Evaluating the Impacts of Forest Treatments

The First Five Years of the White Mountain Stewardship Project

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Evaluating the Impacts of Forest Treatments: The First Five Years of the White Mountain Stewardship Project

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This report, and additional supporting documents, can be found on the following website:
http://www.fs.fed.us/r3/asnf/stewardship/multi-party-monitoring.shtml

Photographs: Arizona Game and Fish Department: Black bear, red squirrel, wild turkey
Bruce Taubert: Lewis's woodpecker, northern goshawk, plumbeous vireo, red-faced warbler, western tanager
Randy Babb: Abert's Squirrel
U.S. Forest Service: Vegetation pre- and post-treatment comparisons, soil classification examples
The Nature Conservancy: All other photographs

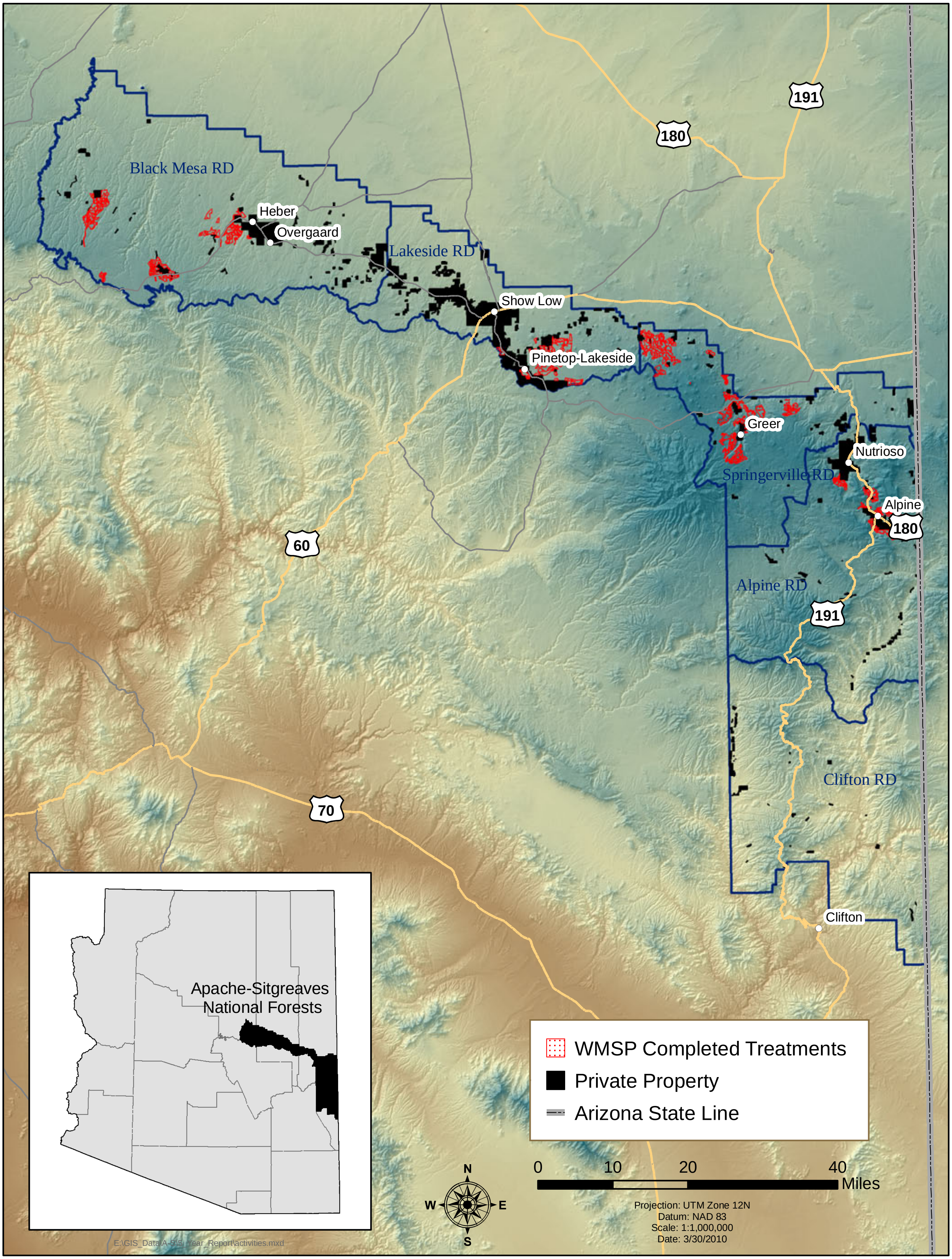


Figure 1. Map of the Apache-Sitgreaves National Forests and areas treated under the White Mountain Stewardship Project

Introductory Letter from the Monitoring Board

To our readers

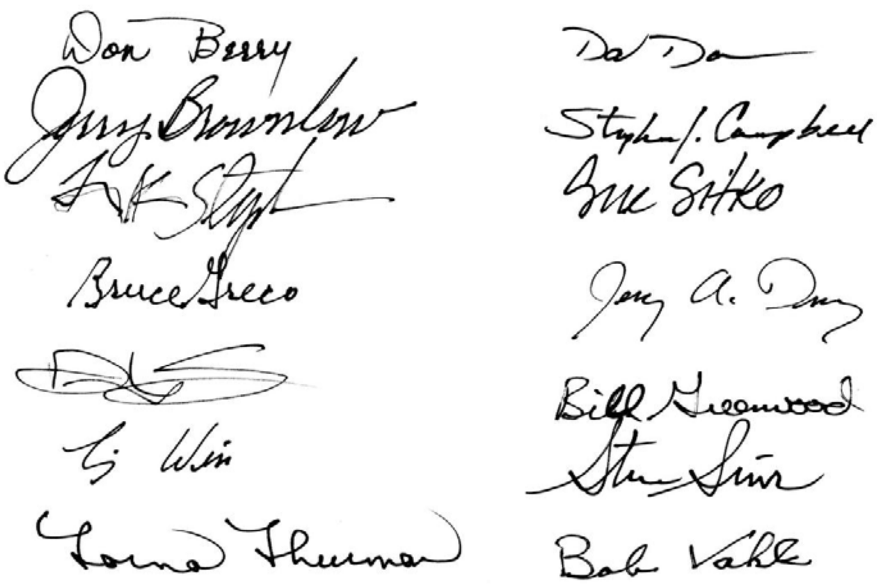
The White Mountain Stewardship Project was, and continues to be, an experiment in adaptive management and collaboration undertaken by dedicated forest managers, local businesses, and community members to find a solution to a complex issue. The Apache-Sitgreaves National Forests, on which our communities depend for recreation, tourism, economic growth, and quality of life, had become vulnerable to severe and uncharacteristic wildfires due to a multitude of reasons. These wildfires risk human lives and private property, impact wildlife and wildlife habitat, and affect our local economies. Since the mid-1990's, many of us were already working together under a committee known as the Natural Resources Working Group to seek common ground and find ways to restore forest health and reduce the threat of uncharacteristic wildfire; we knew what could await us if we didn't work together and find solutions soon. We were a few years too late. In June 2002, communities from Forest Lakes to Show Low woke up to the "perfect storm" that many of us knew would, but hoped wouldn't, occur. Two large wildfires, occurring in dry conditions and at times each burning over 50,000 acres per day, merged to become the largest wildfire in Arizona history, the Rodeo-Chediski. For many of us, we were not surprised. For others who had not been exposed to forest health issues, it was a wake-up call. Many conflicts related to forest management that occurred in the past were set aside to agree on a solution.

With our forests overstocked with small trees and limited markets for the wood fiber to be available, we were left at a stalemate. In 2003, Congress approved legislation that allowed federal agencies to commit to ten-year stewardship contracts by paying private entities for land management activities. Many of us felt that this was our opportunity to make some dramatic improvements to our communities and forests. However, most, if not all, National Forests were skeptical. Committing to a long-term contract was one thing; fulfilling that contract was another. Providing the wood was a social and political risk; environmental analyses that eventually determine what was available, and where, could be delayed. Costs were largely unknown and annual budget appropriations were uncertain. It was over one year later, in late 2004, before one National Forest stepped up to accept these risks—the Apache-Sitgreaves. The experiment of the White Mountain Stewardship Project began.

The contractor, the U.S. Forest Service, and the Monitoring Board embarked upon this effort as a learning experience. No one single Board member had extensive experience with monitoring, particularly monitoring a ten-year, landscape-level project. No prior ten-year stewardship project across the country existed; nor was the Board aware of an attempt made by any collaborative network to monitor multiple aspects of a ten-year project using the stewardship contracting authority.

After working together to understand basic monitoring concepts and to determine what would be the priority lessons to learn from the project, we decided that our monitoring needed to address aspects of the project that would mostly influence planning and management. Budgetary limitations forced us to choose between undertaking more of a scientific research approach or, alternatively, a broader approach by implementing a coarse study of multiple aspects that may influence future planning and management efforts. We chose the latter, ultimately preferring to obtain data on a variety of parameters that could help managers in the field.

We have worked together, in tandem with the contractor and Apache-Sitgreaves staff, for five years to gather data and analyze the effects of this Project. This report is the culmination of this effort, and marks the midpoint of the White Mountain Stewardship Project. Some analyses confirm assumptions that seem to be intuitive, but data are needed to validate these premises. Some analyses show us that there are unforeseen and unanticipated impacts that can be either positive or negative. Some analyses enlighten us and let us know we have had impacts far beyond what we thought we could achieve five years ago. What has been most valuable, however, is the belief that all of us are working towards a better future for those who come after us.



Acknowledgements

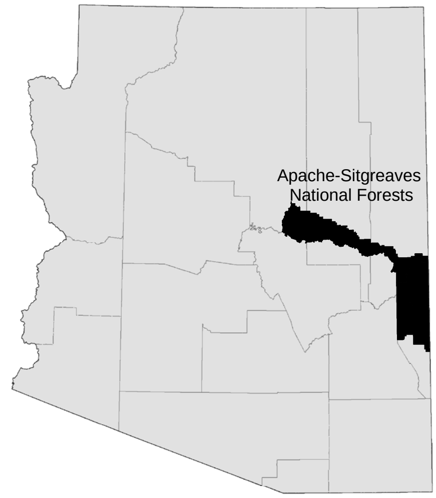
We would like to thank Chris Knopp, Bob Taylor, and Jerry Drury for their invaluable support in this project. We also give special thanks to Jim Pitts and Gayle Richardson for providing vegetation data and insight on treatment details. We thank Pam Klein-Taylor and Steve Richardson for providing GIS data and Evan Girvetz for technical review of the PatchMorph models. We also would like to thank Dave Dorum, Genice Froehlich, and Beth Humphrey for participating in focal wildlife species selection and habitat connectivity model reviews. Jennifer Hill and Jim Snyder provided insights and data on Best Management Practices and soil compaction monitoring. Mitchel White provided input on analysis of vegetation data. Molly Pitts provided thorough reviews of the economic and administrative monitoring sections. Mark Engle provided an additional perspective on the economic monitoring section. Kirby Bristow provided reports on the Arizona Game and Fish Department's black bear research project. Mike Ingraldi and Vincent Frary provided information and data on the northern goshawk prey study. A special thanks to Tessa Nicolet for completing the fire modeling on areas that received forest thinning implementation. We would also like to thank Dave Cagle, Troy Corman, Norris Dodd, John Koprowski and his students, Rick Langley, Steve Rosenstock, Bob Vahle, and Brian Wakeling for providing expert input and reviews for habitat connectivity models on selected species. Also a special thanks to Dave Huffman and Pete Fulé from the Ecological Restoration Institute for a technical review of the analyses completed for this report. Rufus Cole at the U.S. Forest Service's Region III office provided valuable insights on the contract administration. We also want to thank the many other Forest Service personnel and others who provided input and reviewed many versions of this document.

We especially thank the White Mountain Stewardship Project's Multi-Party Monitoring Board for their participation, contribution, and support throughout this analysis.

This project would not have existed without the foresight and commitment by former Forest Supervisor Elaine Zieroth; Stewardship Contractors Dwayne Walker and Rob Davis; and Contract Officer Rufus Cole. We thank you for taking risks to protect communities from wildfire, enhance employment opportunities, and help restore forest conditions in the White Mountains and Rim Country of Arizona.

Executive Summary

In August, 2004, the Apache-Sitgreaves National Forests implemented the country's first ten-year stewardship contract. With this contract, the White Mountain Stewardship Project (Project) began as an experiment in collaboration with multiple stakeholders, the Apache-Sitgreaves National Forests, the contractor, and community members working together to resolve decades-long forest health issues. The Project's goals were to reduce the impact of wildfires to communities at risk, to improve wildlife habitat, and to restore forest health, while helping rural communities stimulate employment in the wood products industry. How will we know we've met these goals? With monitoring, we will measure changes that occurred to the resources of interest from these management actions. Determining the effects of these forest treatments in a systematic monitoring program will help inform and improve future management actions.



