



Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Rocky Mountain Research Station

June 2024

Forest Service Research and Development

Rocky Mountain Research Station Technology Transfer Report FY 2023



COVER: Purple elephant head flowers against a backdrop of burned and healthy trees in Medicine Bow National Forest. USDA Forest Service photo by Lexi Neukirch.

Contents

Station-Wide Science Delivery And Technology Transfer Efforts.....	1
Science You Can Use Webinars.....	1
Stories of coproduction: DNA solving wildlife management challenges	2
Effects of wildfire and forest management on Canada lynx	2
National Fire Simulation update.....	3
Fire Weather Alert System mobile app	4
Safety Zone Research and the Safe Separation Distance Evaluator	4
WildfireSAFE videos	4
Wildfire Risk to Communities project.....	5
ICS-209/National Wildfire datasets	6
Fire Effects Information System (FEIS)	6
Prescribed fire emissions	7
International wildfire decision support	7
Wildfire Crisis Strategy seminar series.....	8
Wilderness fire workshop	8
FireWorks conservation education	9
Cohesive strategy technology transfer	9
Next Generation Wildland Fire Decision Support System (WFDSS NextGen)	9
Spatial Fire Planning Services	10
Fuel Treatment Effectiveness Monitoring (FTEM)	10
Interagency Fuel Treatment Decision Support System (IFTDSS).....	11
Incorporating drones into forest monitoring and management strategies	11
Co-producing land management solutions using remotely sensed data	11
Research supporting management strategies for the federally listed whitebark pine	12
StockSmart and associated programs: Decision support for grazing management in a variable and changing world.....	12
Contributions to the Incident Strategic Alignment Process (ISAP), a structured process to assess and communicate risk with partners on wildfire incidents	12
Raising awareness of U.S. firefighter workforce retention and well-being to improve policy.....	13
The Wildfire Research Center (WiRē) creates impact by presenting research results with community partners.....	13
Diversity, equity, and inclusion and engagement in outdoor recreation	15
Mountain goats and recreation: Effects on an alpine sky island	16

Past precipitation alters current-year plant growth.....	16
Climate change impacts invasive perennial grass establishment.....	17
Fire ecology and management: Past, present, and future of U.S. forested ecosystems	18
Fall fertilization during nursery production increases nitrogen status of antelope bitterbrush seedlings: Implications for outplanting	18
Responses of ponderosa pine seedlings to moisture limitations in the nursery and their implications for restoration	19
Genotypes from lower latitudes are less susceptible to insect herbivory	19
Reintroduction of at-risk forest tree species using biotechnology depends on regulatory policy, informed by science and with public support.....	20
Spatial Stream Network Model Training workshop.....	20
Indigenous Traditional Ecological Knowledge workshop	21
Environmental Flows workshop	22
Revegetation efforts of high-elevation forests in Colorado to improve postfire watershed health	22
Integrated Centre for International Mountain Development.....	23
Northwest Forest Plan—the first 25 years: Status and trends of late-successional and old growth forests	23
Forest Inventory and Analysis continues work with LANDFIRE	23
FIESTA desktop application: A user-friendly application to generate forest inventory estimates	24
Using FIA Data and the Forest Vegetation Simulator (FVS) to support forest planning	24
New national-scale Tree Canopy Cover maps available.....	25
Using the Forest Inventory and Analysis dataset for Collaborative Forest Landscape Restoration Project monitoring	25
Biochar science communications.....	27

Station-Wide Science Delivery And Technology Transfer Efforts

The Rocky Mountain Research Station (RMRS) [Science You Can Use](#) publications continue to be highly regarded and sought after by land managers, congressional staff, and scientists. This year we continued to expand our reach and impact. Science You Can Use is directly distributed to a mailing list of over 15,000. We produced a total of 23 Science You Can Use publications in FY23: 7 Science You Can Use Bulletins, 14 Science You Can Use (in 5 minutes), and 2 Connected Science publications. We also continued to share RMRS science with the public and media through 17 news releases, 57 media pieces featuring RMRS scientists and publications, and 424 social media posts.

The [RMRS public-facing website](#) is hosted on a modern, expandable platform that is integrated with all stations across Research and Development (R&D). Our site is the most visited Station site within Research and Development. This year the website had over 700,000 page views, with users spending an average of over 1 minute on our site. RMRS is actively engaged in the ongoing R&D web modernization effort that will greatly improve efficiency of IT resources, unify R&D, and allow R&D web content to align with USDA web requirements.

Science You Can Use Webinars

In spring 2023, the science application staff hosted a total of seven Science You Can Use manager-focused, 60-minute webinars highlighting a wide breadth of RMRS science. The format of short presentations of 30 minutes or less was followed by facilitated Q&A, and the topics selected were well received by the management community. The virtual atmosphere was once again leveraged to make meaningful science-management connections. Attendees represented many staff levels, agencies, and organizations—from on-the-ground managers to leadership, National Forest System (NFS) and State & Private Forestry, scientists, other federal and state agencies, and nongovernmental organizations.

The webinar series was well advertised through Science You Can Use mailing lists, Forest Service mailing lists, Inside the Forest Service, social media, fire science exchanges, and scientist and manager networks. Targeted invitations were also sent to key NFS staff for distribution. The webinar attendance was excellent (1,016 attendees in total). Perhaps the most exciting result of these webinars is the development of new partnerships and collaborations between RMRS scientists and managers. Webinars were recorded, closed captioned, followed Forest Service visual standards, and posted on the RMRS website. This content is expected to be of continued interest. Overall, we consider this webinar series to have been a successful science delivery effort and plan to offer a FY24 Science You Can Use webinar series early in the 2024 calendar year.



Stories of coproduction: DNA solving wildlife management challenges

[Taylor Wilcox](#), RMRS scientist, delivered a presentation as part of Forest Service Research and Development's ScienceX webinar series that highlighted [three stories of DNA science solving wildlife management challenges for the National Forest System](#) (43:27–55:43 in the linked webinar). This presentation highlighted how our agency's leadership in wildlife genetics has paid dividends for management by coproducing timely, defensible, and actionable science with National Forest partners. The first story describes how DNA testing by the [RMRS National Genomics Center for Wildlife and Fish Conservation \(NGC\)](#) enabled managers on the Lolo National Forest to confidently assess endangered bull trout presence in real time, enabling an aquatic habitat improvement project to move forward because it was clear that bull trout were not present. The second story describes how collaborative monitoring and new genetic tools from the NGC revealed that Endangered Species Act-listed Canada lynx were spatially distributed on the Beaverhead-Deerlodge National Forest, resulting in the Forest being listed as occupied habitat in a Biological Assessment. The third story describes how RMRS scientists used genomic tools to determine that a snowfly species that was warranted for listing under the ESA was actually a hybrid—thus ineligible for ESA listing—which enabled a reservoir-building project on the Arapaho and Roosevelt National Forest to move forward. In each case, an ESA-listed or warranted species on National Forest lands presented a management constraint due to a lack of information. In each case, National Forest System biologists worked with RMRS scientists to build and implement study designs. The results were impactful: new information brought clarity and enabled management action.

Effects of wildfire and forest management on Canada lynx

RMRS scientists [John Squires](#) and [Lucretia Olson](#) and several agency collaborators published important, management-relevant research highlighting the effects of wildfire and forest management on Canada lynx, which are listed as threatened under the Endangered Species Act. The scientists examined the responses of Canada lynx and snowshoe hares to forest management actions that took place in areas that were also burned by wildfire. They found that postfire forest management negatively impacted Canada lynx habitat for at least 10 years after treatment, while lynx use was highest ~25 years after wildfire and regeneration harvests, or clearcuts. They also found that areas with prefire management burned less severely and were used more quickly by lynx after a wildfire, while nonmanaged areas maintained more mature trees after the fire but had more high severity fire. This has important implications for forest management, as this work suggests that a mosaic of active and passive management will best conserve

lynx habitat in landscapes impacted by the increasing likelihood of large scale fire. This research is featured in both a [research highlight](#) and [Science You Can Use in 5 Minutes publication](#).



