modeling Institute that synthesizes information about fire ecology and fire regimes. FEIS syntheses are published on their website. FEIS enables its users to easily find science relevant to land management decisions. FEIS offers three peer-reviewed publication types: Species Reviews, Fire Regime Syntheses and Reports, and Fire Studies. Species Reviews include information about plant and animal species' biology, habitats, regeneration or reproductive processes, relationships with fire, and management considerations. Fire Regime publications provide information including how often and how severely fires burned in specific ecosystems and contemporary changes to those ecosystems. Fire Studies summarize one or more related fire research publications. Since its inception in 1986, FEIS has published about 1,100 Species Reviews, over 175 Fire Regime publications, and over 150 Fire Studies. Publications for 2022 include Species Reviews for saguaro, bigleaf rhododendron, Arizona walnut, Arizona sycamore, desert-willow, and Pine Hill flannelbush.

Wildfire Risk to Communities (WRC)

The *Wildfire Risk to Communities* project was created under the 2018 Consolidated Appropriations Act. It is designed to help community leaders, such as elected officials, community planners, and fire managers to find information about wildfire risk to homes, wildfire exposure, and wildfire likelihood in all 50 states. The data and easy-to-use interactive maps routinely support efforts like Community Wildfire Defense Grants. The project is co-led by WO Fire and Aviation Management, and the Fire Modeling Institute (FMI), part of the RMRS Fire, Fuels, and Smoke Science Program. In FY2022, FMI worked with the FS Office of Tribal Relations, Fire and Aviation Management, the Bureau of Indian Affairs, and the DOI Office of Wildland Fire to update *Wildfire Risk to Communities* to include information about wildfire risk to homes, wildfire exposure, wildfire likelihood, and vulnerable populations for tribal areas in all 50 states. The website was also updated with the latest data from the U.S. Census Bureau's American Community Survey for socially vulnerable populations to include families in poverty, people with disabilities, people over age 65, people with difficulty speaking English, households with no cars, and mobile homes.

Secretarial Memo Response

The RMRS Fire Modeling Institute (FMI) and scientist Karin Riley collaborated with the Washington Office, helping to prepare a response to the June Secretary's Memo on Climate and Carbon Resilience (section 2.a.(1)). The memo called on the agency to update the fireshed risk map by the end of November 2022 to include risks to ecosystem values and risks to under-served and socially

disadvantaged communities. It also requires that carbon storage data be added to the fireshed risk map. FMI brought a series of geospatial datasets relevant to the task in a format that could be used in the fireshed registry, ultimately helping complete the needed exposure analyses by the deadline requested. Without the foresight and effort to have already created geospatial layers useful for this request, the deadline for the memo would have been extremely challenging for the Agency to meet. Karin Riley's TreeMap was used to add high resolution carbon storage data to the map viewer application being developed in response to Section 2a1 of the June 2022 Secretary's Memo.

Wildland Fire Behaviour: Dynamics, Principles, and Processes

In FY22 RMRS scientists Mark Finney, Sara McAllister, Torben Grumstrup, and Jason Forthofer published *Wildland Fire Behaviour: Dynamics, Principles, and Processes*. This book was written to help fire practitioners, firefighters, managers, and others understand the science behind wildland fire spread and behavior. The book summarizes the current state of knowledge surrounding wildland fire behavior, explains how combustions, heat transfer, and ignition produce spreading wildfires, summarizes methods for measuring fuels and fire behavior in research or management, and uses a simple one-dimensional fire spread model to demonstrate complex dynamical fire behavior.

Wildland Fire Smoke in the United States: A Scientific Assessment

In 2022 Forest Service Research published *Wildland Fire Smoke in the United States: A Scientific Assessment*. This publication summarizes the current understanding of smoke science and issues surround smoke from wildland fires, along with providing information for improving smoke and fire management. Several RMRS employees were involved in the development of this book, including recently retired RMRS scientist Sarah McCaffrey as one of the editors and lead author of the chapter on Social Considerations, Shawn Urbanski as lead author of the chapter on Emissions, and Duncan Lutes, Andrew Hudak, and emeritus scientist Bob Keane as contributing authors for the chapter on Fuels and Consumption.