Monitoring the White Mountain Stewardship Project

Together, forest stakeholders ranging from businesses, conservation interests, county, state, and local governments, and interested individuals became integral partners with the Apache-Sitgreaves National Forests and the stewardship contractor under a Multi-Party Monitoring Board. The Monitoring Board recommended which aspects of the Project to monitor in four categories: project administration, ecological effects, economic impacts, and social support. Monitoring objectives and related questions were developed for each category. Information was gathered to answer these questions. Forest Service staff collected most of the monitoring data, with additional help from other collaborators, including the Arizona Game and Fish Department, The Nature Conservancy, the University of Arizona, and private consulting firms. Most funds were provided under the Project's budget, with additional grant monies awarded from the Eastern Arizona Resource Advisory Council and the All-Birds Conservation Initiative. The report is the culmination of monitoring the first five years of this ten-year project. It provides an analysis of all monitoring data, interpretation of results, and recommendations for the next five years. This Executive Summary reports key findings, lessons learned, and recommendations.

Examples of Monitoring Questions:

- How many jobs are associated with the Project?
- Are patches of dense forest connected?
- Did forest treatments significantly reduce potential crown fire?
- Have contractors become more efficient over time?

Communities Targeted by the Project:

Alpine
Eagar
Forest Lakes
Greer
Heber-Overgaard
Nutrioso
Pinetop-Lakeside
Show Low
Springerville

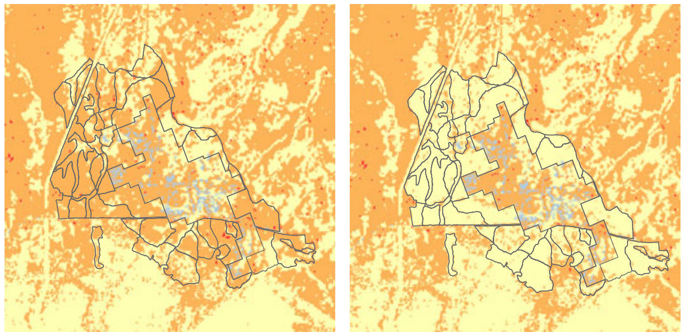
Project Administration

The Project tests the mechanism of stewardship contracting on a ten-year contract cycle. The contract guarantees wood for its duration to generate private business investment in wood product industries with the hope of eventually building a sustainable market, thereby reducing the need for further government assistance. Currently, 35,166 acres have been treated, with an additional 14,553 acres in progress. The exposure of the Project across the country has helped generate an atmosphere in which landscape-scale forest restoration projects can occur, such as the Four Forest Restoration Initiative across four National Forests in northern Arizona.

Findings and Lessons Learned

- While contract costs per ton have not changed, the contractor has provided additional services on treatment areas, such as conducting a total removal of all fiber for the cost associated with partial treatment (leaving piles of residue for future burning).
- The contractor has acted to improve marketability of the wood harvested, including supporting 20 local businesses making products from small-diameter wood.

- The amount of expenditures and taxes generated by businesses and employees directly associated with the Project supersede contract costs. The Project has cost the federal government approximately $30 million in its first five years, while businesses have generated approximately $40 million in investments, expenditures, and tax revenue.


Predicted fire behavior before and after treatments; lighter color indicates a reduced fire severity

- A long-term stewardship contract can reduce administrative procedures for contract activities through the duration of the contract. A stewardship contract negates the need to undergo individual contract bids for each project area, which can take months, allowing multiple task orders to be bundled under one contract and completed in days. Use of a single contractor over multiple projects facilitates the use of descriptive treatment prescriptions rather than the labor-intensive task of marking each tree needing to be cut. As both parties become educated to each other's needs, treatment implementation becomes simplified, reducing internal Forest costs.
- Flexibility and open communication are keys to meeting the harvesting objectives set by the Apache-Sitgreaves and the wood fiber market needs determined by the contractor. By working closely together, wood harvest operations are designed to meet site-specific conditions, environmental requirements, and the type of materials purchased from the contractor by businesses.

Recommendations

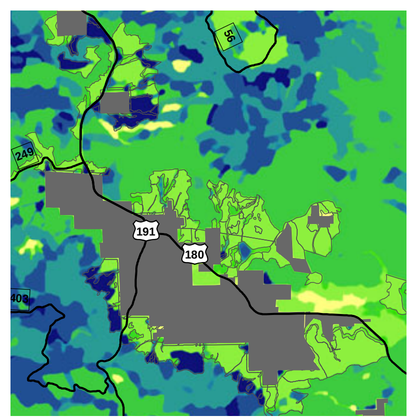
- Stewardship contracts require long-term commitments of funding, available stock of wood (with completed environmental analyses), and a calculated amount of funds set aside to cover U.S. Forest Service liability in case of contract cancellation. Regional U.S. Forest Service offices must work closely with their contracting National Forests on budgets associated with stewardship contracting to effectively plan for these encumbrances.
- Analyze which business niches, such as uses for biomass (which comprises 40% of the overall wood fiber resulting from treatments), would be helpful to improve markets and reduce costs further.
- Use descriptive treatment prescriptions where appropriate, reducing site preparation costs.
- Review contract language to determine if adjustments can be made to adapt to improved methods of calculating costs and to better reflect cost reductions.

Ecological Effects

Monitoring ecological impacts was the most complex and challenging aspect of Project monitoring. Obtaining sample sizes adequate to make inferences on changes and effectiveness of treatments becomes difficult when there are multiple treatment prescriptions, each having different results on the ground. Additionally, modifying only parts of a landscape generally incurs gradual changes at various scales; inferring impacts after a few years of treatments does not indicate what may transpire in the long-term, as forests grow and change over time.

Findings and Lessons Learned

- A variety of treatments based upon different objectives has created a mosaic of diverse forest conditions across the forest. In all cases, the potential for active or passive crown fire has been reduced in forests surrounding the communities targeted for protection. Monitoring data have indicated that multiple objectives for fire behavior, forest structure, and wildlife habitat can be integrated together in developing treatment prescriptions.
- Habitat connectivity for the suite of species modeled was altered by the implementation of forest treatments and the resulting vegetation characteristics and forest structure. Connectivity of patches of dense forest was largely a result of the exclusion of such areas from treatment due to topographic features, slope, sensitive soils, or other factors. As treatments continue to increase across the landscape, maintaining connectivity of dense forest patches may become challenging unless addressed in the planning stage.



Habitat connectivity for wild turkey; blue areas indicate high levels of connectivity

- Songbird surveys indicate an increase in density among the five most common breeding forest songbirds in post-treatment areas. Composition and diversity indices are varied; more post-treatment surveys will be conducted in future years to increase sample size.

- Preliminary data suggest that black bears are generally not affected by treatments in ponderosa pine. However, for future treatments that occur in mixed-conifer vegetation, the ability to maintain movement corridors and denser forest structure near preferred feeding areas may warrant additional monitoring.
- Understory herbaceous cover increased after treatments at several project areas.
- Soil compaction from equipment operating across the landscape was minimal; compaction does occur at landings and on roads and skid trails, particularly in wet soil conditions.

Recommendations

- Forest managers could implement prescriptions that meet multiple resource objectives more frequently where appropriate site conditions exist.
- Developing treatment scenarios and modeling impacts to wildlife species in the planning phases may help maintain or increase wildlife habitat connectivity in future treatments.
- Maintaining songbird surveys over the life of the Project will be important to understand if the initial changes observed in density, diversity, and composition persist over time.
- Increase contract oversight in wet soil conditions.
- Ecological monitoring protocols should be evaluated and improved to reduce uncertainty in monitoring results and to better define quantitative-based objectives.

Economic Impacts

One of the goals of the Project was to use a long-term contract mechanism to facilitate private business investment in the management of public land resources, with the end result being an ecologically and economically sustainable system of resource extraction and benefits. Evaluating how the Project impacted local economies and employment, as well as how economic benefits compared to administrative costs, were priority monitoring objectives for the Monitoring Board.

Products Created from Project Wood:

- Wood Pellets
- Biomass Electricity
- Pallets
- Lumber
- Furniture
- Moulding
- Soil Fertilizer
- Animal Bedding

Findings and Lessons Learned

- Twenty businesses, representing diverse industries, purchased material from the contractor. Materials produced, including wood pellets, pallets, moulding, and small-diameter lumber, have helped the Project weather national market demands and fluctuations, particularly in the context of a national decrease in demand for housing materials, which has affected the lumber industry nationwide.
- While this diversity has helped increase the value of small-diameter wood, government investment in the Project remains necessary to offset treatment costs.
- An average of 319 jobs per year have been attributed to the Project (226 direct and 93 indirect). The Project is one of the largest economic development programs in the White Mountains.
- Over $13 million has been spent in local communities each year, on average, by businesses purchasing wood fiber from the Project and by contractor operations.
- An average of over $600,000 is generated every year over the lifespan of the Project in tax revenue for Navajo and Apache county governments by business purchases and employee residency.
- The Project offers mid-level wages for heavy equipment operators, loggers/sawyers, mill operators, and manufacturing jobs. This economic sector diversifies employment opportunities in this rural region by adding other sectors to the current primary employers, such as government, health care, and tourist-based industries.

Recommendations

- The contractor, or locally-based economic development programs, should continue to research and promote new markets to improve the likelihood of continuing a diverse wood-product network beyond the ten-year timeline of the stewardship contract.
- Annual economic monitoring should continue to track employment and users of the Project's wood fiber, and be broadened to include effects of the product sales and other factors.
- Non-local expenditures by wood-product businesses should be evaluated to determine if a local business could fill needs.

Social Support

When the Project was initiated, the 2002 Rodeo-Chediski wildfire was still fresh in most residents' minds. A social assessment undertaken after the fire indicated that most residents supported the need for forest management, including both thinning and managed fire. This assessment was used by the Monitoring Board as a baseline to gauge social support for the Project. Several outreach projects were implemented, such as newspaper inserts, highway signage, and brief bulletins and annual reports.

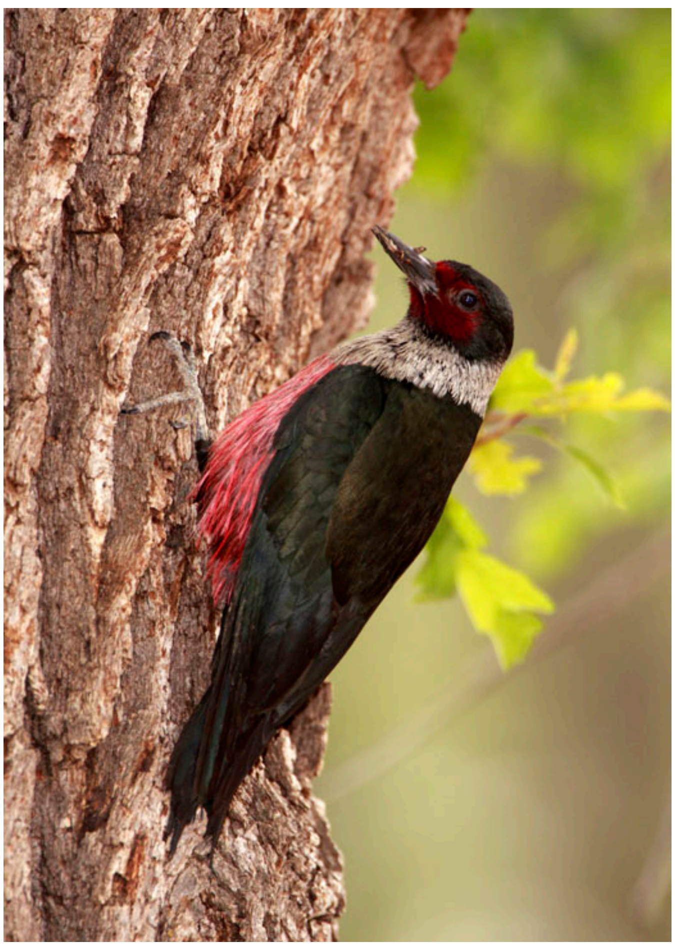
Findings and Lessons Learned

- The social assessment conducted in 2005-2006 in Navajo and Apache counties found that of 722 households, 94% supported mechanical treatment in our forests and 92% indicated their support of using prescribed fire.

- This assessment also found that Navajo and Apache county residents have a good basic knowledge of the ecological benefits of fuel treatments, forest restoration, and prescribed fire, with relatively less knowledge of the ecological role of fire in ponderosa pine ecosystems. Respondents answered correctly on various forest ecology questions 80% of the time.
- In 2007, the Northern Arizona University's Ecological Restoration Institute commissioned a study to evaluate the collaboration effort of the Project and its monitoring and management approaches. Key findings include: 1) communities can play indispensible roles in preparing National Forests for stewardship projects; 2) there may be a need to structure stewardship contracts on a socially-defined "zone of agreement;" and 3) a collaborative framework can address challenges and opportunities as they arise. The report found that forest stakeholders in the White Mountains region were able to "transition from stalemate to stewardship," providing a model for increasing the scale of forest restoration.

Recommendations

- Develop a social assessment for the latter half of the Project period (2013-2014) using the baseline assessment questions for comparative purposes and including questions specific to the Project to obtain some level of understanding of public perception of the Project.



What Have We Learned?

The first five years of the Project have been a time of learning, experimenting, and building trust among stakeholders, businesses, and forest managers. The Project illustrates how a National Forest can receive input from stakeholders and incorporate changes into future projects; this is exemplified by the incorporation of a wildlife habitat-based prescription to test its ability to meet ecologically-based objectives while simultaneously reducing the potential for active or passive crown fire in treated areas. While the Project demonstrates adaptive management, monitoring should be improved to include a better level of specificity to measure outcomes and to trigger management changes.