Image modified from a courtesy photo by Steve Sunday.

National Fire Simulation update

Developed by scientists with the RMRS Fire, Fuel, and Smoke program beginning in 2007, the Large Fire Simulation System (FSim) simulates fire spread across a landscape given historical fire occurrence, weather, terrain, and fuels, allowing researchers to map wildfire hazard and risk at a national scale. Using FSim, RMRS scientists [Karen Short](#), [Mark Finney](#), and [Karin Riley](#) work closely with the Fire Modeling Institute, led by Greg Dillon, to produce a national map of simulated fire events. This map, often referred to as the National FSim product, is generated every few years and was updated in FY23. This national dataset serves as an underlying source for many important fire-related decisions, products, and tools. The National FSim product feeds into numerous national data products, including [Wildfire Hazard Potential](#), [Wildfire Risk to Communities](#), and the [Fireshed Registry](#). FSim products also inform several national risk assessments completed by Fire and Aviation Management's Risk Management Assistance (RMA) program, available on the [RMA Dashboard](#). Moving forward, FSim products are being used to evaluate carbon risk and the outcome performance metrics for the Wildfire Crisis Strategy.



Courtesy photo by the National Interagency Fire Council.

Fire Weather Alert System mobile app

In FY23, RMRS scientists [Jason Forthofer](#), [Natalie Wagenbrenner](#), and [Mark Finney](#) worked with Fire and Aviation Management and contractor Technosylva to release [the Fire Weather Alert System mobile app](#). Many firefighters have been injured or killed due to rapid changes in weather causing unexpected fire behavior. The Fire Weather Alert System continuously monitors weather data and information and provides early warnings to firefighters on the ground when dangerous weather conditions arise. The app is designed to be straightforward and intuitive—users set custom weather thresholds for their location and the system sends an alert when one of these thresholds is reached. The alert includes information about what threshold was met, where, and from what source. Ultimately, the information provided by the Fire Weather Alert System has potential to increase safety and inform decision-making on wildland fire incidents.

Safety Zone Research and the Safe Separation Distance Evaluator

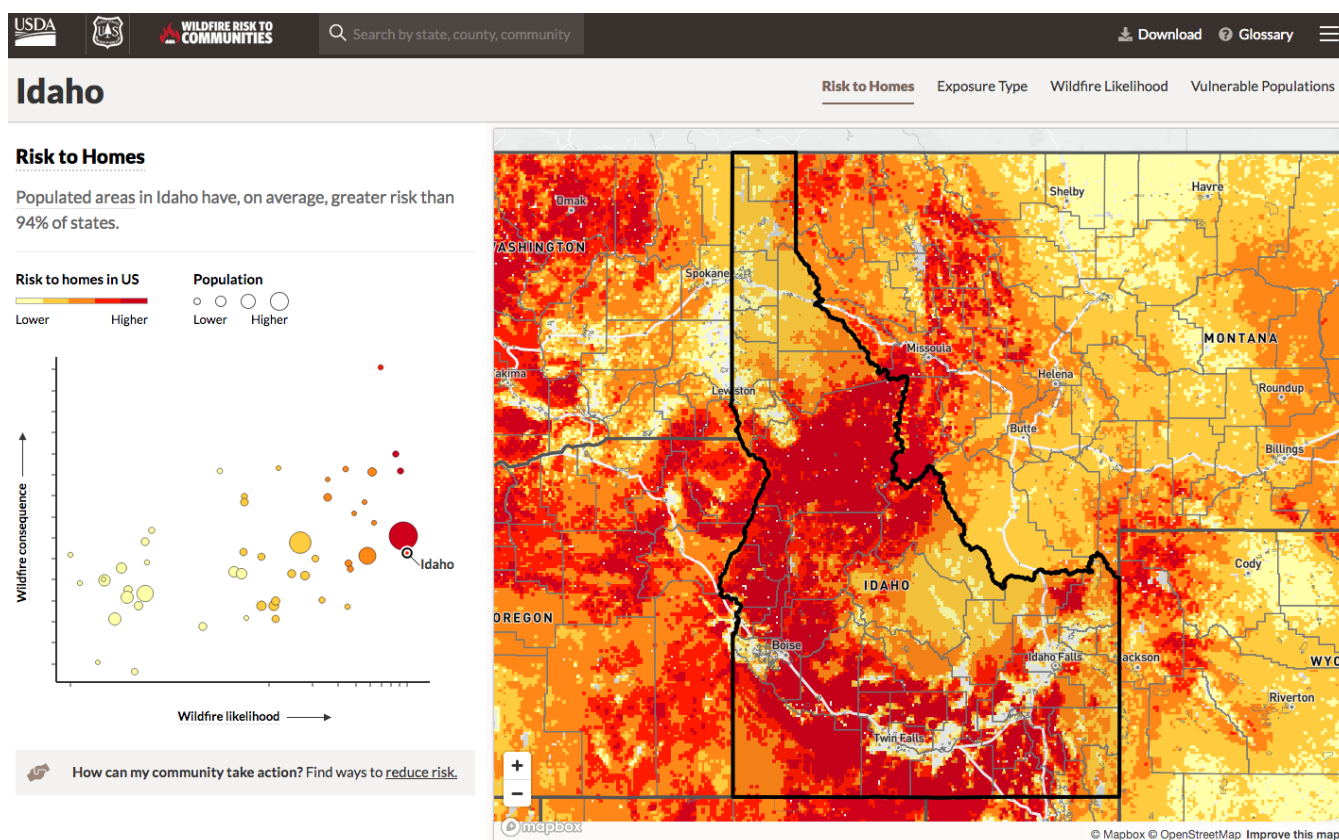
Safety zones are fundamental to wildland firefighters to avoid injury or fatality when engaging in wildland fire operations. RMRS scientists [Daniel Jimenez](#) and [Bret Butler](#) (emeritus), and former RMRS scientist Matt Thompson, partnered with the University of Utah to [develop a new tool to improve firefighter safety](#). The [Safe Separation Distance Evaluator \(SSDE\)](#) is an interactive, open-access Google Earth engine-based tool that helps identify and evaluate potential safety zones anywhere in the United States. Based on years of safety zone research, the SSDE accounts for slope, vegetation height, and wind—all factors that can quickly render a previously designated safety zone unsafe.

WildfireSAFE videos

Fire hazard conditions can change rapidly, and fire managers have access to many sources of data to help them make decisions. This information, however, often resides in multiple, noncompatible databases, models, applications, and websites. To help make it easier, RMRS scientist [Matt Jolly](#) partnered with Technosylva to create the [WildfireSAFE app](#)—a web-based, mobile solution that integrates real-time data from multiple data sources into a single, user-friendly platform. In FY23, Jolly partnered with RMRS science delivery lead Nehalem Clark, and Conversketch artist Karina Branson, to produce a series of short, animated videos on WildfireSAFE intended for firefighters and the public living near, working, or recreating within public lands. These videos inform viewers how the new WildfireSAFE web-based app, combined with other safety measures, can help assess risk and make decisions in the face of wildfire.

Wildfire Risk to Communities project

The [Wildfire Risk to Communities](#) project was created under the direction of Congress ([2018 Consolidated Appropriations Act](#)) and is designed to help community leaders, such as elected officials, community planners, and fire managers, 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 Washington Office Fire and Aviation Management, and the Fire Modeling Institute (FMI), part of the RMRS Fire, Fuel, and Smoke Science Program. In FY23, FMI worked closely with partners in Headwaters Economics and Pyrologix LLC to create datasets to update the first edition of data published in 2020. This included updates to the eight nationwide raster datasets depicting wildfire hazard and risk across all lands, 10 nationwide raster datasets depicting elements of wildfire risk in populated areas, and one new nationwide dataset of community wildfire risk reduction zones. Summaries of some of these datasets by communities, counties, tribal areas, and states were also completed. All of this work will facilitate publication of the new data products and updating of the Wildfire Risk to Communities website in FY24. In FY23, FMI also worked with Headwaters Economics and Fire and Aviation Management to provide hazard and risk information needed to implement the Community Wildfire Defense Grant program application process.