Mortality of Fire-Resistant Giant Sequoias

RMRS scientist Sharon Hood participated in a study that looked at increases in mortality of giant sequoias (*Sequoiadendron giganteum*) due to recent wildfires. Looking at sequoia groves that burned between 2015 and 2017, the researchers found that in high severity areas ~84% of the large sequoias were killed and ~28% of giant sequoias were killed in moderate severity areas. The study found that mortality was linked to prior fire damage in the lower tree bole, lower crown ratios, and lower elevation. Total crown damage and the presence of fire scars were the best predictors of delayed mortality. With the rapid increases in fire activity more forest treatments that reduce fire severity could help protect giant sequoias into the future.

Tree Planting: Understanding How Trees Grow Roots

To better understand how to maintain resilient forests as the frequency and intensity of storms changes with altered global climate, RMRS scientist Kasten Dumroese led an international team to determine how nursery practices affect long-term tree root development. The research focused on 32-year-old ponderosa pine trees growing in northern Idaho. Although the original focus of this work was on understanding how nursery practices affect the long-term root growth of reforestation seedlings, the data coming from this long-term experiment is also answering some fundamental questions about how trees produce roots and remain stable and upright in response to mechanical stresses. While a few nursery-caused modifications to root systems were evident three decades later, most root systems traits observed were a response to localized mechanical stresses and reflect a tree's ongoing response to changes in its environment. This research was highlighted in an associated Science Spotlight.

Fire Ecology and Management: Past, Present, and Future of US Forested Ecosystems

Several RMRS Scientists, including Mike Battaglia, Paula Fornwalt, Brice Hanberry, Serra Hoagland, Sharon Hood, and Victoria Saab, contributed to *Fire Ecology and Management: Past, Present, and Future of US Forested Ecosystems,* a new book that provides a comprehensive synthesis of fire ecology designed to help reduce wildfire risks while supporting healthy forests. The book provides fire ecology information for every forested ecosystem in the United States, and includes topics such as fire frequencies and severities, the role of fire in maintaining forest composition and structure, current and historic fire regimes, and fire management. RMRS scientist helped author chapters looking at ecosystems in the Southeast, Southwest, Rocky Mountains, and managing resilience under changing climates and fire regimes.

USDA Forest Service photo by Karen Wattenmaker.

Where Were Eastern Grasslands?

More than 95% of grasslands in the eastern U.S. have been lost to other land cover or land uses, such as agriculture and pastures. Brice Hanberry, an RMRS researcher, identified potential locations of fire-maintained grasslands, by modeling known grassland locations based on wind speed and topography to approximate fire compartments. This paper was highlighted in a Science Spotlight. A generalized ruleset was that fire-maintained grasslands occurred at topographic roughness values of less than 95, or flatter sites, and wind speeds ≥ 3.4 m s^{-1}. Potential grasslands covered 27 million ha, or 14% of the 200 million ha eastern U.S., although these fire-maintained locations also may have been savannas or open woodlands historically. Currently, potential grassland locations are 40% crops, 25% pasture, 18% forests, and 13% developed land, with about 1.5% each of herbaceous upland vegetation, herbaceous wetlands, and shrublands. According to historical accounts, fire-maintained grasslands generally transitioned to dense young tree growth within a 20-year interval after fire exclusion; in Kentucky, the transition transpired during the periods 1790 to 1810 and 1810 to 1830, but dates vary with Euro-American settlement time. A comprehensive map of potential eastern grasslands is a progressive step for recovery of grasslands and biodiversity conservation.