The White Mountain Stewardship Project has demonstrated that an investment by the federal government to provide a ten-year supply of wood fiber to the private market has encouraged investment by businesses in the wood products industry. This public-private partnership has helped to add value to small-diameter wood products, increase employment opportunities in rural communities, and boost local economies. More work is needed, however, to develop a sustainable forest-based economy, particularly for currently under-utilized fiber, such as biomass.

The White Mountain Stewardship Project has confirmed the hope held by many that by working together, those with different perspectives can find common ground, achieve shared goals, and ensure that their efforts benefit the communities and wildlife that depend on a healthy forest environment.

The Next Five Years

In the next five years, the Multi-Party Monitoring Board will evaluate and refine its monitoring program and tailor data collection to meet specific information needs and to fill data gaps. We will continue to build on the use of monitoring data to improve planning and treatment designs and project layout. Lastly, we will share lessons learned with other collaborative projects to further forest restoration across the nation.

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List of Abbreviations

AGFD = Arizona Game and Fish Department
ARRA = American Reinvestment and Recovery Act
ASNF = Apache-Sitgreaves National Forests
BA = Basal area (square footage of stems per acre)
BBSA = Black Bear Study Area
BIA = Bureau of Indian Affairs
Board = Multi-Party Monitoring Board
CSE = Common Stand Exam
CI = Confidence Interval
DBH or dbh = Diameter at Breast Height (tree measurement)
ERI = Ecological Restoration Institute at Northern Arizona University
FA = Foraging Area for northern goshawk
FAIR = Fort Apache Indian Reservation
GAO = Government Accountability Office
GIS = Geographic Information System
GPS = Global Positioning System
ha = hectare (equivalent to 2.47 acres)
kPa = kilopascals (measurement of pressure)
LMP = Land Management Plan
MRNG = Management Recommendations for the Northern Goshawk technical report RM-217
NAICS = North American Industry Classification System
NEPA = National Environmental Policy Act
NRWG = Natural Resources Working Group
PFA = Post-family Fledging Area (northern goshawk territory)
Project = White Mountain Stewardship Project (when in uppercase)
SE = Standard Error
SD = Standard Deviation
SWMP = Snowflake White Mountain Power Company
TNC = The Nature Conservancy
USGS = United States Geological Survey
USFS = United States Forest Service
WMAT = White Mountain Apache Tribe
WUI = Wildland Urban Interface

Report Organization

This report is divided into seven primary parts:

1) Preface, Executive Summary, and Introduction
2) Administrative Monitoring Results
3) Ecological Monitoring Results
4) Economic Monitoring Results
5) Social Monitoring Results
6) Project Evaluation
7) Appendices

In each section or sub-section, you will find a light green box with a short overview of the section, followed by a darker green box with monitoring questions pertaining to that section with brief answers to those questions. These shorter descriptions are intended to introduce the reader to the section and provide a brief synopsis of the results. Following these overviews, each section then describes the analysis methods, results, and discussion of that analysis. Additional information, data, and more technical methods of how these analyses were completed are available in the appendices.

This report, along with any supplemental information and original source documents, is available on the Apache-Sitgreaves National Forests White Mountain Stewardship Project Monitoring Board's website:

http://www.fs.fed.us/r3/asnf/stewardship/multi-party-monitoring.shtml

Hereafter, the Report refers to this as the Board's website.

Stewardship Contracting and the White Mountain Stewardship Project

Overview: Stewardship contracting is an administrative tool authorized by Congress for federal agencies to use for trading "goods for services" (Public Law 108-7). For several years, small stewardship contracts were implemented across the United States to test the validity of this contracting mechanism. Recognizing that guaranteeing a long-term supply of wood could spur private businesses into building a demand for small-diameter trees, thus reducing the overall cost per acre of treatment, in 2003, Congress authorized the use of stewardship contracts for up to ten years per contract. Embedded within this authorization language was the directive for the contracting agency (i.e., U.S. Forest Service) to establish and oversee a "Multi-Party Monitoring Board" to represent a collaborative effort that includes stakeholders in monitoring the stewardship contract projects.

In 2004, the Apache-Sitgreaves National Forests (ASNF) initiated the nation's first ten-year stewardship contract, called the White Mountain Stewardship Project (Project). The Project was intended to remove primarily small diameter trees in an effort to reduce uncharacteristic wildfires around communities. Other resource benefits and treatment outside of immediate urban boundaries were included, but the primary focus was to improve the ability to manage fire on the landscape.

The Project's objectives were to achieve approximately 150,000 acres of treatments over the ten-year contract period, treating up to 15,000 acres per year, as feasible. The Project has been implemented for five of the ten-year contract cycle. This report is intended to evaluate monitoring data collected in the first five years of the Project, with the goal of providing a single-source review of the Project's collaborative monitoring effort.

Stewardship Contracts

The use of stewardship contracts to address forest management has a history dating back to the mid-1990's. The term "stewardship contract" evolved from multiple terminologies associated with land management, including "end-results" and "goods for services." Such contracts were meant to save public funds by consolidating various forest treatments into one contract where costs could then be offset by the value of the material harvested (Ringgold and Mitsos 1996). Initially developed to facilitate timber management activities, such contracts evolved to include wildlife management objectives, soil conservation practices, and other resource activities. The term "stewardship" was then used as a result of this evolution. Several pilot projects were developed in the 1990's to test and apply this mechanism, now known as stewardship contracts, to demonstrate their value and usefulness (Pinchot Institute for Conservation 2008).

Most stewardship contract demonstration projects at the time were funded by Congressional appropriations, and it was Congress, in 2003, that authorized the use of stewardship contracts by the federal government for up to ten years (Pinchot Institute for Conservation 2008). This authorization allowed federal agencies to enter into long-term partnerships that could guarantee a wood supply from public forests in order to facilitate and encourage private investment in appropriate wood-product businesses, with the anticipation that increased private investment would decrease the amount of public funds used to manage forests and, simultaneously, restore forest health. The evolution of stewardship contracts into a long-term administrative tool for federal agencies coincided with the nation's experience of several large wildfires that burned in Arizona, Colorado, Montana, New Mexico, and Oregon. Stewardship contracts were anticipated to be a highly-used mechanism to address the problem of forests densely stocked with small-diameter trees to reduce the risk of wildfires and associated effects on the forest and within adjacent communities.

The Apache-Sitgreaves National Forests (ASNF) was the first National Forest to utilize the authority for a ten-year stewardship contract. This contract, referred to as the White Mountain Stewardship Project (Project), has been a learning experience for ASNF staff, interested stakeholders, the contractor, the U.S. Forest Service (USFS) agency as a whole, as well as the U.S. Congress. While this report focuses on analyzing data to answer the Project's Multi-Party Monitoring Board's (Board) priority monitoring questions, stewardship contracting, as a program authorized by Congress, has been monitored and evaluated extensively by the Pinchot Institute for Conservation (www.pinchot.org). Several reports are available that provide additional insights on stewardship contracting in general. We encourage readers to review the Pinchot reports for additional information.

White Mountain Stewardship Project

The ASNF comprises a portion of the largest contiguous ponderosa pine (*Pinus ponderosa*) forest in the world. Decades of fire exclusion and suppression, livestock grazing, and industrial timber harvesting resulted in a forest structure that is dramatically different from that recorded by European settlers

(Covington et al. 1997; Allen et al. 2002; Covington 2003). The historic ponderosa pine forest was generally described as an open forest, with small groups, or clumps, of large, mature trees interspersed with grassy openings (Cooper 1960; White 1985; Covington and Moore 1994; Covington 2003; Sánchez Meador 2009). Low-intensity surface fires occurred approximately every two to 25 years, burning herbaceous ground cover, limiting pine seedling establishment, and invigorating mid-story shrubs and understory plant growth (Covington et al. 1997; Covington 2003). The ponderosa's thick, platy bark withstood these fires, and contributed to trees that surpass centuries in age and could measure over 60" in diameter (Covington 2003). This open structure was maintained as a result of naturally-occurring and sometimes human-induced fires, in addition to localized competition among plants, insect outbreaks, and wind throw (Cooper 1960; Allen et al. 2002; Covington 2003).

The fire regimes in the Southwest were disrupted by fire exclusion in the 1800's. The increase in livestock grazing in the late 1800's removed much of the herbaceous layer (Harrington and Sackett 1988; Allen et al. 2002). The advent of active fire suppression in the early 1900's completely removed the role fire plays in this ecosystem as a natural process (Covington 2003). Selective large-tree harvesting removed many of the most fire-resistant trees (Allen et al. 2002). Regeneration in the Southwest often occurs in pulses, such as in 1919, when wet and warm conditions favored above average seed germination and seedling survival across the region, producing trees that are, in part, the focus of current treatments (Swetnam and Betancourt 1998; Allen et al. 2002). In combination, these activities modified the landscape to allow the continued growth and rapid expansion of pine regeneration (Covington and Moore 1994; Covington et al. 1997; Allen et al. 2002). Decades after these management actions, the forest structure has been altered. Smaller-diameter trees, mostly those in the 6 – 12" diameter category, blanket the forest. Competition for water and other resources from these small trees impact the health of the remaining larger trees (Covington et al. 1997). Forests that were once characterized by 8 – 51 trees per acre now averaged more than 1,000 trees per acre (Allen et al. 2002). These current forest conditions destabilized the overall resiliency of the forest, making it more vulnerable to large, high-intensity wildfires (Covington et al. 1997; Allen et al. 2002). Natural or human-induced fires now have the potential to be shifted from smaller trees into the tallest tree canopies, creating large areas of tree mortality.

An extreme representation of this change in fire behavior occurred in June 2002. The Rodeo-Chediski wildfire complex burned 469,000 acres on National Forest, Fort Apache Indian Reservation (FAIR), and private lands. In some areas (27% of National Forest and private lands within the burn perimeter; Subirge and Lovely 2003), 100% mortality of vegetation occurred, leaving soils at high risk of erosion and stream drainages exposed and vulnerable to extreme floods from precipitation events.

Recognizing the need to address the build-up of fuels such as small trees and brush, the ASNF evaluated the applicability and usefulness of initiating a long-term, ten-year stewardship contract, the administrative option recently authorized by Congress. A long-term contract has many advantages:

- Such a contract could guarantee a level of product supply to spur investment in the private sector wood-product industry, thereby, over time, increasing economic benefits in the business sector while simultaneously reducing federal government costs;
- A long-term contract could ensure that a larger number of acres would be treated, with concomitant reductions in potential fire behavior to both adjacent urban communities and wildland resources;
- Long-term business investment could help provide jobs to rural communities;
- Ecological benefits from fuel removal could be realized, such as improvements to some wildlife habitat parameters; improved water infiltration and groundwater retention from an increase in production of herbaceous groundcover and reduced competition for water from highly-dense forest stands; and a reduction in the risk of uncharacteristic, high-severity wildfire across the landscape.
- The successful bidder for the contract is evaluated on several factors, only one of which is "lowest cost." This process of evaluation, known as "best-value contracting," allows decision-makers to also include past performance, workforce development potential, and other factors in their selection process.

However, stewardship contracts came with risks:

- This administrative tool had never before been used by the USFS for a ten-year project; outcomes, challenges, costs, and processes were uncertain;
- Annual funds for this long-term contract were not appropriated by Congress, nor provided as funds above and beyond normal USFS budgets. Payment for services was to be included within Regional budgets, which inherently meant that some internal budget re-alignment would occur, potentially impacting other programs and projects;
- Project planning under the National Environmental Policy Act (NEPA) carried risks of lengthy approval processes, which could stall the ability for the ASNF to provide contracted acreage;
- One million dollars was required to be set aside as a "contingency clause," unavailable for any projects; and
- Internal administration processes for large stewardship contracts were largely untested and unfamiliar to staff.

After a thorough internal review and external bidding process, in August 2004, the ASNF initiated a ten-year stewardship contract with an independent business, Future Forests, LLC, a partnership between a harvesting operator (Walker Brothers Contracting) and a wood pellet manufacturer, Forest Energy. The contract emphasized thinning primarily small-diameter ponderosa pine trees in both the wildland-urban interface (WUI) and interior forest, emphasizing WUI zones surrounding several communities in the White Mountains of Arizona. Other stewardship objectives within the Project could include treatment of existing slash and dead trees; erosion control; resource protection; road maintenance; wildlife habitat treatments; and biomass management. While the ASNF, the contractor, and the Board support maximizing the number of acres to be treated annually, the contract mandates a minimum of 5,000 acres to be offered to the contractor per year.

In 2004, the ASNF had slightly over 30,000 acres that had completed the NEPA process that were ready for the Project. Continuous planning efforts by ASNF staff have maintained the availability of NEPA-completed projects to satisfy the acreage requirements of the contract over the duration of the Project thus far. The use of the Sitgreaves and Apache Community Wildfire Protection Plans aided ASNF staff in prioritizing planning areas for the Project. At the time the contract was being developed, the Forest Supervisor made public statements that to provide an available cycle of NEPA-ready projects to meet the 5,000-acre contract guarantee with minimal controversy, the Forest would develop and analyze treatments that generally focused on trees less than 16" diameter at breast height (dbh; *E. Zieroth, communication to the Board*). It was believed that focusing on small trees would address much of the forest health and fire concerns while simultaneously addressing social concerns and allowing for mechanical treatments to begin across the landscape.