Screenshot of the Wildfire Risk to Communities tool.

ICS-209/National Wildfire datasets

Spatial data that depicts contemporary vegetation and fuel conditions, as well as historical wildfire occurrence, firefighting response, and fuel treatment activities, are integral to many facets of wildland fire research and management. The Fire Program Analysis Fire-Occurrence Dataset (FPA FOD) was the first national compilation of federal and nonfederal wildfire records georeferenced precisely enough for fine-scale assessments of recent historical wildfire activity in the United States. In FY23, scientist [Karen Short](#) released the sixth edition of the FPA FOD. The FPA FOD includes linkages to daily Incident Command System situation reports (ICS-209) and to the large-fire perimeter dataset from the Monitoring Trends in Burn Severity mapping effort. Short worked with university colleagues to develop a [science-grade compilation of ICS-209 data](#), called ICS-209-PLUS. This dataset includes linkages to the FPA FOD and, by extension, the Monitoring Trends in Burn Severity perimeter dataset. The second-edition product was also published in FY23.

Fire Effects Information System (FEIS)

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 online. FEIS enables its users to easily find science relevant to land management decisions and is consistently among the most viewed RMRS websites. 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 2023 including Species Reviews for chuck-will's-widow, eastern whip-poor-will, Sahara mustard, Port Orford-cedar, and Fire Regime Syntheses for Sonoran desert scrub communities and ponderosa pine ecosystems in two ecoregions of New Mexico.



A researcher conducts a study at the edge of a crib fire. USDA Forest Service photo by Kari Greer.

Prescribed fire emissions

Wildfire smoke contains hundreds of different gases and aerosols, which have significant negative impacts on air quality, climate, and public health. One way to reduce potential future wildfire activity is through prescribed burning, but the smoke from these fires also poses a risk and nuisance to nearby communities. To better understand the relative abundance of smoke pollutants, known as emission factors (EFs), RMRS scientist [Shawn Urbanski](#) and chemist [Emily Lincoln](#) [measured the EFs from several types of conifer forest fuels](#). The new EFs can be modified into prescribed fire-specific EFs, which will improve smoke modeling tools and the understanding of how specific prescribed fires may impact air quality and emissions. Estimates suggest that prescribed fire particulate matter emissions might be 90 percent lower than a high intensity wildfire, helping to inform the use of prescribed fire.



Prescribed fire at Fishlake National Forest, Utah. USDA Forest Service photo by John Smith.

International wildfire decision support

As climate change continues to alter ecosystems and increase wildfire challenges around the globe, RMRS scientist [Matt Jolly](#) has expanded his international fire support efforts to ensure countries that need wildfire decision support tools have access to the best available science. In conjunction with International Programs, he worked with partners from South America, Morocco, and Ukraine in FY23. The specific objectives of these efforts were to identify opportunities for improving wildland fire forecasting, mapping, modeling, and system development in order to generate pertinent information for wildfire decision-making. Specifically, Jolly helped develop a strategy to implement a nationwide wildland fire prediction system in Morocco, continued efforts to build a fire danger rating system for South America, participated in an International Programs-sponsored study tour for the delegation from the State Emergency Services of Ukraine, and participated in a workshop focused on strategies to improve Colombia's Wildland Fire Forecast System.

Wildfire Crisis Strategy seminar series

The core of the Wildfire Crisis Strategy is to match the pace and scale of fuel and forest health treatments across land ownerships to the scale of wildfire risk. For decades RMRS has supported research on fire science topics relevant to wildfire hazard, risk, behavior, and ecology, and provided knowledge support to land managers and a myriad of partners. The expertise and tools developed by RMRS are central to providing a scientific basis to address the Wildfire Crisis. In FY23, RMRS ecologist [Chris Stalling](#) and [Greg Dillon](#), Director of the Fire Modeling Institute, organized a [series of nine hybrid seminars](#) to share the individual contributions of RMRS scientists to developing and supporting the Wildfire Crisis Strategy.

Wilderness fire workshop

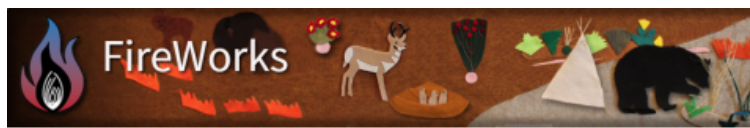
Wilderness fire management is more complicated than “letting it burn.” Wilderness fire management decisions are guided by policy, risk, seasonality, suppression resource availability, institutional knowledge, and on-the-ground experience. In June of 2023, RMRS scientists and science delivery specialists assisted the Northern Rockies Fire Science Network in organizing a workshop to help inform the next decade of wilderness fire management and research. The [workshop](#) brought together 50 people—fire and wilderness managers, researchers, and agency decision-makers—to discuss the complexities of wilderness fire, hear the latest science, and participate in a shared learning opportunity. The two-day event was hosted on the Bitterroot National Forest West Fork Ranger District.



A wildfire burning through a Wyoming big sagebrush ecosystem with a cheatgrass understory in southern Idaho. Courtesy photo by Douglas J. Shinneman.

FireWorks conservation education

[FireWorks](#) is an educational program about the science of wildland fire, designed for students in grades K-12. It provides students and teachers with interactive, hands-on curricula and specialized materials to study wildland fire. In FY23, Fire Lab ecologists participated in 22 FireWorks events. These included teaching students about fire science at the Fire Lab and at community events and loaning trunks of FireWorks materials to teachers to use with their students. They also provided three train-the-trainer workshops for educators to learn how to use the program. Highlights from 2023 included international recognition. They shared the FireWorks Program during an invited panel discussion at the International Association for Fire Ecology conference in Florence, Italy, and provided a USAID-sponsored virtual presentation for fire managers from Peru, Ecuador, Brazil, and Columbia.



Cohesive strategy technology transfer

Tami Parkinson and others from the Wildland Fire Management Research, Development, and Application program (WFM RD&A) have been integrated with the National Cohesive Wildland Fire Management Strategy, working to showcase the science and tools being developed to the collective wildland fire community. Engagement in these opportunities provides outreach beyond the federal fire agencies; they have had the opportunity to engage states, tribes, academics, local government, counties, insurance and utility companies, and any other entity interested in having access to tools to assist in decision-making around wildland fire.

Next Generation Wildland Fire Decision Support System (WFDSS NextGen)

In FY23, Wildland Fire Management Research, Development, and Application program product owners Wes Hall, Rick Mowery, Jim Riddering, Sarah Synowiec, and [Sam Amato](#); GIS and data subject matter experts Susan McClendon, Jonah Vaughn, and Amanda Rumsey; technology and software development subject matter expert Reggie Goolsby; Fire and Aviation Management; Enterprise Application Services (EAS); Science Applications International Corporation (SAIC); and the University of Idaho developed the Next Generation Wildland Fire Decision Support System (WFDSS NextGen). WFDSS employs the use of the Risk Informed Decision Process, which helps fire managers save lives, property, and ecosystems when used to manage wildland fire. The use of WFDSS is mandatory for all five federal public land management agencies, but the current system's technology infrastructure is aging. WFDSS NextGen will use a micro-service architecture to provide agency administrators, line officers, and fire managers with the most up-to-date authoritative information so informed and timely decisions can be made and leaders' intent on the management can be made clear to all stakeholders and personnel involved in wildland fire.

Spatial Fire Planning Services

Advances in cloud-based mapping solutions have allowed the Wildland Fire Management Research, Development, and Application team to redesign fire planning language and shape management for the next iteration of the Wildland Fire Decision Support System (WFDSS) application. The new Spatial Fire Planning Services will allow agency fire planning and geospatial personnel to own and manage their fire planning language and shapes through editable data services hosted on the NIFC ArcGIS Online Organization. WFDSS NextGen will consume the data needed for wildland fire decision support from the data services hosted in ArcGIS Online. The new Spatial Fire Planning Services are advantageous to the wildland fire community as they streamline data management and improve data accessibility.