Activating an Urban Definition

No common global definition exists of urban populations, resulting in a lack of shared standards across countries for equivalent comparisons. Brice Hanberry, an RMRS researcher, solved the problem of the lack of a standardized definition by classifying continuous population density models into density classes after calibrating to the United Nations global urban percentage. This publication was also highlighted in a Science Spotlight. Because the three population density models varied in population distribution, different urban density thresholds were necessary for each population model. Population density is an enduring attribute to differentiate urban lands from rural lands. Population density thresholds permit standardized calculation of urban proportions across countries, rather than relying on national reporting based on inconstant standards that are fluid, changing with population patterns. All three population models with adjusted thresholds agreed on a divergent reported urbanized or rural status for 32 countries, representing about 30% of the global population, and greatly reduced urban percentages for

another 13 countries. By limiting the definition only to population densities, the definition avoids inconsistencies that arise from dynamic processes, such as economic transformation.

Back By Popular Demand: Tribal Nursery Manual Reprinted

In 2008, a collaboration of private nursery managers, academics, and former FS national nursery specialist, led by RMRS research plant ecophysiologist and national nursery specialist Kasten Dumroese, created Agriculture Handbook 730 in response to a need defined by Native Americans. Based on Native American input and with a better understanding of how they prefer to obtain information obtained through on-going discussions, the 17-chapter **"Nursery manual for native plants: A guide for tribal nurseries - Volume 1: Nursery management"** assists them with all aspects of designing, building, and using a native plant nursery to meet their unique needs. Per their request for a more visual approach, more than 300 figure illustrations were used to reinforce key points. Within 6 weeks of publication, more than 2000 copies were requested and distributed across the US, and because of the simplicity of presentation, the manual is used by others well beyond the Native American community. A review in the prestigious journal *Ecological Restoration* stated it "is a masterpiece of applied horticulture and ecological restoration," and this publication was the 2009 Outstanding Technology Transfer Publication in RMRS. Jeremiah Pinto, the Forest Service Tribal Nursery Specialist, uses the manual as the basis for workshops and training sessions for Native Americans. During 2022 the manual was reprinted to meet the need for growing reforestation seedlings spurred by recent national legislation.

RMRS scientist Kasten Dumroese at the Coeur d'Alene, ID nursery. USDA Forest Service photo by Alexis Neukirch.

The Reforestation Pipeline in the Western United States

The reforestation pipeline topic has been rapidly gaining momentum with recent scientific articles addressing the issue as well as recent policy and legislation aimed at supporting it. In September 2022, three nursery associations (Western Forestry and Conservation Nursery Association, Intertribal Nursery Council, and Intermountain container Seedling Growers' Association) joined to conduct a meeting on the four aspects (seed, nursery production, outplanting, post-outplanting practices) of the reforestation pipeline as they relate to science, technology, management, traditional ecological knowledge, legislation, and policy. Rocky Mountain Research Station research plant physiologist Jeremiah Pinto, co-organized and led the meeting, bringing students, professionals, and scientists from across the US to present and participate (held in-person and virtually). Presentations were accompanied by tours to local nurseries (Great Bear Native Plants, Confederated Salish and Kootenai Tribes Forestry Greenhouse, Montana Conservation Seedling Nursery).

Predicting Herbicide Resistance in Noxious Weeds

Noxious weeds are designated plant species in the United States that cause damage to crops, livestock, poultry or other resources. Therefore, managers often seek methods, such as herbicide, to control these species. However, repeated herbicide use can enable herbicide-resistant populations to develop. Predicting which species are most likely to evolve herbicide resistance and which conditions support this evolution is critical knowledge for managers. Determining which plant traits are associated with herbicide resistance can assist managers in identifying species with the potential to develop herbicide resistance and allow us to identify species that are most likely to become herbicide resistant. To examine plant characteristics that potentially contribute to herbicide resistance, herbicide resistance of 283 noxious weed species was modeled - by RMRS scientist Jacqueline Ott in collaboration with South Dakota University and the Pacific Northwest Research Station - as a function of ten biological and ecological plant characteristics. Species with persistent seed banks and with short life spans (i.e. annuals) that occurred outside of riparian or wetland areas were most likely to develop herbicide resistance. In 2022, 47 of the noxious weed species analyzed in this study are herbicide resistant and our models identified an additional 63 species in the United States with traits that that would be conducive to becoming herbicide resistant. A ranked assessment of the risk that current, non-resistant noxious weed species may become resistant in the United States in the future is available in Hartway et al. 2022.