Current Progress

The Project has been in effect since August 2004, and is scheduled to terminate in August 2014. To date, 49,719 acres have been awarded under multiple task orders for project areas distributed across the Sitgreaves National Forest and the northern half of the Apache National Forest, in four Districts (Alpine, Black Mesa, Lakeside, and Springerville). Of those 49,719 acres awarded, 35,166 have been treated as of April 2010, with the remaining acres still in progress. Upon completion of the task orders awarded to date, over 1,700,205 tons of small-diameter trees will have been treated; approximately 60% is comprised of saw logs and small-diameter trees that are processed into various products and slightly over 40% is comprised of residual matter from treatments, such as small stems, limbs, needles, and other waste material (*J. Drury and R. Taylor, personal communication*). Table 1 illustrates the general categories of wood product utilization under the Project.

The majority of these treated acres have been located adjacent to communities within the White Mountains to reduce the potential for active or passive crown fires in the WUI. Several thousand acres have been treated in non-WUI areas, providing additional protection to smaller, unincorporated populated areas; National Forest infrastructure (i.e., campgrounds, high-use recreation areas); and wildland areas for the benefit of multiple resource objectives, such as wildlife habitat and watershed improvement. Table 2 summarizes the communities,

Table 1. Fiber class percentages of all wood volume harvested and general uses for wood from the White Mountain Stewardship Project, 2004-2009

Fiber Class / Dimension	General Uses	Percent
Merchantable non-sawtimber logs or roundwood (5" – 8.9" diameter)	Electrical generation, pellets, pallets, other small-dimension wood products	30%
Merchantable stemwood (9" – 11.9" diameter)	Electrical generation, pellets, pallets, other small-dimension wood products	25%
Merchantable stemwood (> 12" diameter)	Dimensional lumber, pellets, pallets, other wood products	4%
Residue from all above merchantable and pulpwood (< 4.9" diameter)	Electrical generation	41%

unincorporated areas, and infrastructure benefitting from targeted fire and fuels reduction treatment thus far (2004-2009); currently under treatment (2009-2010) and projected for the remainder of the contract (2011-2014). Appendix A depicts a map of the Project's analysis areas.

The Project has consistently exceeded its 5,000-acre per year contract minimum. The environmental analysis process has kept pace with the contract demands to this point. Demand for wood fiber from the Project is increasing (*D. Walker, personal communication*); the ASNF is anticipating the need for increased environmental analysis and site preparation activities. Three large areas are currently slated for inclusion in the Project: Rim Lakes (Black Mesa Ranger District; 27,000 acres) should become available for inclusion after a decision due in 2010; Beaver Creek (Alpine Ranger District; 27,000 acres) and Timber Mesa (Lakeside Ranger District; 20,000 – 30,000 acres) are in the beginning planning phase, with decisions anticipated within the next two years.

Table 2. Communities, unincorporated areas, and National Forest infrastructure benefitting from treatments occurring under the White Mountain Stewardship Project; completed (2004-2009), current (2009-2010), and projected (2010-2014)

Areas	Project	Project acres
Completed Activities, 2004-2009		
Community		
Alpine	Alpine WUI (Units 3, 5, 6, 7, 9)	2,810
Eagar	Eagar South	1,095
Forest Lakes	Little Springs	2,039
	Forest Lakes WUI	946
Greer	Greer (Units A, B, D)	5,853
Heber-Overgaard	Heber-Overgaard	2,632
	Brookbank	1,248
Nutrioso	Nutrioso WUI (Unit 1A)	817
Pinetop-Lakeside	Blue Ridge (Units 2A, 2B)	2,534
	Country Club Escape	915
	Camps Tatiyee/Grace	344
	Woodland Lake Park	851
Unincorporated Areas		
Hideaway	Mineral (Units A, B1, B)	3,146
	Hideaway (Unit B2)	766
Bunger's Ranch	Dutch Joe (Units A, B)	1,164
ASNF Infrastructure or Wildland		
Los Burros Campground	Los Burros (Trap)	844
Springerville District	Mineral (Unit BX)	3,208
Black Mesa	Water Springs (Unit A)	984
Green's Peak	Green's Peak	11
Current Activities, 2009-2010		
Community		
Alpine	Alpine WUI (Units 2, 4, 8)	5,533
Greer	Greer (Units C, E)	3,197
Nutrioso	Nutrioso WUI (Units 1B, 1C, 2)	5,579
Show Low	Show Low South	4,637
ASNF Infrastructure or Wildland		
Black Mesa Campgrounds	West Chevelon, Wolfe (Unit A)	1,348
Los Burros Campground	Los Burros (McKay, Butler)	1,880
Projected Treatments, 2010 – 2014		
Community		
Greater Pinetop-Lakeside area to Vernon	Timber Mesa, Vernon WUI	30,000 – 50,000*
Unincorporated Areas		
Beaverhead	Beaver Creek	27,000*
Hidden Meadows	Hall Ranch	1,750
ASNF Infrastructure or Wildland		
Woods Canyon recreation area	Rim Lakes	32,000*
Green's Peak	Green's Peak	160

**These projects are large areas that will undergo the NEPA analysis process, from which a subset of treatment acres will be identified*

Multi-Party Monitoring Board

Overview: When the White Mountain Stewardship Project was initiated, the ASNF convened the Multi-Party Monitoring Board (Board) that developed administrative, ecological, economic, and social monitoring priorities. The Board works in tandem with the ASNF to determine the impacts of the contract to ecological systems; specific wildlife species and wildlife habitat characteristics; fire behavior; jobs; treatment costs; economic benefits to local communities; social and community perspectives; and Project costs borne by the ASNF.

Establishing the Monitoring Board

Congress's authorizing language for stewardship contracts requires that the USFS solicit input on the effects of each stewardship project through a collaborative, multi-partnered effort. In particular, the authorizing language specifically states that the USFS must determine the administrative, ecological, economic, and social effects of any stewardship project through a collaborative effort made up of invited external interests. Shortly after the Project was awarded to Future Forests LLC, the ASNF convened the Board to fulfill the stewardship contract mandates to monitor the effects of the Project. The Board, currently comprised of 13 individuals representing local government entities, organizations, and individuals, was initiated in August 2004. The Board's primary objectives were two-fold:

- To work together as a group representing multiple interests to prioritize what information is desired from the monitoring effort;
- To provide input to the ASNF on Project outcomes based upon monitoring data, in order for the ASNF to incorporate input into future planning and management in an "adaptive management" cycle.

The concept of a multi-party monitoring effort assumed that a sharing of perspectives between multiple interests and stakeholders would foster understanding, incorporate monitoring results and the ever-growing body of science into planning efforts, and result in better forest management. This effort also affords an opportunity to monitor landscape level issues not covered in project level monitoring.

Budget

Each year (2004-2009), the ASNF has allocated approximately 3% of the annual Project costs to the Multi-Party Monitoring effort. Initially, the Board solicited and heard proposals for allocating the money for specific monitoring projects. They also recommended ways to accomplish Project monitoring and provided feedback for future Project monitoring expenditures. In most cases, funds for monitoring are provided directly to the ASNF for their staff to collect monitoring data. In other instances, the Board has elected to fund external parties to conduct specific monitoring activities. At times, grant funding is sought for specific projects. For more information on monitoring expenditures, please refer to the Administrative Monitoring Results section.

Administrative Process

The Board met monthly for the first year of its existence. Meetings focused on the group's responsibility to develop priority monitoring goals and indicators to measure progress toward these goals; to listen to local, statewide, and regional expert presentations on existing monitoring efforts and feedback on draft goals and indicators; and to prioritize these monitoring goals. Often, narrowing the focus of monitoring was largely due to the need to align monitoring priorities with fiscal realities.

The Board works on achieving consensus, with discussion encouraged on all topics. This Board, in general, focuses its energy on finding common ground, while simultaneously asking hard questions and seeking answers despite a potential negative outcome. Differences in opinion have been diligently worked through by all members of the Board. After five years, this Board works together as a cohesive unit to solve problems and make decisions.

After the first two years of its initiation, the Board met, and currently continues to meet, approximately every quarter, with at least one field trip to Project sites per year. Administrative support for meetings, presentations, staff assistance, and other logistics is provided by the ASNF. Initially, meeting minutes were taken by ASNF staff; after two years, this responsibility shifted to Board members. Minutes are circulated to key ASNF personnel participating in that meeting for editing and proofing, and then distributed to the Board.

Representation

The Project's Board membership is comprised of the following individuals and their affiliation:

Don Berry	Interested Citizen
Jerry Brownlow	Navajo County Board of Supervisors
Steve Campbell	University of Arizona Cooperative Extension, Navajo County
Dave Dorum	Arizona Game and Fish Department
Bruce Greco	Ecological Restoration Institute
Bill Greenwood	Town of Eagar
Dustin Sanders	Red White & Blue Realty
Steve Sims	Creative Green Homes, Inc.
Sue Sitko	The Nature Conservancy
Larry Stephenson	Eastern Arizona Counties Organization
Lorna Thurman	Life in the Forest
Bob Vahle	Arizona Wildlife Federation
Liz Wise	White Mountain Conservation League

Establishing the Monitoring Program

Upon initiation of the Project in 2004, the newly-developed Board, in cooperation with the ASNF, was tasked to develop a monitoring plan for the Project. The Board quickly learned that monitoring is not a simple process, especially monitoring a multitude of projects where changes to the landscape occur in small patches, scattered across the forest, over a ten-year period. Research indicated that very few projects similar in scope existed. In addition, the Board did not have the technical expertise to develop a statistically-sound monitoring plan.

The core of the Board's first exercise was to determine what the Board wanted to learn from these treatments; how monitoring data would be collected; who would be the party responsible for collecting the data; what the estimated cost might be; and where this monitoring would occur. In some cases, USFS-standardized protocols were used. In other instances, known experts on selected monitoring objectives were asked to review monitoring protocols. Modifications were made to protocols based upon expert input and incorporated prior to implementation. However, in the case of vegetation plot monitoring, no power analysis was conducted to ensure the design adequately included enough plots in order to extrapolate data to a stand or cut unit level. The formulation of a monitoring plan took place for each of the areas of interest to the Board (e.g., administrative, ecological, economic, and social).

Administrative Monitoring Plan

As part of the stewardship contracting authorizing language, monitoring must include tracking administrative costs of the Project. The ASNF tracks internal planning, preparation (marking, site preparation), and contract costs throughout the span of the Project. The Board prioritized the following administrative monitoring questions for the Project (Table 3).

Table 3. White Mountain Stewardship Project Administrative Monitoring Questions

Category	Question	Data gathering and analysis method(s)	Party responsible
Internal Costs	1. What are the annual internal ASNF costs for the Project?	Tracking and summarizing	ASNF
	2. What are the annual costs for monitoring the Project?	Tracking and summarizing	ASNF; Monitoring Board
Contract Costs	1. How does the U.S. Forest Service calculate contract costs?	Tracking and summarizing	ASNF
	2. Has the Project demonstrated an increase in value or in efficiency to the U.S. Forest Service?	Tracking and summarizing	ASNF
	3. How many acres have been treated per year?	Tracking and summarizing	ASNF
Stewardship Contracting	1. What are some positive aspects of stewardship contracts relating to internal administration?	Internal discussion and summarizing	ASNF
	2. What are some challenges associated with stewardship contracts relating to internal administration?	Internal discussion and summarizing	ASNF

Ecological Monitoring Plan

Ecological monitoring is the most complex aspect of monitoring the Project. To obtain information that is beyond subjective or anecdotal, enough data must be collected prior to treatment (pre-treatment), as well as multiple seasons or even years after treatment (post-treatment), to be able to fully understand effects of the treatments. Factors such as fluctuating annual weather patterns (ranging from a singular event such as a heavy late spring snowfall to long-term drought), wildlife seasonal movements or annual migration patterns, fires, and more can affect data collection from year to year; multiple years of data collection are often needed to attribute changes in a given monitored element to forest treatments. Often, that level of analysis demands a large sample size to yield statistically-significant results. In general, the more information that was needed increased the cost of obtaining that information.

To prioritize ecological monitoring questions, a sub-committee of natural resource managers from the Board met with ASNF biologists to design a multi-pronged series of monitoring activities to assess effects to ecological resources. The Board prioritized studying effects to: 1) forest vegetation composition and structure at both project and landscape levels; 2) fire behavior; 3) specific wildlife populations and habitat characteristics; and 4) soil and water quality. The sub-committee determined that obtaining data to quantify forest vegetation changes in composition and structure through the use of vegetation plots would also assist in extrapolating effects on fire behavior, and in some instances, wildlife habitat characteristics. Other monitoring projects were determined through analyzing cost effectiveness, quality of information, and capacity. As a result, the Board prioritized ecological monitoring questions for the Project (Table 4).

In most cases, data were analyzed by long-established and widely-accepted methods. In other cases, data were analyzed using new tools recently published to explore landscape level assessments through modeling. In all cases, however, data analysis techniques were vetted among internal and external experts to the extent possible. Assumptions, data gaps, and uncertainties are outlined where appropriate.