Fuel Treatment Effectiveness Monitoring (FTEM)

[Fuel Treatment Effectiveness Monitoring \(FTEM\)](#) is the system of record to document the effects of fuel treatments on wildfire behavior and control. Managers within the five federal land management agencies answer a few questions to evaluate whether fuel treatments mitigated wildfire behavior or helped firefighters manage wildfire using FTEM's spatial overlay of wildfires on fuel treatments. FTEM is incorporated into the Interagency Fuel Treatment Decision Support System (IFTDSS) application, which is developed and maintained by the Wildland Fire Management Research, Development, and Application program (WFM RD&A).



A forest that was fuels treated before the Caldor Fire in Christmas Valley, South Lake Tahoe, California. USDA Forest Service photo by Cecilio Ricardo.

Interagency Fuel Treatment Decision Support System (IFTDSS)

The [Interagency Fuel Treatment Decision Support System \(IFTDSS\)](#) is a web-based application designed to make fuel treatment planning and analysis more efficient and effective. Developed and maintained by the Wildland Fire Management Research, Development, and Application program (WFM RD&A), IFTDSS provides access to data and models through one simple user interface. It is available to all interested users, regardless of agency or organizational affiliation. IFTDSS is designed to address the planning needs of users with a variety of skills, backgrounds, and needs. A simple and intuitive interface provides the ability to model fire behavior across an area of interest under a variety of weather conditions and easily generate downloadable maps, graphs, and tables of model results. Additionally, the application provides a step-by-step process for testing a variety of fuel treatment impacts, such as thinning, clear cutting, and prescribed burning, on fire behavior and comparing results to determine which modeled treatment best achieves desired results in terms of reduced fire behavior potential. It can be used at a variety of scales from local to landscape level.

Incorporating drones into forest monitoring and management strategies

RMRS scientist [Wade Tinkham](#) has been working with Forest Inventory and Analysis (FIA), Colorado State University, and other organizations to develop workflows for managers to incorporate drones and drone-derived data into forest monitoring and management. Wade presented a [webinar](#) on his work with drone-based monitoring and his extensive body of research was summarized in a [Science You Can Use Bulletin](#). Wade has been providing technical assistance, training, consultations, and collaborative support to numerous internal and external entities, including Colorado State Forest Service, Forest Service Geospatial Technology and Applications Center (GTAC), Forest Service International Programs, FIA operations, WO CIA Mission Support Systems, and the Forest Service Enterprise Program.

Co-producing land management solutions using remotely sensed data

[Applied Earth Observations Innovation Partnership \(AEOIP\)](#) is a boundary spanning, interagency collaboration between the Forest Service, NASA, and other agencies that seeks to link remotely sensed data products to land manager needs. The partnership supports webinar series, trainings, and workshops, and maintains datasets regularly used in management decisions. On April 25–27, 2023, RMRS scientist [Andrew Hudak](#) and Edil Sepulveda Carlo from NASA co-chaired the “[2023 USFS-NASA Joint Applications Workshop: Addressing Land & Water Monitoring Needs Using Remote Sensing](#)” at the Forest Service Geospatial Technology and Applications Center (GTAC) in Salt Lake City, Utah. The goals of the workshop were to: (1) increase awareness at NASA of Forest Service (and other land management agencies) of operational needs, and (2) increase awareness among Forest Service resource managers of NASA data products that could help inform their decisions. The workshop featured presentations by senior administrators, scientists, and managers from many federal, state, academic, private, and nongovernmental organizations. Many of the 324 attendees (92 in-person, 232 virtual) participated as presenters, panelists, moderators, tutorial leads, and breakout group facilitators. Through these activities, participants identified challenges and opportunities for connecting Earth Observations remote sensing data and technologies to natural resource management needs.

Research supporting management strategies for the federally listed whitebark pine

The High-Five Elevations Pine group has collectively produced research that directly supported information in the [USFWS Species Listing Rule](#) (U.S. Fish and Wildlife Service, published 12/15/2022; effective 01/17/2023). The group has also provided consultations with NFS, nongovernmental organizations, and other government agencies to help co-produce regional whitebark pine management plans and management practices in the Northern Rockies and Greater Yellowstone Ecosystems. The group's research is being used to support the forthcoming National Whitebark Pine Recovery Plan. The group, led by [Jason Reinhardt](#), and including [Anna Schoettle](#), [Sharon Hood](#), and [Stephanie Yelenik](#), received Bipartisan Infrastructure Law funding to support a researcher-manager Whitebark Resilience Network to test the impacts of vegetation management treatments on whitebark resiliency against drought, fire, blister rust, and bark beetles.

StockSmart and associated programs: Decision support for grazing management in a variable and changing world

RMRS scientist [Matt Reeves](#) collaborated with researchers at Washington State University and the University of Arizona to develop [StockSmart](#), an online, USDA-NIFA funded decision support tool for grazing management. This program enables private landowners, land managers, and others to calculate stocking rates for cattle, horses, and sheep. It visualizes livestock terrain use by defining animal distribution related to water and slope. The program uses water locations, vegetation trends since 1984, and the forage needs of native ungulates to evaluate a sustainable balance of forage supply and demand. In a nutshell, a group of people can gather around a computer screen and run different model scenarios with differing design criteria to evaluate “What If” questions for any location in the western United States. This is especially useful in determining Appropriate Management Level (AML) for wild horses and burros (Region 5), initial bison stocking rate (Region 3), and National Environmental Policy Act (NEPA) concerns about total forage requirements stated in a forest plan. It allows managers to compare different water locations and vegetation management scenarios to estimate how different choices will change outcomes or alternatives in a NEPA setting. The science is being used in Regions 2, 3, 4, 5, and 6 to evaluate how vegetation change and various rangeland developments and improvements are affecting available forage.

In terms of impact, they have the potential to change livestock permits and estimate new values for AML, which can directly alter management solutions. Researchers discovered that on the Apache-Sitgreaves National Forest (Region 3), there was no difference between allotments that had been grazed or ungrazed for decades, suggesting a reasonable stocking rate and management style. However, on the Rio Grande National Forest (Region 2), researchers discovered that the impact of increasing woodiness and dead and dying timber has reduced the suggested stocking rate.

Contributions to the Incident Strategic Alignment Process (ISAP), a structured process to assess and communicate risk with partners on wildfire incidents

[Brad Pietruszka](#), a scientist and member of the [Wildfire Risk Management Science \(WRMS\) Team](#) at RMRS, serves on an interagency task group appointed by the [National Wildfire Coordinating Group \(NWCG\)](#) to develop standards for the [Incident Strategic Alignment Process \(ISAP\)](#). ISAP is a structured process to assess and communicate risk and to collaboratively make operational decisions on wildfire

incidents. The standards are “to ensure strategic thought process and alignment of management actions is occurring between Agency Administrators, fire management organizations, and Incident Management Teams throughout the duration of an incident.”

During the 2023 fire season, Pietruszka served on an Incident Management Team on the San Juan National Forest (Region 2), where he facilitated adoption of ISAP and use of other risk analytic tools that have been co-developed at RMRS, including [Potential Operational Delineations \(PODs\)](#) and the [Risk Management Assistance \(RMA\) Dashboard](#). Managers on the San Juan National Forest had utilized these tools for fire mitigation, but this was their first application of them along with ISAP to manage wildfire response. Their experience working with Pietruszka to implement these tools changed their approach to wildfire response management. In conjunction with RMRS and the WRMS Team, managers on the San Juan National Forest worked with Pietruszka to create a [video, titled “An Evolution in Thinking.”](#) to tell the story of their learning experience to other fire managers and beyond. Members of the WRMS team that focus on communication about wildfire and wildfire narratives shared the video with the Region 3 Regional Leadership Team and R3 District Rangers during an interactive session about wildfire communication at their annual meeting in Sedona, Arizona.

