

Science Supporting Timber Management

America relies on timber and wood products from national forests for building materials, jobs, firewood, biochar, paper, and more. Forest Service researchers, since the inception of the Agency, have worked shoulder to shoulder with forest managers to ensure sustainable and efficient timber production from the nation's forests. Rocky Mountain Research Station science has supported timber production for nearly a century and our research continues to provide important insights for public and private forest lands.

Cutting-edge science produced by the Rocky Mountain Research Station improves timber management efficiency and profitability, projects future forest resources, reduces risks to timber resources, increases efficiency of silvicultural practices, protects water and soil, informs salvage logging, and improves reforestation efforts after fire, flood, blowdowns and other major disturbances. We partner with States, local governments, Tribes, rural communities, private companies and industry to develop and assess future wood supply, economic scenarios, timber harvesting techniques, biomass markets and wood innovations.

Rocky Mountain Research Station researchers work closely with regional and local forest managers, making us uniquely situated to respond to the recent [Executive Order 14225](#) to increase timber production on America's public lands. We don't just "do research"—we develop tools and applications, design new technologies, and bring these innovations to market.

Improving Feasibility, Efficiency, and Profitability of Timber Projects

Growing trees is one thing, but harvesting, hauling, and selling is another. Our scientists are finding solutions that enhance the feasibility, efficiency, and profitability of America's timber industry.

Our scientists are contributing to the Agency's Forest Management Analysis Platform, a new approach to identifying



Logging operations on the Coconino National Forest. USDA Forest Service photo by R. Shaffer.



priority areas for timber harvest and hazardous fuel treatment. In fact, with our wildfire risk data and expertise, our scientists are helping delineate the actual acres available for timber harvest under Executive Order 14225.

What might future opportunities to expand this industry look like? Rocky Mountain Research Station scientists partnered with the University of Idaho to evaluate the future wood supply on the Salmon-Challis National Forest in an [economic feasibility study of the forest industry](#). The team projected economic scenarios with different types of forest industries and associated mills and bioenergy options that could use materials from timber harvesting, fuels reduction, and other activities.

Stewarding tax dollars to ensure the best bang for the buck is critical to the Forest Service. Developed by Rocky Mountain Research Station scientists, the new [Delivered Cost Model helps ensure the profitability of timber and fuels projects](#). This new model is an important update to past harvest models because it accounts for any type of material, including dead trees and biomass, not just green trees. The Delivered Cost Model converts the distance from a tree removal project to a processing plant into dollars, calculates the market value of removed products, and identifies related communities and infrastructure while combining these metrics to show where forest management projects optimize funds.

Our science helps forest managers determine the best timber harvest and wood procurement scenarios. Because hauling lower value wood products to a sawmill or biomass facility may cost more than the products are worth, minimizing transportation costs can be critical to project viability. The [RMRS Raster Utility is a decision tool that integrates lidar-derived maps in an easy-to-use GIS toolbar](#). This tool is used by managers to better calculate the volume of biomass in a given harvest area. The add-in allows users to input prices for their region to account for fluctuating machine rates and gate prices.

We mapped the [suitability of different harvest systems across a 74,000-acre landscape area of the Nez Perce-Clearwater National Forests](#). By combining lidar and ground plot inventory data with engineering information, our scientists provided forest managers information about optimal deployment of harvest systems, including tethered and winch-assisted equipment. This approach can be replicated across other national forests.

While reducing hazardous fuels, forest managers also harvest timber and biomass to offset treatment costs and provide local economic benefits to the forest products industry. Rocky Mountain Research Station researchers and partners are digging into the details of forest industry supply chains tied to forest management and fuel treatments. We are describing current forest operations, providing recommendations to improve operations and logistics,

Fontaine Mill in Stratton, Maine manufactures a broad range of wood products. USDA Forest Service photo by P. Keres.

developing supply chain models and fuel treatment optimization methods, and providing decision tools for facility siting.