Table 4. White Mountain Stewardship Project Ecological Monitoring Questions

Category	Question	Data gathering and analysis method(s)	Party responsible
Stand Structure	1. Did forest treatments significantly reduce tree density?	Stand Exams/Live Tree Variable Plot	ASNF
	2. Did forest treatments significantly alter canopy cover?	Stand Exams/Canopy Cover Transect	ASNF
	3. Did forest treatments significantly alter snag density?	Stand Exams/Snag Fixed Plot	ASNF
Understory Community	1. Did forest treatments significantly alter community composition?	Daubenmire Plots	ASNF
	2. Did forest treatments significantly alter understory percent cover?	Daubenmire Plots	ASNF
Fire Behavior	1. Did forest treatments significantly reduce the threat of uncharacteristic high-severity wildfire?	Stand Exams/FVS/Flammap	ASNF / USFS
	2. Did forest treatments significantly reduce crown bulk density?	Stand Exams/FVS	ASNF / USFS
	3. Did forest treatments significantly alter height to live crown?	Stand Exams/FVS	ASNF / USFS
	4. Did forest treatments significantly reduce fuel loading?	Stand Exams/Flammap	ASNF / USFS
Forest Landscape	1. Are remaining trees aggregated or randomly dispersed across project area?	Ripley's K Spatial Test	TNC / Experts
	2. Did forest treatments increase structural heterogeneity across the forest?	Ripley's K Spatial Test	TNC / Experts
	3. Are patches of dense forests connected?	Patch Morph Connectivity Analysis	TNC / Experts
	4. Are patches of open forests or pine savannahs connected?	Patch Morph Connectivity Analysis	TNC / Experts
Avian Community	1. Did forest treatments significantly alter avian composition?	Songbird Surveys/DISTANCE Program	ASNF / TNC
	2. Did forest treatments significantly alter avian density?	Songbird Surveys/DISTANCE Program	ASNF / TNC
	3. Did forest treatments significantly alter avian diversity indices?	Songbird Surveys/ "Estimate S" Program	ASNF / TNC
Black Bears	1. Did forest treatments significantly alter bear movement?	Black Bear Spatial Ecology	AGFD
	2. Do bears avoid or prefer treated areas?	Black Bear Spatial Ecology	AGFD
	3. Is bear movement correlated with topographic features or forest attributes?	Black Bear Spatial Ecology	AGFD
Soil Compaction	1. Did forest treatments result in compacted soil?	Soil Compaction Study	ASNF
Best Management Practices (BMPs)	1. Did contractors adhere to Best Management Practices?	Best Management Practices Compliance Monitoring	ASNF
	2. Do Best Management Practices result in maintenance of water quality standards and guidelines?	Best Management Practices Compliance Monitoring	ASNF

Field Reviews

The ASNF and Board conducted annual field trips to both untreated and treated areas, examining project objectives and results. Input was provided as immediate feedback to Forest personnel. Experts with knowledge related to various project objectives and/or issues were invited to provide professional expertise and input. These field trips resulted in many suggestions by participants; photographs and summaries are part of the monitoring record and can be found on the Board's website. In several instances, changes in treatment prescriptions and other aspects of the Project were altered based on the feedback provided by the Board and other forest stakeholders. While this report is the first analysis of the monitoring data, some Project planning efforts have incorporated this feedback. The Eagar South Demonstration Area is the most significant example.

Eagar South Demonstration Area

In 2004, the towns of Springerville and Eagar were listed as "communities at risk" for wildfire in the Apache County Wildfire Protection Plan (Logan Simpson Design 2004). To address this risk, the ASNF developed the Eagar South Wildland Urban Interface Fuels Reduction analysis area that same year, and initiated an environmental assessment under NEPA. Management activities planned by the ASNF were guided by the ASNF Land Management Plan (LMP). The LMP directed that the ponderosa pine vegetation type within the Forest be treated under northern goshawk (*Accipiter gentilis*) guidelines based upon concepts outlined in the Management Recommendations for the Northern Goshawk in the Southwestern United States (MRNG; Reynolds et al. 1992). These management recommendations are hereafter referred to as "goshawk guidelines." However, in order to meet fire behavior reduction goals, a perceived conflict existed between the goshawk guidelines and hazardous fuels management objectives. It was perceived that meeting fire behavior objectives was incompatible with the goshawk guidelines. This project area could then be used to test goshawk guidelines for their ability to meet fire risk reduction objectives.

Based upon the NEPA decision, several silvicultural prescriptions could be implemented to meet fire and fuels risk objectives within the project's plan. Previous fuels treatment projects were reviewed to generate ideas as to how these prescriptions could be modified to also meet other resource objectives. Concurrently, stakeholder interest in modifying typical ponderosa pine fuels reduction prescriptions to encourage a more historic clumpy structure, as represented in the goshawk guidelines, was increasing. Demonstrating compatibility between the goshawk guidelines, fuels reduction, and ecologically-based forest restoration concepts became one of the goals of the USFS Southwest Region; a site to implement these concepts was then needed.

The Eagar South project was selected to demonstrate this compatibility. This project was a good candidate for a demonstration area for several reasons. The NEPA decision did not include a diameter cap on trees to be harvested, which allowed flexibility in implementing goshawk guidelines. Two northern goshawk Post-fledgling Family Areas (PFAs) were present. In addition, the original analysis included historic condition ecological forest restoration concepts in northern goshawk Foraging Areas (FAs; the largest management block for this species). Now known as the Eagar South Demonstration Area, this landscape is anticipated to provide a framework for understanding and restoring forest conditions based on historic evidence, ecological processes, and wildlife management concepts while still meeting fire and fuels reduction goals.

The Natural Resources Working Group (NRWG), a socio-political forest-stakeholder committee established in eastern Arizona in 1996, was approached to ensure that a collaborative effort to implement this project was used. The NRWG appointed several members to work with the ASNF on a separate Northern Goshawk Collaborative Interdisciplinary Working Group. This working group met several times over 2007 and 2008 to develop project monitoring goals; to better understand the MRNG guidelines and goshawk guidelines; and to provide input on prescriptions. The ASNF also approached the Board to include their input on this demonstration project. In addition, Northern Arizona University's Ecological Restoration Institute (ERI) became involved in the project and set up vegetation monitoring plots to demonstrate the restoration of this area to historic reference conditions.

The primary management objective under the goshawk guidelines was to create a mosaic of age and structural classes of trees across the landscape in order to provide a diverse habitat for the prey species of the northern goshawk. This required that stands be managed to provide for the desired representation of groups of differing age-classes (uneven-aged forest management). Interpretation of these guidelines differed amongst forest managers; age-class structures could be measured either at a landscape or at a stand or group level. In 2006, the USFS Southwestern Region developed workshops to obtain consistent implementation of the goshawk guidelines. These workshops included discussions with the authors of the MRNG, who indicated that management should focus on creating or maintaining uneven-aged forest structure within stands. As a result of the workshops, it was determined that age-classes and canopy cover measurements should be focused on the group level, not the previously-measured stand or project level. The goshawk guidelines specify minimum canopy cover levels within mature tree groups, but no density levels are specified for immature tree groups. With this knowledge, managers realized that the combination of mature and immature tree groups and openings between groups would result in a clumped, discontinuous arrangement of forest canopy at the stand level.

The prescriptions would create clumpy forest structure based upon pre-settlement reference conditions (when apparent and feasible). Pre-settlement evidence could be used to locate uneven-aged clumps and density of replacement trees. In stands with limited pre-settlement evidence, clumps could be designed. Openings between groups could be increased in size to decrease crown fire potential. In some cases where dwarf mistletoe infections prevented implementation of the guidelines, a different prescription would be used to address this issue.

Several field reviews were hosted for the NRWG, the collaborative workgroup, and the Board to obtain input on marking trees and designing clumps. When the Springerville Ranger District was marking trees, members of these groups participated in this effort.

Specialized Monitoring for Eagar South

This project demonstrated a different treatment scenario than most Project fuel reduction treatments; it was also the first site in the region to implement the most recent interpretation of the goshawk guidelines. Interest in determining the effects of the project was high. As a part of the Project, monitoring would occur under the existing monitoring program (i.e., avian community, fire behavior, vegetation plot collection, black bear research). However, a separate and specialized monitoring plan was developed by the collaborative working group to enhance the Project's monitoring effort and provide answers to questions specific to the Eagar South Demonstration Area. Table 5 on this page outlines these specific questions.

To answer the above monitoring questions, the collaborative working group worked closely with the ASNF and the Board to determine which monitoring questions could be answered by the Project's overall monitoring program and which questions would need additional data. For example, avian community monitoring transects were established in the demonstration area and are included in the songbird density, diversity, and composition analyses. Fire behavior, snag density, understory vegetation, and stand structure information would be collected as part of the existing vegetation plot protocol and for the Ripley's K spatial aggregation statistical test. To determine effects on wildlife species that depend on high levels of canopy cover, the monitoring program used a wildlife habitat connectivity model for Abert's squirrel and results from the black bear research project by the Arizona Game and Fish Department (AGFD). ASNF biologists annually monitor northern goshawk nests for reproductive success and adult survivorship. In addition, the ASNF tracks internal and contract costs as well as volume removed as a part of their administrative monitoring.

Additional monitoring was then needed to answer the specialized questions developed for the demonstration area. The AGFD was approached to assist in small mammal research; a project was designed in 2008 and initiated in 2009 that would compare population indices on eight key prey species of the northern goshawk between treated and untreated areas. ASNF silviculture staff quantified large-tree removal and layout and marking costs. Results of this project-specific monitoring effort are included in the Ecological Monitoring section.

Table 5. Monitoring questions developed specific to the Eagar South Demonstration Area

Category	Question	Data gathering and analysis method(s)	Party responsible
ECOLOGICAL MONITORING			
Wildlife and Wildlife Habitat	1. Did treatments improve habitat for northern goshawk prey species?	Small mammal surveys; Avian surveys	AGFD; ASNF
	2. Did northern goshawks continue to occupy existing nests in the Eagar South Demonstration Area?	Field survey	ASNF
	3. Did forest treatments impact species requiring more cover?	Black Bear research project; Patch Morph Connectivity Analysis; songbird point counts	AGFD; TNC; Experts; ASNF
Tree Removal	1. How many trees greater than 16" dbh were removed across the treatment area?	GPS all trees >16 marked GPS; number of tree harvested	ASNF
ECONOMIC MONITORING			
Internal USFS Costs	1. What was the difference in costs for treatment layout and marking time between Eagar South and other fuel reduction treatments?	Time and cost tracking	ASNF
Product and Utilization Value	1. Was the volume of material removed different from other Project treatments?	Contract oversight; volume calculations and payments	ASNF
	2. Were treatment costs different for the contractor than other Project treatments?	Contract oversight; payments	ASNF

Economic Monitoring Plan

One of the objectives of all National Forest management across the country is to work in tandem with appropriately-scaled private industry to help especially rural communities adjacent to these public lands derive some level of economic benefit from the multiple use of Forest resources. The realization of economic benefits was a Project objective. Stewardship contracting language authorizing a ten-year contract cycle was developed in part for the purpose of helping facilitate private businesses to create a sustainable wood product industry in order to decrease the overall cost of treatment. The Board prioritized economic questions for the Project (Table 6).

The Board determined that annual surveys by an outside contractor with experience in economic analyses, rural economics, and "cluster" economies would be the most efficient means of responding to most of the above questions. An expanded perspective of the Project's impact on the regional tax base, including sales tax, school funding, and property taxes was developed by the Northland Pioneer College's Small Business Development Center.

Table 6. White Mountain Stewardship Project Economic Monitoring Questions

Category	Question	Data gathering and analysis method(s)	Party responsible
Local Business Capacity	1. How many wood-product businesses are directly involved, through either purchasing or processing, material from the Project?	Annual survey by contractor	University of Arizona / Private Contractor
	2. Where are these firms located?	Annual survey by contractor	University of Arizona / Private Contractor
	3. What is the effect of local expenditures for Project expenses in the community?	Annual survey by contractor	University of Arizona / Private Contractor
	4. What are the opportunities to keep Project expenditures within the local communities?	Annual survey by contractor	University of Arizona / Private Contractor
Employment	1. How many jobs within these firms are tied directly to the Project?	Annual survey by contractor	University of Arizona / Private Contractor
	2. How many jobs rely on exporting produced goods, thereby bringing "new" money into the region?	Annual survey by contractor	University of Arizona / Private Contractor
	3. Given a multiplier effect, how many total jobs in the region can be attributed to the Project?	Annual survey by contractor	University of Arizona / Private Contractor
	4. Do employees live where they work? If not, which local communities benefit the most from the Project?	Annual survey by contractor	University of Arizona / Private Contractor
Contribution to Regional Tax Base	1. What is the overall value of the Project (including multiplied effects) to the general tax base of the region?	Economic Analysis	Small Business Development Center, Northland Pioneer College

Social Monitoring Plan

Most forest managers and interested stakeholders have studied the current conditions of the forest and recognize the departure from historical conditions that have transpired in the last several decades. They understand the need for mechanical harvesting of small-diameter trees to reduce the risk of high-severity wildfires, and the need to return the forest to a condition that is resilient to low-severity surface fires. However, the 2002 Rodeo-Chediski wildfire was an alarm to the general public, and brought forward a level of social acceptance to harvesting trees that had not been present beforehand. The Board prioritized social monitoring questions for the Project (Table 7).

The Board decided that a social assessment conducted for a post-doctoral research project by Timothy W. Collins, Ph.D. in 2005 would provide good baseline data for future comparison in the latter half of the Project period. A follow-up survey is anticipated in the Project's later years. There are other indirect efforts undertaken by the Board and ASNF to increase the awareness of the Project by the general public and specific constituencies that are further described in the Social Monitoring Results.