Raising awareness of U.S. firefighter workforce retention and well-being to improve policy

[Erin Belval](#), RMRS scientist and member of the [Wildfire Risk Management Science \(WRMS\) Team](#), conducted research on Interagency Hotshot Crews using workforce data from 2012 to 2018. She and her colleagues found that the more additional days Hotshots were assigned on fires during the year, the more likely they were to stay on the job. Belval drew on her expertise in wildland firefighter workforce issues to serve as a subject matter expert and contributor to the [USFS Interagency Hotshot Crew: Programmatic Review, released in September 2023](#). This review, directly supported by Belval’s body of research on the topic, has informed active conversations with Congress about legislation to make permanent pay increases for wildland firefighters. It continues to [serve as technical assistance](#) during federal budget negotiations.

The Wildfire Research Center (WiRē) creates impact by presenting research results with community partners

RMRS scientist [Patty Champ](#) and the [Wildfire Research Center \(WiRē\)](#), which receives funding from RMRS, continued research and outreach efforts to support evidence-based community wildfire education efforts so that communities can live with wildfire. They conduct household surveys and parcel-level wildfire risk assessments in communities primarily across the western United States. Their research approach includes returning study results to community partners so they can improve local programs and outreach, depending on needs identified in the research. WiRē’s outreach earned them the RMRS Award for Science Delivery in 2023.

Members of the WiRē Center shared research project findings in Santa Fe, New Mexico, at in-person meetings with the Greater Santa Fe Fireshed Coalition and members of the Fireshed Ambassadors Program. As a direct result of their meeting with the Fireshed Coalition, they began considering a Fireshed-wide WiRē project. To communicate project results back to survey respondents, the WiRē Center developed a public-facing [website](#) highlighting actionable project findings and sent a postcard

with a link to the website. WiRē also shared research findings (household survey results) in several other research sites, including in Chelan County, Washington. The discussion with partners in Chelan County prompted WiRē to create a handout oriented toward policymakers that describes their research about acceptability of wildfire-related policies. Another outcome of community partnership and study outreach in Chelan County: WiRē partners from Cascadia Conservation District added custom survey questions about the acceptability of shutting off the power grid as a way to mitigate wildfire hazard risk. Results showed relatively low acceptance, which could be explained by the fact that there had not been communication about that potential policy with the community. They shared these results with the local power company, which prompted them to improve their communication and outreach with community members. Furthermore, WiRē partner Patrick Haggerty from Cascadia Conservation District presented their project to the Chief of the USDA Forest Service. Finally, WiRē presented research results to the North Central Washington Forest Health Collaborative. This engagement sparked a new WiRē project with communities in the Methow Valley in 2024.



Handout made by WiRē for Patrick Haggerty, Cascadia Conservation District, and shared with USDA Forest Service Chief Randy Moore in May 2023.

Additionally, the [Routt County Wildfire Mitigation Council](#) and [Genesee Fire Rescue](#) incorporated their WiRē projects into their websites.

In October 2023, the WiRē Center hosted an in-person Community of Practice Workshop in Denver, Colorado, bringing together 18 WiRē partners to discuss opportunities for WiRē to broaden the impact

of the work. Testimonials from participants provide a glimpse of the impacts it had on participants and their ongoing work:

I have been employed in the natural resources field for 25 years and with the Colorado State Forest Service since 2010. I never had any formal training on educational outreach methods to the public on being prepared for a wildfire. I think over the years I managed to do a decent job, but never knew if my message was correct. The WiRē program and how it analyzes what residents are doing, what they need to do more of to reduce their wildfire risk and lets practitioners know topics they could focus on to more effectively educate the public. The WiRē program with its analysis and recommendations has helped me fill this gap of knowledge and give me the tools to work better with the public. Their program goes further with the WiRē Community of Practices meetings where we are able to hear about newer research and how participating agencies have used the WiRē process to reach more residents. These are but two examples of how WiRē has effectively helped reduce the wildfire risk for communities around the nation. I fully support continuing to fund and let staff work on the WiRē project.

— Adam Moore, Supervisory Forester—Alamosa Field Office, Colorado State Forest Service

The WiRē Community of Practice Workshop was an appreciated addition to the impressive package of information already provided through our Teton County project. Connecting with other practitioners and subject matter experts who have participated in a community survey helped spur new and innovative ways to continue to use our data. It also compelled me to revisit some of the specific pieces of data in my local survey that will help support recommendations in our CWPP revision. I hope to see this workshop as a regularly scheduled event.

— Bobbi Clauson, Wildfire Prevention Specialist, Jackson Hole Fire/EMS and TAWPC

For additional information about WiRē’s FY23 activities and impacts, see their [2023 Annual Report](#), which is available on their [website](#).

Diversity, equity, and inclusion and engagement in outdoor recreation

RMRS scientist [David Flores](#) and a team of researchers from the Forest Service and University of California, Davis collaborated with Outward Bound Adventures to study inequity in outdoor recreation on public lands. Motivated by demographic trends showing disproportionately low visitation by minority groups to public lands (including National Forests), they are studying the barriers to access and benefits of outdoor recreation among racial and ethnic minority youths. In July 2023, they led a 3-day trip to Malibu Creek State Park with a group of seven youths. This trip contributed to data collection, but it also contributed to an opportunity for youth participants to experience wilderness. Participants



RMRS Research Social Scientist David Flores (left) with Pacific Southwest Research Station’s Research Economist José J. Sánchez, Outward Bound Adventures partners, and youth participants on a 3-day trip to Malibu Creek State Park, California. USDA Forest Service photo by David Flores.

engaged in independent critical thinking exercises, a map exercise, and prepared meals throughout the trip, the latter appearing to be the most visible form of self-growth. Additional trips are slated for 2024. Dr. Flores has presented with others at RMRS conducting research on DEI and the outdoors in a [Science You Can Use webinar](#) in March 2023.

Mountain goats and recreation: Effects on an alpine sky island

The La Sal Mountains of Utah alpine plant communities support eleven plant and two animal species of conservation concern, an endemic plant species (the La Sal daisy), and a Forest Service Research Natural Area. Nonnative mountain goats were introduced by Utah Division of Wildlife Resources in 2013 and 2014 and recreational use has increased in the intervening period. To evaluate potential effects of mountain goat and recreational use, vegetation monitoring was initiated by the USDA Forest Service in 2016. RMRS scientist [Jeanne Chambers](#) and colleagues [used monitoring data and models](#) to analyze the effects of recreational use, mountain goat use, and time on populations of plant species of conservation concern, cover of grasses and forbs, and ground cover including bare soil, pavement, litter, and cryptogamic crusts. They found decreases in the frequency of La Sal daisy, cover of forbs, and cover of cryptogamic crusts at the end of the monitoring. Several of the observed changes could be attributed to recreation or mountain goat use. In addition, ineffective ground cover (the combination of bare soil and pavement cover) was greatest in high recreation use sites at the end of the monitoring and increased with goat use. Cumulative impacts of recreational use, introduced mountain goats, and ongoing climate warming are a management concern. Continued collaborative monitoring by the Forest Service and Utah Division of Wildlife Resources can be used to develop adaptive management strategies for maintaining the resilience of this alpine sky island.

Past precipitation alters current-year plant growth

Plant biomass production tends to increase with precipitation. However, this relationship is not always straightforward. Frequently, previous conditions that the plants have experienced will impact their responses to current water availability. For instance, plants that had grown under wet conditions may be better able to survive and grow under drought than plants that had grown under drier conditions. Similarly, plants that experienced drought previously may not be able to respond as vigorously to a year of high rainfall as plants that had grown under wetter conditions. These lagged effects, or legacies of past precipitation, may have large impacts on biomass production. RMRS scientist [Robert Heckman](#) and colleagues examined the [importance of legacies of past precipitation on plant performance](#) by testing the impact of year-to-year changes in precipitation on current plant responses with the candidate biofuel species switchgrass. They performed three distinct experiments, including excluding rainfall for multiple years, and switching rainfall regimes from wet-to-dry or dry-to-wet. They found that switchgrass experienced legacy effects of prior wet conditions that resulted in larger plants in the current year than those grown under consistent, longer-term drought. Prior year tiller number was an important determinant of legacy effects on plant production. When prior conditions allow plants to become larger and capable of producing more tillers, they may be better able to withstand drought conditions.