Harvesting timber on steep slopes usually can't be done with conventional ground-based logging operations. Small-scale projects can be conducted by hand crews with chainsaws, but this is more dangerous, slow, and costly. Ground-based, steep slope logging, and cable logging can be performed on such landscapes. [Our researchers found that adjusting investment and implementation strategies can significantly increase the area available for mechanical treatments](#). For example, operating on steeper slopes (grades up to 60%) and expanding temporary road networks would open enough acreage to meet larger-scale project objectives.

Reducing Risks to Timber Resources

Wildfire, bark beetles, pathogens, and drought—these are all threats to America's timber resources. Rocky Mountain Research Station houses some of the world's leading experts on wildfire science, bark beetles, white pine blister rust, Armillaria root rot, and forest health. Our scientists are working to describe, detect, map, and provide management options for emerging risks to timber.

Bark beetles have devastated millions of acres of forest, including valuable timber lands, in the western United States in recent epidemic-level outbreaks. Rocky Mountain Research Station scientists have not only been [studying these recent beetle outbreaks since their inception](#), they are also working hand in hand with forest health protection managers to map areas impacted by beetle mortality and develop management strategies based on the best available science. We are also following the long-term effects of these bark beetle outbreaks at our experimental forests to [describe changes in nitrogen and forest dynamics in the decades after the initial outbreak](#).

A new, high-powered analytical framework developed by the Rocky Mountain Research Station, called [RiskMonitor](#), helps managers [identify the most effective strategies to reduce wildfire risk and monitor progress toward risk reduction goals](#). We are already working closely with Forest Service regional fuels analysts to integrate this framework



Forest mortality caused by bark beetle on the Arapaho Roosevelt National Forest. USDA Forest Service photo by C. Rhoades.

into regional and forest planning. RiskMonitor can be used to understand how treatments will change wildfire risk to timber resources and other natural resources.

How effective are fuels treatments in reducing wildfire risk? This fundamental question guides many Rocky Mountain Research Station studies. Long-term research studies at sites in northern Montana, the Southwest, and elsewhere, have followed fuels treatments over decades, measuring the [effectiveness of fuels treatments over the long term](#). Recently, our scientists [synthesized 30 years of studies on fuels treatment effects on wildfire severity](#). Areas where thinning and prescribed burning occurred experience lower burn severity from subsequent wildfires as compared to areas that were only thinned or untreated.

Our research is yielding [promising new approaches to detecting and managing Armillaria root disease](#), a devastating forest disease that damages valuable timber species such as Douglas-fir. We are using DNA-based tools to correctly identify Armillaria species, allowing us to identify the highest risk areas for this invasive pathogen.

Developing Biomass Markets and Wood Innovations

Biochar is a [carbon-rich soil amendment](#) created by burning slash with specially designed equipment at relatively low temperatures. Benefits and applications of biochar production include reduced wildfire risk, added local revenue, improved soil health, enhanced carbon sequestration, and [mine reclamation](#).

The CharBoss® is an in-woods machine that converts unmerchantable woody biomass into biochar. Under a cooperative agreement, [Air Burners, Inc., a private company based in Florida, worked closely with Rocky Mountain Research Station scientists and managers to design and manufacture the CharBoss®](#). This public-private partnership grew out of a need to find a market solution to the problem of woody waste materials generated from forest management activities, beyond burning it or hauling it off-site. Our researchers teamed up with national forests to host [CharBoss® demonstrations](#) in five western States. Because biochar is not well known to land managers who are potential users of biochar, we are deliberately engaging forest managers with our punchy communication materials



4 The CharBoss® is an air curtain burner-style mobile biochar production machine. USDA Forest Service photo by D. Weseman.

like [Biochar at a Glance](#) and [Soil Restoration with Biochar](#) factsheets and taking field demonstrations to the farms and forests where they work.