Table 7. White Mountain Stewardship Project Social Monitoring Questions

Category	Question	Data gathering and analysis method(s)	Party responsible
Awareness and Support of Forest Restoration	1. Do people understand and support large-scale mechanical and prescribed fire treatments?	2005-2006 Navajo and Apache County Social Assessment; follow-up assessment in latter half of Project period	University Contractor
	2. Do people recognize or differentiate USFS treatments from other agency forest treatments?	2005-2006 Navajo and Apache County Social Assessment; follow-up assessment in latter half of Project period	University Contractor
	3. Are people aware of the White Mountain Stewardship Project?	Follow-up assessment in latter half of Project period	University Contractor
Perceived Wildfire Threat	1. Do people believe that forest treatments reduce the threat of wildfire?	2005-2006 Navajo and Apache County Social Assessment; follow-up assessment in latter half of Project period	University Contractor
Forest and Fire Ecology	1. Do people have an understanding of forest and fire ecology?	2005-2006 Navajo and Apache County Social Assessment; follow-up assessment in latter half of Project period	University Contractor

Administrative Monitoring Results

Overview: Administrative monitoring is largely a function of the ASNF tracking overall Project costs through internal processes. Costs of interest to the Board include preparation of projects (analysis and planning; marking trees); task order oversight (contract administration); and monitoring. Additionally, determining whether or not costs per ton were decreasing per unit over time, a measure which may indicate an increase in the value and market for wood products, is of high interest. The Board relied heavily on ASNF staff, and to a large extent the contractor, to track costs and trends over time. The Board understands that some information held by the contractor (a private business) is confidential. It should be noted, however, that the contractor has been an active partner to the Board, ASNF staff, and USFS staff at the Regional Office level, and has participated in Project monitoring.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

What are the annual internal ASNF costs for the Project?

On average, annual internal costs for managing the Project total $2,550,000, which break down into site preparation ($1,100,000); task order/contract administration ($600,000); NEPA planning ($450,000); pile burning ($250,000); and program management ($150,000).

What are the annual costs for monitoring the Project?

To date, the costs for monitoring undertaken by ASNF staff, contractors, and partners average $221,100 per year, breaking down as follows: the ASNF invests $143,900 per year for internal monitoring; two multi-year projects (black bear and northern goshawk prey) have totaled $293,000; and three one-time projects (social survey, highway signs, and this report) have totaled $93,000. Monitoring costs for the first five years of the project totaled $1,105,500.

How does the U.S. Forest Service calculate Contract Costs?

Due to the variety of stand conditions, type of material harvested on site (i.e., logs, chips), and site-specific tasks in a given task order, the ASNF calculates Project contractor payments on the estimate of tons of wood harvested per task order, with the cost of each ton based upon the type of treatment that will occur on site. Several treatment options are available, ranging from total removal of all fiber to a variety of partial-removal treatments (e.g., leave residue piles for future burning, scattering residue on site for erosion control or soil needs). Each treatment option has a set contract price per ton. The ability to increase costs for treatments, such as for cost-of-living expenses, is embedded within contract guidelines. A bi-annual cost-of-living increase of 6% can be incorporated as requested. The ability to decrease contract costs is dependent upon an audit finding of a proven increase in product or fiber values.

Has the Project demonstrated an increase in value or in efficiency to the U.S. Forest Service?

Given set contract prices, the Project can be better assessed in terms of efficiencies gained per contract dollar, or the extent to which the contractor showed a better value for contracted expenditures. Efficiencies can be generally attributed to the contractor's ability to market a diversity of low-value wood products (e.g., pulpwood, biomass residue). When fiber from a treatment area can be sold, often the contractor would implement a total removal of all wood products, including biomass residue, at a cost equivalent to a partial treatment option. As a result, the contractor removes piles of residue that would otherwise have to be burned later by ASNF staff. This example demonstrates that total removal of all fiber can be accomplished at a partial-removal rate. In addition, the contractor has requested one cost-of-living adjustment rather than the three that have been available between 2004 and 2010. This adjustment was used to offset mandatory wage increases established by the U.S. Department of Labor. With the nation's recession causing a steep decline in lumber demand and prices and an increase in fuel costs, it was anticipated that overall contract costs would increase, yet the Project demonstrated a better value to the federal government during this time period.

How many acres have been treated per year?

Acres treated per year have ranged from a low of 3,105 (2005) to a high of 8,845 (2007). In 2009, the last year of a full data set, 6,203 acres were treated. While annual contract payments have remained relatively similar for each year, annual acreage treated, as well as treatments that include total removal of all wood fiber, have generally increased.

continued on next page

What are some positive aspects of stewardship contracts relating to internal administration?

A long-term stewardship contract affords the ASNF to use task orders for each project under the umbrella contract, rather than developing and bidding out a separate contract for each project. Task orders can be created in a matter of days, while individual contracts could take two months or longer. Additionally, given the short turnaround time needed for a task order, any monies from other National Forests that have not been spent by the end of each federal fiscal year can be re-directed to the ASNF for their use on the Project. While a long-term stewardship contract could be administratively challenging to initiate, once initiated, contracts or task orders for treatments under that contract are simplified.

What are some challenges associated with stewardship contracts relating to internal administration?

Long-term stewardship contracts signify a commitment to a private contractor over the life of that contract. Projects that have been appropriately analyzed and planned under NEPA that meet contract acreage requirements must be prepared. Payment to the contractor must be incorporated within existing budgets. Each long-term stewardship contract includes a cancellation clause, requiring the set-aside of a fee by the USFS in case of contract default. In the case of this Project, the cancellation fee is one million dollars.

Analyzing Administrative Impacts

Administering a large, long-term contract is a complex process. Tasks, such as requesting and reviewing contract bids; providing wood resources through planning and site preparation; developing and overseeing multiple contracts or task orders; and overseeing and monitoring contracted activities, require adherence to federal policies, standards, and guidelines. Planning for random events must be incorporated. For example, an extremely wet season can preclude the use of mechanical equipment for an unexpected period of time, affecting the amount of acreage anticipated to be treated in a given year. Wildfires can remove NEPA-ready available acreage and create the need for more planning on a shorter timeline. Annual budgeting processes can extend beyond the beginning of a new fiscal year and provide uncertainty on what actions can be implemented. Demand for material can fluctuate due to the state of the national economy and impact what is bought and sold from the Project. Local labor shortages can affect how many acres can be treated by the contractor. These, and many other circumstances, have actually occurred throughout the duration of this Project. The commitment to the Project by ASNF and USFS staff, the contractor, and the Board has been an underlying reason why these challenges have been overcome (*D. Walker and R. Taylor, communication to Board*). Many of these challenges have likely affected the administrative process of the Project more so than the ecological, economic, or social aspects. Administration of a project with this duration and complexity should take these somewhat intangible factors into account.

To answer the Board's administrative monitoring questions, the ASNF, as the contract administrator, determined the most effective measurements to track. ASNF staff track their time, travel, and expenditures for supplies and materials through existing time and expense reporting forms.

Measuring the amount of material removed from the forest is a factor used for estimating payments to the contractor. Traditionally, timber volume has been estimated in cubic board-foot. This measurement was established when most wood harvested from National Forests was sawtimber (trees greater than 12" dbh). However, in the case of this Project, the majority of wood material anticipated to be removed was less than 12" dbh. Therefore, using cubic foot was not an appropriate measurement for Project tracking purposes. Initially, payments to the contractor were planned to be calculated on costs per acre. Given the diversity of forest stand conditions across multiple project areas, costs per acre could vary substantially. If a site has a high tree density and those trees are primarily in the smaller diameter size-class, it is more expensive in terms of operation and time to treat that site than a site with fewer, larger trees. Fluctuations in cost per acre could be impacted by which project sites are treated in a given year; arriving at a payment agreement under a ten-year scenario would be extremely difficult. After much discussion, the ASNF determined that the most consistent method to determine costs for contract payment and tracking purposes would be measuring tons treated per acre. Using a spreadsheet, the ASNF tracks contract costs and payments, the types of treatments conducted, the average tons per truckload; number of loads per task order; projects and acres treated; and type of material (e.g., merchantable wood, residue) within each ton.

Cost per ton is measured in two categories: cost per ton removed (treatment with total removal of all material) and cost per ton treated (most material is removed and sold to local forest products markets while residue is left on site according to resource needs). Several treatments that leave wood residue on site are included as options for the ASNF and contractor within the contract. Options may include piling residue for future burning by ASNF staff; "lop and scatter," where limbs and other residue material are scattered on site for erosion control or soil health purposes; or other treatments that perform additional resource objectives. Total removal generally costs more than leaving some material on site; however, costs to burn the piles and to conduct any site restoration are then borne by the ASNF staff at a later date.

Costs for these types of treatments are set at the initiation of the contract. Increasing or decreasing these costs, thereby adjusting the contract, can occur under limited circumstances. Contract costs can be increased by 6% every other year upon request by the contractor to account for cost-of-living increases. The ability to decrease contract costs is dependent upon a proven increase in wood fiber values based on an audited finding.

Evaluating advantages and challenges associated with stewardship contracts, and this Project specifically, is largely subjective and based upon the experiences of USFS staff and the contractor. Monitoring these aspects, then, largely relies on the perspectives of these individuals and the experiences, stories, and anecdotes they share. Some perspectives are based upon actual policies or limitations set within stewardship contracting language that may have been unforeseen when policies and standards were designed; some are a result of on-the-ground experiences that surface over the duration of the Project.

Results and Discussion

ASNF Internal Costs

ASNF staff, on average, spend approximately $2,550,000 per year in preparing analysis areas for treatments. In order of highest to lowest costs, this includes site marking and preparation ($1,100,000); contract oversight ($600,000); all environmental analyses under NEPA ($450,000); pile burning ($250,000); and program management ($150,000). Site preparation includes evaluating and determining road and access conditions for treatment units; conducting stand exams to estimate pre- and post-treatment conditions; developing treatment prescriptions; and marking trees for harvest (or in some cases, marking trees that are to be left). Contract oversight includes the administrative processes involved in developing and writing task orders; on-site inspections and reviews; and administering the task order or contract once completed. A NEPA analysis for a given project area includes completion of wildlife surveys, archeological review, and clearances; public scoping; and an inter-disciplinary evaluation of the proposed action and any alternatives for effects on soil, water, wildlife, air quality, economics, and other parameters. Pile burning includes preparing burn plans and on-site ignitions of residual biomass. Program management includes reporting and budget oversight of the Project and task orders at the Supervisor's Office.

Monitoring Costs

In calculating monitoring costs, the funds expended by the ASNF for internal monitoring are only one part of the entire suite of Project monitoring. Several projects are included that may have been funded by grants or other funding sources. Many monitoring activities occur every year. Some monitoring activities are special projects implemented in multi-year blocks, and there are other projects that are one-time occurrences. Table 8 breaks down these separate projects and costs; however, calculating the average cost per year for all monitoring efforts combined is a valuable exercise for future planning. Lastly, ASNF staff time used to administer Board operations (minutes, agendas, setting up meetings and speakers, planning field trips, etc.) was included.

Treatment with residue piles left for future burning

Table 8. Average annual, multi-year, and one-time monitoring costs in dollars for the White Mountain Stewardship Project, 2004-2009

Monitoring Activity	Annual Cost ($)	Multi-year Project costs, per year ($)	One-time costs ($)	Brief Description
Wildlife surveys per NEPA direction	32,200			Baseline wildlife studies; special status species surveys
Vegetation plots, Forest-wide	28,600			Permanent vegetation plots for forest structure, snag, understory composition; fire models; and wildlife habitat analyses
Songbird monitoring	35,600			Avian density, diversity, and composition
Best Management Practices/soil compaction	20,200			Water quality, erosion, and soil compaction monitoring
Annual economic analysis (contractor)	15,000			Employment and business expenditures
Monitoring Board administration	9,300			Meeting and field trip coordination
"Stakeholder's Report"	3,000			Annual newspaper insert
AGFD black bear research project		233,000 (Project length four years)		Black bear habitat use in treated areas
AGFD northern goshawk prey study		60,000 (Project length two years)		Prey studies of eight primary prey species of northern goshawk
Development of Five Year Report			80,000	Monitoring data analyses and report design
Social assessment (contractor)			10,000	Perspectives on forest management in Navajo and Apache counties
Highway signs			3,000	Project signs designed and placed along highways
Total	**143,900 per year**	**293,000**	**93,000**	
Total 2005-2009	**719,500**	**293,000**	**93,000**	
GRAND TOTAL	**1,105,500 (2005 – 2009)**			

A total of $143,900 has been spent annually on monitoring projects from Project monitoring initiation (2005) through 2009. Two multi-year projects have been initiated, with a total cost of $293,000. An additional $93,000 has been spent on one-time only costs for individual projects. If all are calculated together, monitoring for years 2005-2009 totaled $1,105,500, with an average cost of $221,100 per year.

Contract Costs and Trends

Contract payments for specific treatment tasks (e.g., total removal of all material; piling residue for future burning) have increased by one cost-of-living adjustment requested by the contractor in 2007 to offset mandatory wage increases set by the U.S. Department of Labor. Due to the complexity of conducting an audit to determine proven increase in fiber value, contract payments for specific tasks have not decreased. However, from the increase in local market development and demand for Project wood fiber and where feasible given market locations and transportation costs, the contractor charges a lower payment option (partial treatment) while conducting a total removal operation. Therefore, the USFS receives added value for the treatments, as well as not having to incur costs associated with future internal resource management, such as burning piles of residual material.