Climate change impacts invasive perennial grass establishment

Perennial grasses produce new stems primarily through clonal growth, which involves the production and outgrowth of belowground buds. For a nonnative species to successfully invade a native habitat it must survive multiple hurdles, from dispersal to colonization to establishment to landscape spread. The establishment phase of a perennial grass invasion requires young plants to develop their clonal infrastructure, including their belowground buds. Building clonal growth capacity could be enhanced or hampered by disturbances (e.g., grazing) or climate change (e.g., changing precipitation patterns). Climate change may increase the timing between rainfall events during the growing season in the northern Great Plains, where smooth brome is invading native grassland dominated by western wheatgrass. RMRS scientist [Jackie Ott](#) and colleagues examined [how clonal traits of native western wheatgrass and nonnative smooth brome bud banks](#) were affected under altered precipitation frequencies and a single grazing event during their first growing season. Native seedlings maintained similar clonal growth under three simulated precipitation frequencies, whereas the nonnative seedlings showed decreased clonal growth as precipitation became more intermittent. Clonal growth of the nonnative seedlings was greater than the native seedlings under all simulated precipitation frequencies except the most intermittent scenario. A single grazing event did not affect either species' response to precipitation variability but slightly reduced their clonal growth. 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. Grassland restoration using native western wheatgrass seeds would likely be successful in most years due to its resilient clonal growth in a changing climate.



Scientists at the Buffalo Gap National Grassland setting up a rain shelter for a study. USDA Forest Service photo by Alexis Neukirch.

Fire ecology and management: Past, present, and future of U.S. forested ecosystems

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 are in need of comprehensive syntheses of fire ecology to help reduce wildfire risk while supporting healthy forests. A new book, “Fire Ecology and Management: Past, Present, and Future of US Forested Ecosystems,” 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. The book provides management options for reducing wildfire risk while supporting healthy, resilient ecosystems in the context of climate change. RMRS scientists contributed to the book alongside other experts from the USDA Forest Service, universities, nongovernmental organizations, and other federal agencies. RMRS scientists helped author several chapters, including: [Fire in Floodplain Forests of the Southeastern USA](#); [Fire Ecology of Rocky Mountain Forests](#); [Fire Ecology and Management of Southwestern Forests](#); and [Fire and Forests in the 21st Century: Managing Resilience Under Changing Climates and Fire Regimes in USA Forests](#).

Fall fertilization during nursery production increases nitrogen status of antelope bitterbrush seedlings: Implications for outplanting

In the semi-arid western United States, antelope bitterbrush occurs across ~138 million acres. Bitterbrush is an important browse species, especially in winter, and it contributes to habitat for greater sage-grouse. Restoration is needed as antelope bitterbrush abundance has been reduced across the landscape due to agriculture, invasive species, and increased fire frequency and intensity. In arid landscapes, outplanting nursery-grown seedlings during periods of high soil moisture (typically late fall or early spring) can be more effective in establishing plants than direct seeding. Although outplanting bitterbrush can be effective, competition and drought remain obstacles to success. Producing seedlings to have an advantage when confronted with competition after outplanting could increase seedling survival and growth. RMRS scientists [Kas Dumroese](#) and [Jeremy Pinto](#) and colleagues [investigated nutrient loading in outplanted bitterbrush](#). Stored nitrogen has potential to promptly support new seedling growth, especially roots, after outplanting and thereby promote water and nutrient acquisition, which in turn can boost photosynthesis and promote more root and shoot growth leading to successful seedling establishment. They used isotope labeled fertilizer to track nitrogen movements, and observed that nitrogen-loaded antelope bitterbrush seedlings attained greater nitrogen uptake which they ultimately translocated to their root system. The researchers’ findings suggest that nitrogen loading antelope bitterbrush has the potential to improve outplanting performance.

Responses of ponderosa pine seedlings to moisture limitations in the nursery and their implications for restoration

In the southwestern United States, successful establishment of ponderosa pine (*Pinus ponderosa*) seedlings is often limited by stressful and harsh site conditions related to drought severity and severe disturbances such as wildfire and mining operations. Producing seedlings of high quality helps maximize success, but defining quality attributes for dry planting conditions is sometimes difficult. Can certain growing regimes condition seedlings bound for potentially dry sites? RMRS scientist [Jeremy Pinto](#) and colleagues investigated the possibility of conditioning seedlings for dry soil outplanting conditions by lowering irrigation during nursery culture, and they tested this technique across three seed sources. After drying treatments, they then simulated drought to evaluate drought conditioning performance. Across all seed sources, the seedlings exposed to drying conditions showed better water-use efficiency and higher rates of photosynthesis than controls. In the simulated drought portion of the study, drought conditioned seedlings grew more, accumulating greater biomass, and had greater amounts of active xylem. Their findings indicate that drought conditioning treatments implemented in the nursery can improve physiological functioning and subsequent growth on dry outplanting sites.



Seedlings growing in the Forest Service Coeur d'Alene Nursery in Coeur d'Alene, Idaho. USDA Forest Service photo by Cassidy Motahari.

Genotypes from lower latitudes are less susceptible to insect herbivory

Defending leaves and other tissue against herbivores plays an important role in the success of plants. Defenses are costly, though—nutrients and carbohydrates that the plant uses to defend tissue can't contribute to growing new leaves, stems, and roots, or to producing flowers, fruits, and seeds. Thus, defense levels against herbivory should be tuned to where herbivores are most damaging. For instance, regions closer to the equator often support more herbivores than regions closer to the poles, which could

result in a latitudinal gradient in plant defense. Robert Heckman and [colleagues tested this by growing plants in the same environment](#) and measuring herbivory, which can attribute any differences to genetic factors. Hundreds of switchgrass seedlings from across its native range, from Texas to Minnesota, were grown in a shared location in central Texas. A fall outbreak of the voracious insect herbivore, fall armyworm, then occurred, which gave researchers an opportunity to test whether the latitude of plant origin impacted herbivory. They found southern-origin plants had less herbivory and fall armyworms gained less weight when feeding on these leaves in the lab. This was likely due to the higher amount of defenses against herbivory in the leaves of southern plants—these southern leaves were harder for fall armyworms to chew and digest. These results are consistent with the hypothesized latitudinal defense gradient and suggest that herbivory is an important force driving evolution in this widespread species.

Reintroduction of at-risk forest tree species using biotechnology depends on regulatory policy, informed by science and with public support

Introduced pests (insects and pathogens) have rapidly increased the numbers of at-risk native forest tree species worldwide. Some keystone species have been functionally extirpated, resulting in severe commercial and ecological losses. When efforts to exclude or mitigate pests have failed, researchers have sometimes applied biotechnology tools to incorporate pest resistance in at-risk species to enable their reintroduction. Often erroneously equated solely with genetic engineering, biotechnology also includes traditional and genome-informed breeding—and may provide a holistic approach toward applying genomic-based information and interventions to increase tree species’ pest resistance. To address the potential use of biotechnology to reintroduce at-risk species, an international group of scientists, partners and stakeholders, and representatives of U.S. federal regulatory agencies gathered to understand the perceptions of each group more fully. That discussion was summarized in [“Reintroduction of at-risk forest tree species using biotechnology depends on regulatory policy, informed by science and with public support.”](#) It described how traditional tree breeding is responsible for successes to date, but new technologies offer hope to increase the efficiency of such efforts. While some biotechnologies, such as traditional tree breeding, are commonplace, others, such as genetic engineering, are controversial and highly regulated, yet may be the only viable means of reintroducing some at-risk species. Efforts to modify policy toward allowing the use of appropriate biotechnology, especially genetic engineering, have lagged. Provided that risk-benefits are favorable, policy is likely to follow with public opinion; in some countries, society is now increasingly open to using available biotechnologies. While investing resources into the biological side of biotechnology is essential, a concomitant investment by natural scientists into the social science side of biotechnology may be even more important. Support across the full spectrum of the public, including scientists, land managers, stakeholders, and regulators, will hopefully motivate policymakers to react.