Climate Change Impacts Invasive Perennial Grass Establishment

RMRS scientists are providing contributions in knowledge to climate change and its effects on our biosphere. is expected to increase the timing between rainfall events during the growing season in the northern Great Plains where the perennial grass smooth brome (*Bromus inermis*) is invading native perennial grasslands. These native grasslands provide multiple uses to the public, especially by providing forage for livestock, wildlife, and pollinators. To inform how invasive seedling establishment may shift under climate change, RMRS research ecologist Jacqueline Ott and her collaborators examined how clonal traits of native perennial western wheatgrass (*Pascopyrum smithii)* and non-native smooth brome seedlings were affected under altered precipitation frequencies and a single grazing event during their first growing season (Bam et al. 2022). Clonal growth of the non-native smooth brome was greater than the native western wheatgrass under all simulated precipitation frequencies except the most intermittent scenario. Smooth brome placed large initial investments in stem production under wet conditions which could explain how it is able to rapidly occupy and expand from colonization sites in the field. In young plants, clonal traits of the invasive grass favored its superior expansion and population growth compared to the native grass except under the most severe climate change scenario. Therefore, grassland managers may observe greater success of controlling smooth brome invasion in years with intermittent rainfall and can be confident in the ability of the native western wheatgrass to establish under a range of intra-annual precipitation variability.

Northern Pike Invasion in the Columbia River Basin

The invasion of northern pike in the upper Columbia River basin spans multiple states and jurisdictional boundaries. Effective control of this invasion requires a comprehensive approach with coordination among agencies. Through a collaborative effort, RMRS built a genetic database of invasive northern pike representing populations across the region. By analyzing relatedness among these populations, we identified a previously unrecognized role of human transport in the spread of this invasive species. This work led to many popular press articles, as well as a peer-reviewed product, and a Science You Can Use. This is an excellent example of how results driven science addressed important management questions, with a variety of technology transfer products to engage managers, academics, and the public.

Great Basin Perennial Montane Watersheds-Geomorphology, Hydrology, Vegetation, Disturbance and Species

Jeanne Chambers, RMRS senior scientist emeritus, led a collaborative group of managers and scientists to develop a multiscale approach for assessing the geomorphic sensitivity of streams and ecological resilience of riparian ecosystems, including meadows, in upland watersheds of the Great Basin to disturbances and management actions. This data publication contains the geospatial data, representative of 2020, resulting from that work. The study area, the Great Basin of North America, includes portions of Nevada, Utah, California, Oregon, and Idaho. Nine shapefiles are included, which provide the seven regions (1) and the mountain ranges (2) identified in the study area, streams within each watershed (3) along with the stream heads (4), longest stream (5), lowest drainage points (6), and the stream head that has the farthest stream distance from the pour point (7), and the valley bottom which is considered the area surrounding the stream that is less than 15 meters above the stream's elevation (8) for each watershed. Also included are the watershed boundaries (9) and additional watershed information related to climate, topography, and wildlife. This approach, intended to help riparian managers determine and prioritize where management actions are most likely to be successful, is further described in the associated RMRS General Technical Report and Science You Can Use.

A riparian area in the Great Basin. USDA Forest Service photo by Jeanne Chambers and Jerry Miller.