It should be noted that from 2006-2009, housing lumber market prices have declined due to the recent global recession and the associated decrease in housing demands (Bernhardt 2009), while fuel prices have increased in that same period. These factors had an impact on the degree to which markets have developed and on operational costs (*R. Davis, personal communication*); however, contract payments have remained stable. This indicates the ability of the contractor to promote and support diverse, local small-diameter wood-product markets while obtaining a higher level of efficiency in operations.

A shift in the value of residual material, comprising 41% of the fiber available across all Project treatments, occurred in late 2009. Snowflake White Mountain Power (SWMP), an electrical power generating plant, has signed a four-year contract with Future Forests, LLC to purchase treatment residue from projects occurring on the Sitgreaves portion of the ASNF that was formerly left on site in piles for future burning by the ASNF. Both the contractor and ASNF staff anticipate a continued increase in value of this residue starting in 2010. The use of biomass residue for the energy market has had the effect of helping offset the declining lumber market demand.

Advantages and Challenges of Stewardship Contracting

Administering a stewardship contract affords the opportunity to bundle several task orders under one contract. A task order is a simpler process to complete administratively, as it can be viewed as a sub-contract under one larger umbrella contract. Multiple task orders could be given to a contractor for one project analysis area. Task orders generally are allowed three years for completion. Task order contracts can be processed in a matter of days, rather than the weeks or months that individual contracts take to process. A benefit of the stewardship contract, then, is the ease in which task orders can be used to get treatments accomplished on the ground.

In addition, given the short turnaround time needed for task orders, the ASNF can obligate funds that have not been used by other National Forests, within or outside of that Forest's administrative Region, or by the agency's Washington D.C. office by the end of the federal fiscal year (September 30). If a National Forest finds they have funds remaining in their budget that were not used for some reason, they can transfer those funds to the ASNF as late as the last week in September; the ASNF can then issue a task order and obligate those funds almost immediately. In essence, while a long-term stewardship contract could be administratively cumbersome to initiate, once initiated, task orders under that contract are simplified and processed quickly and efficiently.

A long-term relationship with a contractor can also lead to reduced internal costs by allowing the contractor to work directly under "designation by prescription" or "designation by description" in certain treatment areas. These directives allow the contractor to determine which trees will be cut by using either a written prescription or a fairly simple description of treatment objectives. This allows the USFS to avoid using the labor-intensive and costly effort to mark individual trees to be removed (or left).

Much of the wood fiber harvested from the Project is considered to be of low economic value. As such, efficiency in costs, operations, and contract implementation should be maximized. A potential factor that can enhance the ability for both the contractor and the National Forest to achieve a high level of efficiency is ensuring that both parties communicate and are flexible in the preparation and implementation of each task order under the contract. The contractor often works with potential buyers of material before harvesting begins in order to bring the appropriate wood processing equipment on site. Coordination with the ASNF on equipment needs for each project helped both parties understand if equipment or processing needs were approved under any given project's environmental analysis. A constant flow of communication and flexibility on behalf of both parties helped achieve that level of efficiency.

National Forests are faced with multiple challenges in committing to a long-term stewardship contract. Administratively, stewardship contracts are not a commonly-used mechanism for forest management; they carry additional requirements such as multi-party monitoring and a "cancellation clause" whereby a portion of the total value of the contract must be budgeted and set aside on the chance that the USFS must cancel the contract. At times, this value could exceed one million dollars. Current law under Federal Acquisition Regulations dictates that each long-term contract must carry a separate cancellation fee; one pool of money for multiple contracts is not allowed by law at this time.

A long-term contract also implies that enough project sites must be appropriately analyzed under NEPA each year to provide the contractor with the agreed-upon acreage for treatment. NEPA analysis for a project site can take from six months to over two years due to multiple factors, including threatened and endangered species habitat analyses; the amount of baseline data required (stand exams, road conditions, archeological surveys as examples); vegetation diversity; and potential litigation. These factors could delay the final decision and the availability of the area for treatment.

Long-term stewardship contracts are a financial commitment by each National Forest and their Regional Office. While the use of stewardship contracts is ultimately authorized and allowed by Congress through federal law, at this time, no additional monies are appropriated (beyond demonstration projects) by Congress to carry them out. Each contract must receive the monies they need through the annual USFS budgeting process, which is set for each National Forest by its respective regional office. As a result of the Project, other resource programs on the ASNF and National Forests in Region 3 have contributed to Project costs, thereby experiencing budget decreases in their programs (*R. Taylor, personal communication*).

The Pinchot Institute for Conservation (www.pinchot.org) has been contracted by the national-level USFS office to evaluate the stewardship contracting program. Since the mid-1990's, the Pinchot Institute has evaluated stewardship contracts around the nation. Most have been small projects under 1,000 acres; the White Mountain Stewardship Project is the largest to date. The Pinchot Institute has developed several reports that analyze accomplishments, challenges, and lessons learned for stewardship contracts in several documents which are found on their web page. We encourage readers to access these reports for more information.

In addition, the Government Accountability Office (GAO) of the federal government analyzed stewardship contracts in a report entitled "Federal Land Management: Use of Stewardship Contracting is Increasing, but Agencies Could Benefit from Better Data and Contracting Strategies" (GAO 2008). This report credits stewardship contracts with allowing land managers to perform more work with less money, due to the ability to exchange goods for services. Improvements in collaboration with National Forest stakeholders are discussed. Stewardship contracts allow contractors and industries some level of guaranteed supply over time, enabling them to obtain loans and grants for equipment and other needs. The report recognizes the challenges associated with obligating funds for the cancellation fee and other perceived or real roadblocks, and concludes that federal land managing agencies (particularly the Bureau of Land Management and the USFS) have not adequately developed a long-term strategy to implement these contracts at the national level. This GAO report can be found on the Board's website.

In summary, the Project has afforded the USFS an opportunity to test the use of a ten-year stewardship contract. While there are challenges in the administrative process, the ASNF has treated nearly 40,000 acres under this contract between August 2004 and April 2010. The threat of potential passive and active crown fires has been reduced for communities adjacent to these National Forest lands for the lifespan of the treatments. Rural, economically-challenged areas have seen an average of 319 jobs created per year both directly (226) and indirectly (93) from this contract, resulting in millions of dollars in local purchases and expenditures, as well as hundreds of thousands of dollars generated in local tax revenue annually. In addition, businesses that have invested in the region due to the Project may have created a network for these wood products, which may result in a privately-funded economic niche that could help sustain future forest treatments after the termination of the Project in August 2014.

Lastly, there are intangible benefits of the Project that cannot be associated with a dollar figure. Saving costs from fighting future wildfires that might have occurred in these areas would be an exercise in speculation, but nevertheless could be considered. Additionally, benefits associated with community protection, conserving the forested environment around communities, and the increase in social trust built around this community collaborative experiment are aspects to evaluate and discuss. These overall benefits are discussed in the Project evaluation section.

Alpine Wildland-Urban Interface, two years post-treatment

Ecological Monitoring Results

Introduction to Statistical Results: Basic statistics were used to evaluate the Project's monitoring data. Basic statistics test what is known as the "null hypothesis," which asks if there is a difference between two averages or means. For several monitoring datasets, the difference between pre-treatment and post-treatment means of the ecological factor of interest was examined. To determine if these different means are significant, an "alpha level" threshold is applied. For these analyses, an alpha level of 0.05 was selected. This alpha level is commonly used in scientific research, which attempts to discern discreet changes from a robust sample size. With an alpha level set at 0.05, it means that there is a 5% chance that the observed differences in the two means tested are actually not different; or, alternatively, there is a 95% chance that the observed differences are actually different. When the pre- and post-treatment data means differ based upon this alpha level, you have a "significant difference" between the means.

When a statistical test is completed, the results include a p-value (commonly represented in the text as P = some value less than 1.0). The p-value is a measure of how much evidence you have against the null hypothesis of no difference, and represents the probability of observing the results from your sample data. The p-value, however, does not indicate the size or importance of the observed effect; it is merely the probability of that observation occurring. If no significant differences were found from the datasets, it was difficult to determine if that result was due to too few samples, or if no change actually occurred; or that changes did occur, but not at the prescribed alpha level to determine significance.

When Project monitoring was initiated, the Board did not specify the desired level of change they thought was needed to achieve their objectives for the key questions they outlined. The monitoring effort was focused on extrapolating more general trends and impacts over a larger landscape. Due to various factors, sample sizes were limited, affecting interpretation of the results.

Modifying the alpha level may lower the stringency of the test, but may still provide meaning for management purposes and interpretation of the results. Using fire behavior models as an example, we see that with an alpha level of 0.05, three out of the five project sites modeled resulted in a statistically-significant difference in crowning and torching indices. However, the model outputs in all projects indicated a net change in fire behavior from passive or active crown fire to surface fire conditions, despite not showing a statistically-significant change in these indices. If the alpha level were modified to 0.2, all project areas would show a statistically-significant difference in the crowning index. For future evaluations of monitoring data associated with the Project, it may be beneficial to explore what alpha level is appropriate and biologically relevant to the monitoring question at hand prior to the analysis phase.

Introduction to Thinning Prescriptions Implemented: Over the course of the Project's first five years, many prescriptions were implemented across the ASNF. In a cursory tally, over 75 different prescriptions were counted. It was determined that using three general categories would be most beneficial for analysis purposes: restoration, northern goshawk guidelines, and evenly-spaced treatments. Within each category there was considerable variation; for example, the evenly-spaced treatments ranged from 19' to 34' spacing, some with basal area targets, others without. Within the restoration category, some prescriptions had a restricted distance from remnant evidence to the replacement tree, while others used the remnant evidence for targeting trees per acre, with grouping replacement trees with the best or healthiest tree available. Differences within each prescription category are incorporated into some analyses as feasible.

Stand Structure and Understory Community Vegetation

Overview: Treatments within the Project vary in objectives and prescriptions. In the first three years, most forest treatment prescriptions emphasized evenly-spaced, non-connecting trees, with minimal retention of downed logs, snags, and other fuel sources in order to reduce the potential for passive or active crown fires. Feedback from stakeholders, including the Board, emphasized the desire to shift to treatments based upon general historic ponderosa pine forest conditions (groups or clumps of trees interspersed with openings) or the use of northern goshawk guidelines, which attempts to create a mosaic of stratified age-classes in clumps and groups. Understanding how the thinning prescriptions changed forest structure and understory vegetation, regardless of treatment objectives, was a key monitoring priority of the Board.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

Did forest treatments reduce tree density?

Yes. One measure of tree density commonly used is basal area (BA; square footage of stems per acre). Project treatments, regardless of prescription, reduced basal area. The Alpine WUI, Eagar South, and Mineral sites had the greatest reduction in BA, which was found to be statistically different between pre- and post-treatment conditions.

Did forest treatments alter overstory canopy cover and snag density?

Canopy cover, or the amount of land area covered by tree canopy, was also reduced at all project sites measured; however, the Eagar South and Mineral sites were the only locations with a statistically significant reduction in canopy cover. At most sites, a small sample size precluded the ability to determine the difference between treatment conditions in this highly variable ecological factor.

Snags, or standing dead trees, are a forest component that provide valuable wildlife habitat. Snag density was lower in some project areas after treatment; in some cases, significantly lower. Due to the small number of points sampled in each project area, not enough data were collected to determine which factors most influenced the reduction in snag density. It does not appear that any one treatment prescription impacts snags more than any other. However, snags may have been negatively affected by treatments, either directly through prescriptions or inadvertently due to mechanical equipment operation. This report recommends that modifications be made to the current vegetation plot protocol to improve snag density monitoring to better understand the mechanism behind their loss.

Did forest treatments alter understory community composition and percent cover?

Species-specific information will be assessed during the Project's tenth year to allow a longer period for growth and recovery and to include the affects of prescribed fire. General cover categories (bare ground, litter, grasses, forbs, and coarse woody debris) were assessed to determine the impacts of forest treatments on the understory community. Percent cover of grasses declined post-treatment at Alpine WUI and Mineral, but they were not found to be significantly different between sample periods. There was a statistically significant increase in grasses and forbs at Greer and a significant increase in total vegetative cover at Brookbank and Forest Lakes. Combined, the data collected to evaluate changes in understory cover have identified a minor trend toward recovery.

Analyzing Stand Structure and Understory Community Vegetation

A major emphasis in the Project monitoring effort was to determine changes in forest structure and understory vegetation. Vegetation changes were a key component of the monitoring program because of the implications for exotic species introduction, fire behavior, grazing, recreation, understory diversity, and wildlife habitat. A vegetation plot protocol was developed and implemented beginning in 2004, described in Appendix B. Trees were measured on variable-radius plots; understory and canopy cover were measured along transects. These data were used to identify trends in understory recovery after thinning treatments, as well as to inform wildlife connectivity and fire behavior models. Under the protocol, vegetation data were measured at permanent plots stratified by forest type, in a rotating manner, with data collected at each plot prior to treatment and three and ten years post-treatment. New plots were initiated every year, and in some cases, certain plots were revisited more frequently. Control plots were included for comparison purposes.

Data collected at these plots include trees per acre in three different size classes, basal area, canopy cover, snags per acre, fuel loads, and downed wood. This plot protocol also provided information on the understory vegetation community, which was used to test the hypothesis that a reduction in tree density and overstory canopy would open the forest floor to sunlight and more precipitation infiltration, therefore resulting in increased herbaceous groundcover. Vegetation data collected at these plots were summarized and analyzed as part of the fire behavior modeling process. Six project sites were analyzed for the fire behavior model; hence, these six sites were evaluated for vegetation changes after treatments.