Spatial Stream Network Model Training workshop

In May 2023, RMRS scientist [Dan Isaak](#), research fish biologist, and collaborators from National Oceanic and Atmospheric Administration (NOAA) Fisheries and Queensland University of Technology hosted a workshop in Boise, Idaho, on [spatial stream network model](#) training for around 30 participants from across the country and several agencies and universities. Participants learned about the specialized software used to model observations taken on stream networks. Then participants were able to apply

the software to their datasets for customized analyses and use it as another tool back in their jobs. The workshops have been conducted for nearly a decade.



Participants at the Spatial Stream Network Model Training workshop conducted in May 2023. USDA Forest Service photo by Dan Isaak.

Indigenous Traditional Ecological Knowledge workshop

In October 2022, RMRS scientist [Jackson Leonard](#), Scientist in Charge of the [Sierra Ancha Experimental Forest](#) and research ecologist in Flagstaff, Arizona, hosted Native American students from the [Ancestral Lands](#) Restoration Certificate Program led by [Kevin Grady](#) from the nonprofit organization Ecoculture. Together, they are developing a curriculum that integrates technology with ecological research methods to work on projects that focus on traditional indigenous knowledge at the Sierra Ancha Experimental Forest. The students spent 5 days in the field learning about the ecology of the area and participating in research activities. Robert Madera, forest botanist on the [Tonto National Forest](#), joined the students in the field and led a discussion on the rare and vulnerable plant surveys being conducted on the Forest. Students also participated in benthic macroinvertebrate sampling in Workman Creek and collected seeds for the ongoing common garden experiment. Funding for the project came in part from the RMRS in support of the recognition of Indigenous Traditional Ecological Knowledge under the [Tribal Consultation and Strengthening Nation-to-Nation Relationships Memorandum](#) released by the White House last year.



Robert Madera, botanist for the Tonto National Forest, speaks to participants about a rare riparian plant species named Chiricahua Mountain Dock (*Rumex orthonuerus*) that can be found along Workman Creek within Sierra Ancha Experimental Forest. USDA Forest Service photo by Jackson Leonard.

Environmental Flows workshop

In May 2023, RMRS scientist [John Buffington](#), served on an expert international panel tasked with developing environmental-flow recommendations for a major stream restoration and trout reintroduction project in Cascade Creek, [Banff National Park](#), Alberta. The restoration project involves creating suitable habitat for reintroduction of westslope cutthroat trout in a restored stream that has been downscaled in size from a river to a creek due to upstream flow regulation from the Minnewanka Dam. The 17-person panel consisted of physical and biological scientists from [Parks Canada](#) and the [Government of Alberta](#), as well as university partners and private consultants specializing in stream restoration; Buffington was the only U.S. member invited to serve on the panel. The two-day workshop involved reviewing the current management plan and prior research findings, conducting a site visit of the creek, and developing recommendations for environmental-flow strategies and follow-up research investigations including field studies and numerical modeling. Results include an internal technical report, with ongoing involvement in the project.



A black and white photo depicting Lake Minnewanka & Cascade River in 1888 prior to dam. Courtesy photo from Library & Archives Canada.

Revegetation efforts of high-elevation forests in Colorado to improve postfire watershed health

After the intense wildfires of 2020, Forest Service managers and scientists teamed up with conservation groups, water utilities, and universities. Researchers like biogeochemist [Chuck Rhoades](#) and his partners aim to figure out the best ways to promote forest and watershed recovery after wildfire. Since the 2020 fires, they've been keeping a close eye on how forests are responding. Thanks to support from the [Bipartisan Infrastructure Law](#), Rhoades and a group of stakeholders, including the [Coalition for the Poudre River Watershed](#), the Cities of [Fort Collins](#) and [Greeley](#), and [Denver Water](#), have started planting spruce, pine, and other vegetation along Colorado streams in areas hit by the wildfires. These efforts

are projected to have positive effects on downstream water quality, aquatic habitat, and native plant biodiversity and can be further read about [here](#).



Field crew planting Engelmann spruce seedlings at a watershed restoration site in Black Hollow Creek within the 2020 Cameron Peak fire scar. USDA Forest Service photo by Chuck Rhoades.

Integrated Centre for International Mountain Development

Scientists [Sean Healey](#), [Eric Bullock](#), and [Zhiqiang Yang](#) of RMRS, along with partners Nidhi Jha and Ashraful Islam of Oregon State University, have been providing remote sensing and carbon accounting support to Nepal and Bangladesh through the Integrated Centre for International Mountain Development (ICIMOD), an intergovernmental knowledge center in the Hindu Kush Himalaya region. In July 2023, they co-led a training held in Chitwan National Park in Nepal about using lidar data from NASA's GEDI mission for estimating biomass stocks. They have also provided, with support from [NASA's SERVIR Program](#), training materials for both using radar imagery to improve land cover maps and mapping forest degradation from time series of Landsat imagery.

Northwest Forest Plan—the first 25 years: Status and trends of late-successional and old growth forests

[Zhiqiang Yang](#) and [Sean Healey](#) of RMRS contributed to the recent [25-year assessment](#) of late-successional and old growth forests under the Northwest Forest Plan. With partners in National Forest System Region 6 and the Pacific Northwest Research Station, they provided remote sensing of historical disturbances that helped explain mapped changes in old growth. They also built a [web-based viewer](#) to share key maps with the public on behalf of the [Regional Ecosystem Office](#).

Forest Inventory and Analysis continues work with LANDFIRE

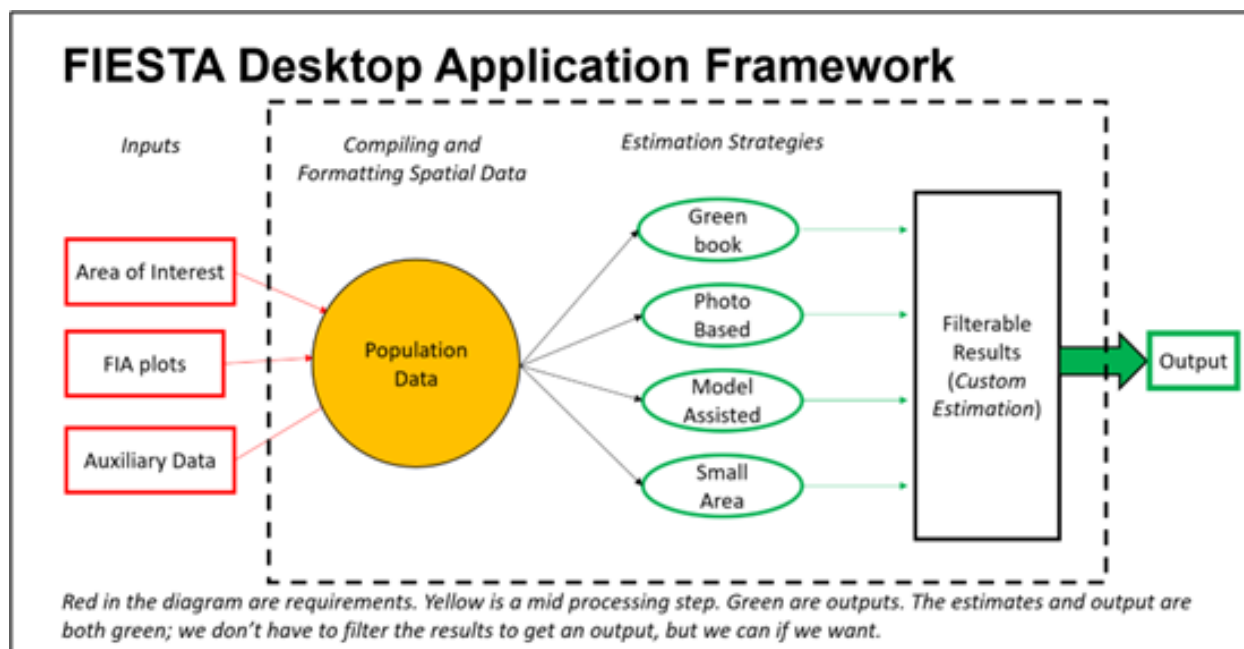
RMRS scientist [Karen Schleeweis](#) contributed to preparing the [LANDFIRE](#) program's 60,000 new FIA records to support new initiatives for annual updates. The LANDFIRE program's prototype team is working toward using Landsat image-based annual updates, rather than rulesets, to update their existing Vegetation Cover, Existing Vegetation Height, Forest Canopy Cover and Forest Canopy Height. Annual updates have long been a goal of the LANDFIRE program, and FIA data represent roughly half of their field-based data on tree structural attributes. The FIA LANDFIRE liaison works within the LANDFIRE teams to ensure timely and well-informed support for working with the FIA data in a confidential

and secure manner. LANDFIRE data are used nearly ubiquitously in analyses related to wildland fire modeling and FIA data are key to this product.