Understanding Post-fire Tree Mortality: Resources & Research

RMRS scientists Sharon Hood, Duncan Lutes, and collaborators developed a StoryMap that compiles information about post-fire tree mortality based on past and current research efforts at the Rocky Mountain Research Station, Fire Sciences Laboratory. It is divided into five main sections that provide basic information on how fires kill trees, research and management applications, a database of tree mortality records after fire, modelling, and user guides. By killing trees, wildland fires influence ecosystems in many ways, including limiting ecosystem productivity, altering resource availability, and changing the structure and composition of vegetation. These changes can have both positive and negative impacts on carbon storage, biodiversity conservation, hydrologic processes, and economic and social services. In fire-adapted and fire-dependent ecosystems, fire controls tree density and species dominance, creating habitat that supports diverse plant and animal species that cannot persist in the absence of fire. However, fire-adapted ecosystems may be vulnerable to climate-driven alterations to fire regimes that have been an emerging threat in recent decades, with observations of increasing fire size, frequency, and severity. Climate-mediated increases in fire severity and frequency are projected to cause large decreases in carbon stocks through loss in forested area, and increased fire frequency is killing trees before maturity. Such changes in fire regimes can shift forests to non-forested states. These impacts make understanding fire caused tree mortality essential to predicting fire effects from local to global scales.

The Scenario Investment Planning Platform - A USDA Forest Service Initiative to Improve Prioritization of Restoration and Forest Management Investments

The USDA Forest Service Scenario Investment Planning Platform was developed by Forest Service Research & Development including RMRS scientists to modernize our approach to prioritizing

investments and provide the agency with a robust framework for simulating prioritization scenarios and measuring outcomes and tradeoffs at multiple administrative scales. This ArcGIS Hub introduces the key concepts of the Scenario Investment Planning Platform, answers frequently asked questions, and shares relevant publications, case studies, and other resources.

Potential Range Shifts in Global Protected Areas

Scientists at the Aldo Leopold Wilderness Research Institute, in collaboration with a variety of partners, have examined global protected areas, and in particular the potential for transboundary range shifts under global warming 2°C above preindustrial levels. As the global conservation community actively deliberates conservation frameworks (e.g. 30 percent by 2030), this research offers insights to reduce the prevalence of novel and disappearing climates within the global protected area network via strategic conservation actions and underscores the importance of setting and accommodating targets and strategies that transcend national boundaries. Along with peer-reviewed products, one important and novel technology transfer product from this research is an "Analog Atlas". The atlas allows users to search any location on a map to find its future climate analog with a 2-degree warming. This tool is an innovative way to engage and communicate with the public about climate change. With a strong scientific backbone, it provides a user-friendly interface to explore future climates across the globe. You can also read more about Parks et al. (2022) in the associated Science Spotlight.

Several chinook salmon, native to the Columbia River Basin. USDA Forest Service photo.

Restoration Through Science-Based Collaboration

RMRS fisheries scientist Russ Thurow worked alongside retired Idaho Department of Fish and Game biologist Jerry Mallet to chronicle case histories of fluvial Westslope cutthroat trout (WCT) restoration. Historically, WCT were extremely abundant, widely distributed, and the dominant trout in central and northern Idaho. Despite restricted harvest and habitat protections since 1899, many Idaho WCT populations declined, primarily from habitat degradation and excessive harvest. By the 1960s, WCT in several major drainages were on the brink of collapse. In response, a dedicated group of fisheries researchers and managers collaborated to investigate WCT and develop evidence-based angling regulations and habitat restoration alternatives. As a result of these sustained efforts, populations in many watersheds have been rehabilitated and WCT remain an important ecological, cultural, recreational, and economic resource. This research is highlighted in an associated Science You Can Use.