Many forests across the western United States are crowded with small, unmerchantable trees that are increasing the risk of large, severe wildfires. Thinning can reduce wildfire risk but can result in large amounts of waste biomass, or slash. Our researchers are studying and developing suitable markets for this slash and converting it to value-added wood products. A team of interdisciplinary scientists at the Rocky Mountain Research Station and university colleagues studied the [feasibility of developing profitable biomass markets in Arizona, New Mexico and Southern Colorado](#) to handle excess waste biomass. Our feasibility study found that developing biomass energy markets would have net benefits over broad areas in the southwest U.S. including reducing wildfire risk and increasing diversity of energy sources.

Maintaining Forest Inventories and Projecting Tomorrow's Resources

Accurate estimates of tree species distributions facilitate timber production and sustained growth and yield. Forest Service scientists develop datasets, tools, and models that aid active forest management.

Based in Forest Service Research and Development, [Forest Inventory and Analysis collects, processes, analyzes, and reports on forest data](#) necessary for assessing the extent and condition of forest resources in the United States. This congressionally mandated program delivers current, consistent and credible information about America's forests and forest resources. The Intermountain West Forest Inventory and Analysis unit operates from Rocky Mountain Research Station.

Mandated by the 1974 Forest and Rangeland Renewable Resources Planning Act, the [Resources Planning Act Assessment](#) (RPA) is conducted by Forest Service Research and Development. Projections in the RPA Assessment are based on scenarios that consider United States and global population and economic growth, the openness of international trade, bioenergy, wood-energy consumption, and other factors. The forecasting in the assessment can help timber managers think about long term management strategies and American timber companies can use the assessment to inform the viability of large investments. Scientists from across Research and Development, including nine from the Rocky Mountain Research Station, contributed to the development of the 2020 assessment.

The National Land Cover Database and its [Tree Canopy Cover dataset inform management of forests, watersheds, and wildlife](#). These datasets are used to investigate land cover projections, postfire vegetation cover, wildlife habitat, bioenergy, and forest health. The National Land Cover Database supports

Timber crew foreman demonstrates timber cruising. USDA photo by L. Cheung.





multiple Forest Service business needs including the Resources Planning Act Assessment, Forest Inventory and Analysis estimation for State and national reporting, [i-Tree Landscape](#), a tree canopy assessment tool, and much more.

[TreeMap](#) is a tree-level model of forests that provides detailed spatial information on forest characteristics, including the number of live and dead trees, biomass, and carbon across the entire forested extent of the continental United States. It combines Forest Inventory and Analysis data with LANDFIRE data to better estimate forest characteristics at a variety of scales. It is used to determine which trees to remove during fuel treatments, inform the distribution of dead trees, estimate risk to forest carbon from wildfire, and map wildlife habitat.

Rocky Mountain Research Station researchers are developing [new methods of using drones to monitor forests](#). Foresters can now use drones to track changes in silvicultural prescriptions, measure forest treatment effects, assess wildfire risk, and plan fuel management treatments. This technology enables managers to more quickly collect monitoring data about forest treatments, allowing for flexible and responsive adaptive management.

Increasing Success of Postfire Reforestation

Reforestation is sometimes necessary to restore healthy and resilient forests after fire. Our [Target Plant Concept ensures that we plant the right trees, in the right place, at the right time](#). It considers the connections among seed sources, nursery practices, seedling characteristics, and postplanting growth and survival to develop the next generation of trees, while ensuring efficiency and cost savings.

Developed by Rocky Mountain Research Station scientists, [REGEN MAPPER](#) is a tool for forest managers to assess and prioritize sites for planting following wildfire and other disturbances. This science-backed tool facilitates acceleration of timber harvest after fire, followed by reforestation.

When severe fires result in large treeless patches, the resulting patches may convert to grasslands or shrublands if trees do not naturally regenerate. The [Southern Rockies Reforestation Tool](#) is a decision support tool developed by Station scientists and our university collaborators. This tool identifies climatically and topographically suitable sites to plant ponderosa pine and Douglas-fir seedlings after wildfire. Managers can now optimize planting efforts by focusing on sites with the greatest chance for success.