FIESTA desktop application: A user-friendly application to generate forest inventory estimates

RMRS foresters [Tracey Frescino](#) and [Chris Toney](#) have been putting together two R packages to facilitate data compilation and estimation using RMRS Forest Inventory and Analysis (RMRS-FIA) data. The gdalraster R package provides functions for raster data processing while the FIESTA R package provides functions for estimation; FIA data queries; and spatial data compilation using the gdalraster package. Both gdalraster and FIESTA are available on the [CRAN package repository](#).

The FIESTA desktop application was developed by Derek Olson (RedCastle Resources), at the Forest Service Geospatial Technology Application Center (GTAC), as a user-friendly stand-alone interface to the FIESTA and gdalraster R packages. The application generates forest inventory estimates using different estimation strategies by leveraging FIA data with auxiliary information. In May 2023, GTAC hosted a webinar to introduce the FIESTA desktop application. The webinar provided an overview of the application, while also walking the participants through steps towards using different estimation strategies with FIA data for custom analyses. Example data sets and self-guided exercises were provided to highlight the flexibility of the desktop application and for more in-depth learning. The FIESTA desktop application provides an opportunity for forest managers to make more informed decisions based on advanced statistical techniques.



Overview of the FIESTA desktop application. USDA Forest Service image.

Using FIA Data and the Forest Vegetation Simulator (FVS) to support forest planning

Forest Inventory and Analysis research forester [John Shaw](#) and a team of planners, analysts, and silviculturists from the National Forest System concluded the first phase of development of a system for use in yield stream analysis in support of forest plan revision. The effort, which started as part of

the Lolo National Forest plan revision, and now continues under the newly formed Mountain Planning Service Group, aims to streamline and standardize the use of FIA data and FVS for use on other forest plan revisions. This process includes selecting appropriate data; structuring the source database(s) to facilitate a wide variety of simulations; evaluating projection results, including calibration and validation steps; and exploiting FIA data in support of FVS model improvement. Final results are used in the PRISM optimization model and other analyses to address planning goals. The next phase will apply the current version of the system to several forest plan revisions in the Rocky Mountain Region (Region 2), with the goal of determining which of the current components can be applied directly and which will require forest-specific modification. Results are being captured in a guide that should facilitate more efficient and consistent forest planning within and among the new Planning Service Groups.

New national-scale Tree Canopy Cover maps available

RMRS scientist [Karen Schleeweis](#), as the science-lead on the Forest Service Tree Canopy Cover project, contributed along with GTAC and RedCastle Resources to the public release of new [Forest Service National Land Cover Database \(NLCD\) Tree Canopy Cover \(TCC\) maps](#). The project relied on FIA program data and the Landsat record to map tree canopy cover across the nation. These data now include annual layers 2011–2021, superseding previous versions of the NLCD TCC data, to better assist land managers and decision-makers with questions related to the trends and magnitude of tree canopy cover change through time on all lands. These data are released in collaboration with the Multi-Resolution Land Characteristics Consortium, a 20+ year partnership. The data can be viewed in the [MRLC viewer](#) where users can clip the national maps to smaller areas of interest for download. National mosaics, including a science product (2008–2011), are also available to download from the [FS Geodata Clearinghouse](#), or to work with in Google Earth Engine or ArcGIS Online. Data are available for CONUS, Southeast Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands.

Using the Forest Inventory and Analysis dataset for Collaborative Forest Landscape Restoration Project monitoring

In partnership with new Collaborative Forest Landscape Restoration (CFLR) projects in northern New Mexico and Colorado—the Rio Chama and Southwest Colorado CFLRs—FIA has been co-developing methods to monitor these projects at the landscape scale. For example, RMRS-FIA has worked with Sheryl Gunn on the San Juan National Forest to develop analyses that will help define the baseline conditions in the Southwest Colorado CFLR, and also will be used for Forest Plan Monitoring. As part of this, [Kristen Pelz](#), [Tracey Frescino](#), and [Nathan Dulfon](#), all with RMRS-FIA, have developed automated reports to analyze and visualize monitoring results about, for example, forest density, composition, and understory conditions across these landscapes. The intent, in collaboration with Bryce Esch (Collaborative Forest Landscape Restoration Program staff in the National Forest System), is to make these reports work for any CFLR inside the RMRS area, and beyond. Additionally, reporting from the Bureau for Business and Economic Research at University of Montana, using data collected as part of the FIA Natural Resource Utilization Monitoring program, contributes to timber products and market analysis for these CFLRs. Work is ongoing as these collaborative projects develop their plans to monitor work over the next decade.



Members of the 2-3-2 Cohesive Strategy Partnership review preliminary monitoring information for the Rio Chama CFLR that includes data provided by the FIA program. USDA Forest Service photo.

Thermal dynamics of front yards

In 2023, the RMRS Human Dimensions and Water and Watersheds Programs collaborated with the University of British Columbia to investigate the effect of front yard landscaping on thermal comfort in residential neighborhoods of Fort Collins, Colorado. For this, they constructed MaRTa, a transportable bike trailer/jogger with a high-precision weather station that quantifies the thermal, humidity, and energy environment experienced by a person. With the cooperation of dozens of enthusiastic local residents who invited MaRTa into their yards, the study demonstrated that sky view and canopy cover had the greatest impact on thermal comfort. Preliminary results have been shared at collaborative and scientific meetings with a manuscript under preparation.



MaRTa outside a home being used to quantify thermal comfort in Fort Collins, Colorado. USDA Forest Service photo.

Biochar science communications

Throughout FY23, RMRS scientists and the Science Application and Communication team have been developing, promoting, and publishing both [science and communications products about biochar](#). Multiple field demonstrations of in-woods biochar production were held across the western United States in Idaho, Oregon, Washington, Montana, Utah, and Arizona. These field demonstrations allowed land managers, local stakeholders, tribal organizations, Congressional staffers, private industries, and all levels of government personnel to ask RMRS scientists their burning questions about biochar, with the added benefit of seeing it made in air curtain burners, rings of fire, and big box kilns. The Science Application and Communication team created a new biochar web page where users can find all RMRS biochar publications, news, and scientists in one place. The web page is the home for several new fact sheets about biochar, which contain easy to read information about biochar basics, biochar as a climate change mitigation tool, and creating biochar using hand-built piles. RMRS is excited to continue its work on biochar communications with more fact sheets and other products planned for FY24.



Biochar created from an air curtain burner in Idaho. USDA Forest Service photo by Timothy Nicosia.

The Rocky Mountain Research Station is one of seven units within USDA Forest Service Research & Development. RMRS maintains 14 field laboratories throughout a 12-state geography encompassing parts of the Great Basin, Southwest, Rocky Mountains, and the Great Plains. While anchored in the geography of the West, our research is global in scale. RMRS also administers and conducts research on 14 experimental forests, ranges and watersheds and maintains long-term research databases for these areas. Our science improves lives and landscapes. More information about Forest Service research in the Rocky Mountain Region can be found here: <https://www.fs.usda.gov/rmrs/>.

The USDA is an equal opportunity provider, employer, and lender.