Developing a Guide for Restoration Using Pollinator Friendly Plants

RMRS scientist Justin Runyon co-authored a publication in collaboration with Ph.D. candidate Will Glenny of Montana State University on assessing the pollinator friendliness of plants and developing seed mixes that benefit bee habitat. Establishing vegetation after a disturbance, such a severe wildfire or flood, can minimize erosion, improve soil health, reduce invasive weeds, and provide forage for grazing animals. Common seed mixes are most often comprised of grasses and shrubs, as these seeds are more readily available in the large quantities needed for wildland restoration. While these seed mixes can be beneficial for erosion control, they may not provide enough floral resources for bees and other pollinators. Researchers in western Montana set out to design a regionally optimal seed mix for bee restoration. By studying bees in natural populations of 24 native plants that are also available from commercial seed sources, they observed how many bees visited each plant, how often bees visited, and the number of different bee species that visited. Additionally, the research team determined how often each plant species blooms, for how long, and if they flowered early, middle, or late in the growing season. This information is critical to match plants with native bees. Seed mixes that maximize the abundance and diversity of bee species will be most beneficial for restoration efforts that also improve bee habitat. Additionally, optimal seed mixes will contain early, mid, and late blooming plants to provide flowers throughout the season. This research is highlighted in an associated press release.

A bee pollinating penstemon. USDA Forest Service photo.

Resources to Improve the Efficiencies of Forest Operations

Nate Anderson and John Hogland, RMRS research foresters, worked with researchers from Idaho and Oregon State University to develop two new mapping tools to improve the efficiency and economy of fuel treatment and salvage operations. These tools are outputs of the Bioenergy Alliance Network of the Rockies (BANR), whose goal was creating a new bioeconomy to derive economic value from dead timber and biomass left in the wake of large-scale disturbances like beetle epidemics and wildfire. The two tools developed are a biomass procurement and supply chain analysis tool and a harvest system mapping tool. Because hauling lower value products to a sawmill or biomass facility may cost more than the products are worth, minimizing transportation costs can be critical to project viability. A GIS-based procurement add-in, developed by RMRS, allows managers to estimate the log and biomass volumes, harvest costs, and off-road and on-road transportation costs for any location on the landscape. The harvest mapping tool was developed by Ryer Becker, a graduate student at University of Idaho. This tool mapped the suitability of different harvest systems to specific treatment units across large landscapes and created a harvest system map for a 74,000-acre study area of the Nez Perce Clearwater National Forest. The method combines lidar and ground plot inventory data with engineering information to facilitate the optimal deployment of harvest systems, including tethered and winch-assisted equipment. This research is highlighted in an associated Science You Can Use.

A New Framework for Fire Aviation Decision Support That Improves Efficiency Through Analytics

Crystal Stonesifer, former RMRS ecologist, and colleagues have recently developed and published a decision support system called the Aviation Use Summary (AUS). The AUS provides a shared understanding for firefighters, fire managers, and fire leadership through near real-time automated mapping of aircraft actions (such as retardant drops) and a structured, repeatable check-in and planning process. The AUS is a framework for a decision support system that bridges the gap between tactical aviators, incident managers, land managers, and fire leadership through near real-time mapping of actions and a structured, repeatable check-in and planning process. The AUS, which is manually developed by RMRS analysts by request, has been in use since 2017 on over 70 different fires, forests, and regions throughout the Western United States. This framework provides analytical insights that facilitate important conversations between land managers and operators about objectives, related risks, and potential outcomes. This research is highlighted in the associated Science You Can Use.

Aircraft dropping retardant on wildfire. USDA Forest Service photo.