The Forest Service aims to plant more than a billion trees on 4 million acres of deforested national forest lands, mostly burned by wildfire, over the next decade. Many Rocky Mountain Research Station scientists are working to improve the success of outplanted seedlings and spend valuable resources where they are most likely to be successful. One of our recent studies,

Tree seedlings ready for planting on the Coconino National Forest. USDA Forest Service photo by C. Motahari.

conducted in collaboration with forest managers on the Arapaho and Roosevelt National Forests, found that [seedling survival was nearly twice as high on north aspects and developed recommendations for managers](#), such as planting seedlings in depressions and the shade of other objects.

Only one-quarter of nursery-grown ponderosa pine seedlings are expected to survive when planted on disturbed sites in the southwestern United States. Our scientists are developing strategies for conditioning seedlings, before they are planted in the field, to improve the establishment success of ponderosa pines planted for forest recovery. One strategy that limits irrigation of seedlings known as [drought conditioning is proving to be a promising strategy for improving outplanted seedling success](#).

Aiding Salvage Logging Decisions

Our research enables forest managers to [predict which trees are likely to die and subsequently plan for salvage](#) and other management activities. Foresters rely on this research to develop postfire tree-marking guidelines that assist timber-marking crews laying out salvage sales on every national forest. This science and collaboration with foresters on the Bitterroot National Forest enabled a planned commercial sale to continue even after it was burned by wildfire, thus preventing substantial losses in revenue for the logging operator.

Forest managers and the timber industry are adapting to changing forest conditions, notably, moving away from the exclusive harvest of green trees and towards increased harvesting of dead trees and smaller materials. Critical to these changes are the modernization of harvest operations and supply chain logistics that are able to remove and use dead trees from salvage timber sales and smaller materials produced by forest health treatments. As part of Rocky Mountain Research Station work with the Bioenergy Alliance Network of the Rockies, our scientists studied [how salvage operations in beetle-killed stands could be made more efficient and safer](#).

Providing useable and state-of-the-art science to land managers quickly is a specialty of Rocky Mountain Research Station's specialties. Timber managers need the most up to date information to plan salvage projects. This is why we teamed up with our Joint Fire Science Program partners to host a [series of Salvage Logging Science technology transfer sessions](#) in which panels of experts provided the newest research and tools for salvage logging management and planning.



Potential salvage timber in the Eldorado National Forest. USDA Forest Service photo by P. Keres.



Conserving Water and Soil During Timber Operations

Increasing timber production from National Forest System lands will require road improvements or, in some cases, new road construction. National Forest System engineers, hydrologists and timber managers rely on tools developed by Rocky Mountain Research Station scientists to evaluate road maintenance needs and erosion potential. For example, [GRAIP-lite](#) is a go-to resource that estimates road maintenance needs and predicts road sediment delivery to streams with less field effort than traditional surveys. It is an efficient alternative to detailed road inventory methods to analyze large projects or across many basins, at scales where field inventories are not feasible.

Forest managers must be able to estimate the erosion potential of both planned management activities and catastrophic events to decide where to use limited funds to focus erosion control efforts. To meet this need, scientists from the Rocky Mountain Research Station and collaborators have spent over a decade developing a suite of online tools that can be used to predict erosion potential of road building, forest management, and wildfire, as part of the [Forest Service–Water Erosion Prediction Project \(WEPP\)](#).

When harvesting timber, some disturbance is inevitable. For example, heavy equipment that moves trees and slash can also compact soil. But do these soils recover? A long-held assumption was that soils take a very long time to recover, if at all, after timber harvest. A 20-year study in collaboration with managers on the Kootenai National Forest asked and answered this question. [Soils in over 85 percent of the harvest units recovered](#) 3–5 years following timber harvest.