Using eDNA Sampling for Surveillance of Invasive Species

RMRS researchers who helped build the National Genomics Center for Wildlife and Fish Conservation (NGC) eDNA Program worked with an interagency team to publish a framework that describes the ins and outs of using eDNA sampling as a tool in invasive species management. The framework is the culmination of the work of nearly 30 Federal scientists and invasivespecies specialists. This effort was initially spearheaded by the National Invasive Species Council (NISC) to find a tangible means to deliver this tool to managers. Managers need detailed information for deciding if, when, and how to use eDNA sampling for invasive species surveillance and management. The first step is to determine whether eDNA sampling is a useful tool given the management objectives. Jeff Morisette, an RMRS science program manager who helped initiate and led this project while working for NISC, says, “eDNA has proven effectiveness, but there are two significant caveats: It is fairly sophisticated from a technical level and secondly, it is extremely sensitive in detecting evidence of a given species, but such evidence does not necessarily imply that there is a viable population present. Our paper provides guidance on these two issues, as well as other aspects of implementing eDNA for invasive species surveillance.” The framework stresses the importance of communication to build trust among managers, eDNA practitioners, and stakeholders. This research is highlighted in an associated Science You Can Use.

New Approach for Estimating Rangeland Carbon Stocks Help Managers Plan Climate Change Mitigation Strategies

Matt Reeves, RMRS research ecologist, and a team of RMRS scientists and managers developed a way to quickly assess rangeland carbon that can be applied at a local or larger scale. The technique involves assessing above ground carbon stocks in shrubs and below ground in SOC, which varies by plant community type. Carbon found in herbaceous species like grasses are not evaluated since that pool is so ephemeral and variable year to year. Compared to grasslands, shrublands store carbon deeper in the soil profile making it more likely to stay put. However, where sagebrush shrublands have shifted to

nonnative annual grasses like cheatgrass, relatively more carbon occurs in the upper part of the soil horizon where it is subject to atmospheric release from disturbance. Scientists estimate that in the last 15 years, nearly 9 million tons of carbon have been lost in the Great Basin to this sort of conversion.

The "Living Map" of Mexican Spotted Owl Habitat

Mexican Spotted Owl sitting on a perch. USDA Forest Service photo.

Scientists from RMRS along with experts from the USDA Forest Service and the Fish & Wildlife Service convened to produce an estimation of habitat trend spanning the last ~35 years across all forests within the Southwestern Region (Arizona and New Mexico). From this effort, annual maps of Mexican spotted owl (MSO) forest habitat across the Southwestern Region from 1986-2020 have been developed using Landsat imagery, climate data, topography, and a large number of known MSO nest/roost locations. The primary purpose of these maps is to identify broad-scale and long-term trends in potential MSO forest habitat. This "living map" product will continually be refined with new data and improved over time. The living map uses these nest/roost locations of nesting and roosting owls to identify MSO forest habitat, which shows areas where owls are most likely to establish nesting territories and exhibit roosting behaviors as a function of forest vegetation, topography, climate, and their complex interactions. The living map also identifies MSO cover type, which shows forest vegetation that is similar to the type owls are known to nest and roost in (or not) but does not account for how topography and climate may constrain nesting or roosting activities. This research is highlighted in the associated Science Spotlight.

FIA and USDA Forest Service Collaborations with International Entities in Technology Transfer and Scientific Exchange Activities

RMRS scientists participated in cooperative exchange of technology and science-related activities, with international cooperation contributing to the Forest Service's mission. These include improving national security by promoting healthy ecosystems and associated social and economic stability in partner countries, developing personal and professional connections that lead to improved international cooperation, ecosystem management, and employee development outcomes, and improving the state of natural resource monitoring and management science in the U.S. and abroad by sharing with and learning from partner country professionals. The work of FIA scientists extends into Central and South America, Sub-Saharan Africa, Western Europe, and Southeast Asia.

In Paraguay, RMRS scientists Eric Bullock, Andy Lister, and Sean Healey worked closely with forestry officials to assess potential sample biases and to update estimates of mean biomass using model-based inference with inventory data and lidar data from NASA's GEDI mission. Africa saw RMRS FIA scientists assisting with science exchange in Zimbabwe (automating aerial photo analysis of baobab tree distribution), Madagascar (collaborating with the Madagascar Ministry of Environment to develop early warning tools for deforestation), Sub-Saharan Africa (piloting a forest degradation monitoring system in Zambia, Ethiopia, Republic of the Congo, and Cameroon), and mapping of mangroves in Zanzibar. Globally, RMRS FIA scientists participate in the Global Forest Observation Initiative, World Forestry Congress, partner with NASA-SERVIR and the Global Forest Operation Initiative on developing remote sensing strategies for forest cover monitoring and trends in Africa, and mentoring in the Women in Forest Carbon Initiative as sponsored by the SilvaCarbon program and IP.