Enhancing Wildlife and Timber Management Compatibility

Supporting timber harvest and thriving wildlife populations are not mutually exclusive. Rocky Mountain Research Station scientists have developed novel approaches that help land managers support both priorities. In some cases, our research provides defensible data that can improve the efficiency of timber project implementation. For example, Canada lynx require large and intact areas of mature forest, but these forests are increasingly at risk of more frequent, severe fire, that jeopardizes lynx habitat. Our research has found that [maintaining a mix of forest stands, including actively managed](#) stands, supports Canada lynx use. Further research on [remapping Canada lynx habitat](#) has helped identify additional areas available for timber removal.

Game species such as mule deer, white-tailed deer, and elk are critical considerations for timber operations given the importance to hunting and recreation-based economies. [Logging may benefit mule deer](#) because early

Rocky Mountain Research Station researcher taking river measurements. USDA Forest Service photo by E. Reiter.

seral habitats often contain a greater variety, quantity, and quality of mule deer forage than mature forests. These and many other important findings are contained in our [Fire Effects Information System](#) species and ecosystem syntheses.

Our cutting-edge wildlife habitat monitoring system, [Living Maps](#), enables us to monitor wildlife habitat for at-risk species in near-real-time. Living Maps are hosted on an interactive, high-resolution and high accuracy platform hosted on Google Earth Engine. This research was used to lift an injunction on fuels management and timber harvest on 11 national forests in the southwestern United States, demonstrating that wildlife and forest management can be compatible.

New studies by Rocky Mountain Research Station scientists provide [rationale for incorporating forest treatments into California spotted owl recovery](#) efforts. Their work shows that forest restoration focused on improving fire resilience can be compatible with spotted owl habitat management in California's Sierra Nevada mountains.

Leading out with Foundational Silvicultural Knowledge

Rocky Mountain Research Station science, and Forest Service Research and Development more broadly, has a long legacy of research supporting the Forest Service's timber management and our multiple use mandate dating back to the early 1900s. Authorized by Congress and designated by the Chiefs of the Forest Service, [experimental forests and ranges host long-term studies over decades or even a century](#) while serving as demonstration and training sites.

White pine, a fast-growing tree that reaches heights of 150 feet, was once an economic driver in the northern Rockies. A combination of blister rust, beetles, and logging severely reduced the range of white pine during the 20th century. Over a decade of research by Rocky Mountain Research Station scientists has resulted in [updated guidelines for regenerating and establishing white pine on the landscape](#) by focusing on factors such as forest openings and visible sky. These recommendations are already being applied, such as on the Idaho Panhandle National Forests where RMRS research helped convince stakeholder groups that bigger openings were needed to establish white pine over larger landscapes.



Technicians collect FIA data in regenerating forest. USDA Forest Service photo by E. Freeman.

The nation's very first experimental forest was the Rocky Mountain Research Station's [Fort Valley Experimental Forest](#), established in 1908, near Flagstaff, AZ. Its focus was to understand why ponderosa pine wasn't regenerating after logging. Silvicultural research continues at Fort Valley and at many of our experimental forests including the [Black Hills](#) in South Dakota, [Coram](#) in Montana, [Priest River](#) in Idaho, and [Fraser](#) and [Manitou](#) in Colorado.

One strategy to increase vigor and decrease mortality of white pines is radial thinning—clearing openings around individual trees. Our researchers worked with white pine managers on the Umpqua National Forest and the nearby Bureau of Land Management Roseburg District Office to understand the effectiveness of this silvicultural treatment. We learned that [radial thinning is not as beneficial for promoting white pine as originally hoped](#), demonstrating the importance of monitoring and learning from treatment attempts.

About Rocky Mountain Research Station

Rocky Mountain Research Station works at the forefront of science to improve the health and use of our Nation's forests and grasslands. We are rooted in a 12-state geography encompassing the Great Basin, Southwest, Rocky Mountains, and portions of the Great Plains. Our science serves the American public by providing Forest Service managers, federal and state agencies, Tribes, industry and many others with the latest knowledge and state-of-the-art technologies.