Forest Fridays

RMRS partnered with Willow Bend Environmental Education Center to provide a program that introduces kindergarteners to nature both in the classroom and in the forest. The goal of this program is to introduce the students – typically 5 to 6 years old - to the outdoors and have them explore and discover nature. This will create a greater awareness of natural resources and ways to be good stewards of their forest communities that surround their town and homes. It also provides a sense of security for the unknown and creates confidence in the students when spending time in nature.

Photo courtesy of WillowBend Environmental Center.

Star Party

Free interactive star party field day full of interactive activities and telescope viewing for families. Information and activities on bird migrations at night provided by RMRS. RMRS partnered with the Dark Skies Coalition of Flagstaff to create a greater awareness and provide information to the community about the importance of dark skies in modern society. They demonstrate and explain how light pollution can have a large impact on the heath of humans and wildlife.

STEM Community Event

The annual STEM Community Event strives to support and encourage our schools in their efforts to educate our children to be successful in an ever-more-technological, competitive, and complex world. This event of 65 exhibitors (in 2022) is free to the community and provides an excellent opportunity for hands on, engaged and informative examples of the many STEM related organizations and careers available in today's world. RMRS provided interactive activities about birds and wildlife research being conducted. To promote STEM literacy among students, families, and the community will be strengthened by, pursuing high quality STEM curricula in our schools, creating sustained and meaningful partnerships between STEM businesses and organizations and our schools, and across the PK-12-adult continuum, increasing STEM opportunities for students that are outside of the regular school day or year, and promoting community dialogue around the importance of STEM in Flagstaff's education, businesses, and culture.

Photo courtesy of StemCity.

Science Saturdays

Science Saturdays are events held on the first Saturday of every month. Each month is focused on a different theme and each event offers fun and educational hands-on activities. Artists, scientists, and experts join us on occasion to provide extra special opportunities to learn and explore. RMRS has provided experts, activities, and information for this Science Saturday that focuses on Wildfire Prevention week to create awareness of forest ecosystems, fire and fire management and research for the local community.

Flagstaff Festival of Science-Scientists in the Classroom

The Flagstaff Festival of Science is a free annual 10-day event wholly designed to promote awareness and enthusiasm for science in and about northern Arizona and beyond and is fondly known as the Best 10 Days of the Year. Established in 1990, it is the longest, continuously running, entirely free science festival in the world. RMRS has been a partner and supporter of the festival since 1999. The Flagstaff Festival of Science serves to connect and inspire people of northern Arizona, particularly youth, with the wonders of science and the joy of scientific discovery. The scientists in the classroom program connects scientists with students to create awareness about the scientific world and inform students of the potential careers in the natural resource fields of study. RMRS provides in class presentations to students in grades K-12. Topics presented are focused on the research that the Station conducts.

Photo courtesy of Scott Godwin Mount Elden Middle School.

Field Trips with Local Elementary and Middle School Classes

Field trips focus on creating a connection between students and their environment through simple observation, fun activities, songs, art, data collection and critical thinking exercises. Field trips are conducted in outdoor locations such as Aspen Corner on the San Francisco Peaks, Frances Short Pond in the City of Flagstaff, and Picture Canyon also within the Flagstaff City limits. Objective of these field trips is to introduce students to the ecosystems that occur within their community. Students learn that they can be good stewards of their local environment and learn the importance of caring for the land. RMRS also provides the opportunity for students to use research equipment and learn about various research projects taking place in the forests near their homes.

Photo courtesy of WillowBend Environmental Center.