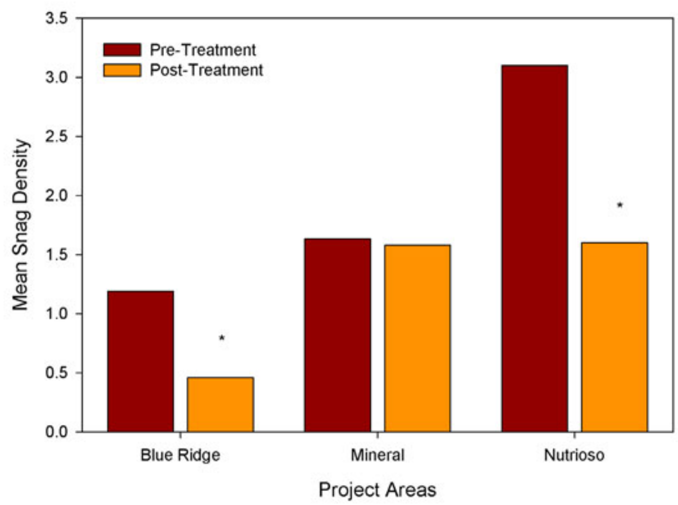
Results and Discussion

Basal area was measured at five project areas (Alpine WUI, Eagar South, Greer, Forest Lakes, and Mineral). At all sites, basal area was reduced, ranging from a 22% to 63% reduction. Alpine WUI, Eagar South, and Mineral were found to have a statistically-significant reduction in basal area measured between pre- and post-treatment periods. Canopy cover was measured at these same sites. A reduction in canopy cover was shown in the post-treatment period across all areas modeled, and the reduction ranged from 23% to 50%. Eagar South and Mineral, however, were the only sites that had a statistically significant difference.

A total of 167 permanent plots were sampled for snags in both the pre- and post-treatment period thus far. Project areas where post-treatment surveys were completed included the Alpine WUI, Blue Ridge, Brookbank, Forest Lakes, Greer, Mineral, and Nutrioso. Each project area was analyzed separately to account for variation across the forest. There was no significant difference between snag density on permanent sampling plots pre- and post- treatment for Brookbank ($P = 1.0$), Forest Lakes ($P = 0.11$), Greer ($P = 0.25$), and Mineral ($P = 0.96$). There was a significant reduction in snag density measured at permanent sampling plots at Alpine WUI ($P = 0.02$), Blue Ridge ($P < 0.001$), and Nutrioso ($P = 0.03$).

Snags are an important habitat characteristic for many wildlife species, including songbirds, raptors, bats, and small mammals. Previous research has shown that there are fewer snags on the landscape than the target density in Forest Service management documents (Ganey 1999). Therefore, the implementation of forest treatments that remove this habitat resource, directly or indirectly, requires continued monitoring. For most treatments, the desired result was no change in snag densities from the pre-treatment to the post-treatment period. From the analysis of these data, we found that there was a trend in snag reduction over the course of treatment implementation. It is unclear at this time the reasons behind this decline. We recommend that additional data collection associated with snag densities be implemented to track these changes in future treatments to better understand the mechanism leading to their reduction, and to make changes to future prescriptions to help retain these habitat features at higher densities.

Figure 2. Mean snag density (snags per acre) changes in pre- and post-treatment conditions for permanent plots sampled at three project areas in the White Mountain Stewardship Project



*Indicates statistical significance

Illustration of loss of a snag between pre- and post-treatment conditions

Pre-treatment

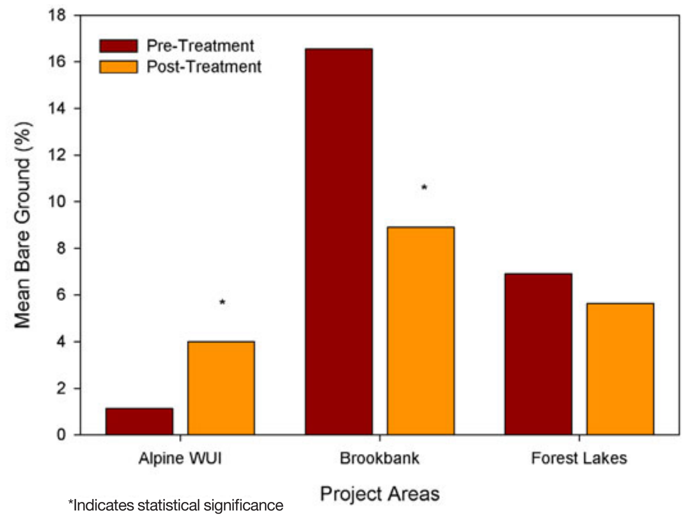
Post-treatment

The analysis of fixed-radius permanent plot snag densities only represents a small portion of the treated areas; not enough plots were included in the study design to extrapolate results across all areas treated. Snags, especially larger snags (dbh > 16"), occur infrequently across the landscape. Measuring snag density can be difficult because of their rarity. These results cannot be attributed to any particular prescription or set of prescriptions implemented. Additional specialized sampling focused in specific treatment areas would be needed in order to determine causes for these declines.

A total of 88 surface cover transects were sampled in both pre- and post-treatment conditions. Project areas that had post-treatment data available included Alpine WUI ($n = 21$), Brookbank ($n = 11$), Forest Lakes ($n = 11$), Greer ($n = 16$), Mineral ($n = 19$), and Nutrioso ($n = 10$). Categories of surface cover analyzed include forbs, grass, bare ground, litter, wood, and total vegetative cover. At Brookbank and Forest Lakes, data were not collected in categories as specific as grass and forbs, but lumped together in a "vegetation" category. Therefore, analyses for these two project areas do not contain results specific to grass and forbs, only total vegetative cover.

No statistically significant difference in pre- and post-treatment percent cover of forbs was found at Alpine WUI ($P = 0.12$), Mineral ($P = 0.54$), and Nutrioso ($P = 0.94$). However, a statistically significant increase occurred in forb cover at Greer ($P < 0.01$). Similarly, there was no statistically significant change in grass cover at Alpine WUI ($P = 0.63$), Mineral ($P = 0.20$), and Nutrioso ($P = 0.51$). There was also a statistically significant increase in grass cover at Greer ($P = 0.02$). A statistically significant increase in vegetative cover was observed at Brookbank ($P < 0.01$) and Forest Lakes ($P = 0.02$). There was a statistically significant increase in the bare ground cover class at Alpine WUI ($P = 0.03$), but no difference in the bare ground cover class at Forest Lakes ($P = 0.69$), Greer ($P = 0.50$), Mineral ($P = 0.42$), and Nutrioso ($P = 0.47$). A statistically significant decrease occurred in bare ground at Brookbank ($P < 0.01$). There were no statistically significant changes in the percent cover of litter or wood pre- to post-treatment at any of the project areas, except for an increase in litter at Alpine WUI ($P = 0.02$).

Figure 3. Mean bare ground (%) changes in pre- and post-treatment conditions for permanent point-intercept transects sampled at three project areas in the White Mountain Stewardship Project



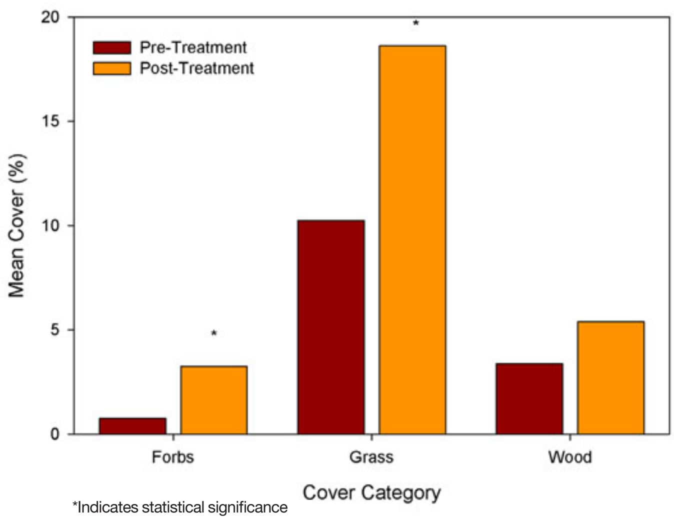
Understory measurements were taken three years after treatments were implemented to allow the forest understory time to recover after mechanical treatments and to provide at least one growing season of recovery. Even with several years of recovery time, there were few changes in understory vegetation cover. The Board had hypothesized that by opening up the canopy, the understory would respond to increased light and potential water availability. Nonetheless, fire plays a key role in ponderosa pine systems and has been shown to promote understory vegetation growth (Korb and Springer 2003). Many of these sites have not yet

Calculating basal area with prism

received broadcast burning as a treatment, which will likely help increase grass cover as these sites recover.

These analyses, however, provide some insight as to the trend in how the understory community has begun to recover. To date, the Greer project area was the only area to see a significant increase in both grass and forb cover. Bare ground was the other cover class that appears to be most affected by forest treatments. In several areas, there was no change in the percent bare ground along the transects; however, the Alpine WUI area had a significant increase and the Brookbank project area had a significant decrease in the percent bare ground cover. Because of the limited sample size in each project area, it is difficult to infer the mechanism driving these changes in cover. It is recommended that future transects focus on a specific prescription or project area to improve our understanding of how various treatments impact understory cover. Another confounding factor was that these measurements were recorded on permanent transects that were not monumented on both ends making it difficult for field technicians to record data in the exact location in re-measurement periods, introducing sampling error.

Figure 4. Mean forb, grass, and wood cover (%) changes in pre- and post-treatment conditions for permanent point-intercept transects sampled at the Greer project area in the White Mountain Stewardship Project



*Indicates statistical significance

Acorn woodpecker food cache in snag

Illustration of minimal change observed in ground cover post-treatment

Pre-treatment

Post-treatment

Fire Behavior

Overview: Forest ecologists understand that fire, as it occurred historically in ponderosa pine forests, is a natural ecological process that rejuvenates the herbaceous, shrub, and soil layers; thins dense, small trees; and provides the tree spacing and openings important to wildlife, water infiltration, and plant growth. Modifying current forest conditions to enable future fire use and to return these areas to their natural fire regime was a primary goal of the Project. Understanding how fire behavior could be modified by forest treatments was a high priority monitoring objective for the ASNF and the Board. The use of fire models helps inform managers if treatments achieved their fire and fuels objectives, and to what degree treatments were successful in reducing certain fire patterns and behaviors. Tree densities, canopy cover, downed woody material, basal area, and other information gleaned from the vegetation plots and information from Geographic Information System (GIS) spatial layers were incorporated into fire models in order to predict potential post-treatment fire behavior.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

Did forest treatments impact potential fire behavior (crowning and torching indices)?

Fire behavior characteristics were assessed by torching and crowning indices. The values indicate the wind speed 20 feet above the ground that would cause a fire to torch or crown. As the index value increases, it shows that it would take a greater wind speed to induce torching and crowning fire events. At all sites evaluated, both indices were higher post treatment, indicating that the potential for passive or active fire behavior has been reduced due to forest treatments. However, Alpine WUI, Eagar South, and Mineral were the only sites to show a statistically significant difference in torching and crowning indices. Statistical testing is only one way to judge whether the treatments implemented achieved the objectives of the ASNF or the Board. No quantitative measures were set by the Board when the monitoring plan was developed to assess if treatments achieved their objectives. This was true for all ecological factors monitored, but became noticeably absent while interpreting the fire modeling results.

Did forest treatments reduce crown bulk density and fuel loading?

Crown bulk density is a measure of canopy volume and provides information for fire behavior models regarding canopy fuels. Ground-based fuels were also measured using a planar transect. Forest treatments implemented by the Project reduced crown bulk density at all sites; however, reductions were only statistically significant at three of the five sites measured. Eagar South and Forest Lakes also had a significant decrease in fuel loads measured during the post-treatment period.

Did forest treatments increase height to live crown?

The height to live crown measurement is the distance from the ground to the lowest living branch. This measure is important because this is generally how fire "climbs the ladder" of fuels into the forest canopy. The higher the height to live crown, the lower the likelihood of a fire reaching the canopy. Forest treatments increased the height to live crown at all sites. However, only half of the sites measured showed a statistically significant difference.

Natural History of Fire

Fire has been a naturally occurring process in northern Arizona forests for millennia (Covington 2003). A fire regime is a general description of the role fire plays in an ecosystem, and commonly includes a description of the frequency and severity of fire that occurred historically. It also refers to the pattern and variability of fire occurrence and the effects it has on the native vegetation. Several researchers have developed coarse-scale definitions for natural or historic fire regimes (Hardy et al. 2001; Schmidt et al. 2002) which were then interpreted for fire and fuels management by Hann and Bunnell (2001). Ponderosa pine, other long-leaf pines, and dry Douglas fir forests were grouped into a single category. These vegetation types were characterized by frequent low- to mixed-severity fires occurring at return internals ranging from 0 to 35 years. The Western United States Biophysical Setting Key (Comer et al. 2003) further refines the fire return interval by identifying the mean fire return interval as four years for Southwestern ponderosa pine and ten years for mixed-conifer. These fires typically maintained existing open areas and created new openings through small-scale tree mortality. On a landscape level, both ponderosa pine and mixed-conifer vegetation types have already missed several natural mean fire intervals. With this absence, these forest types have accumulated unnatural levels of fuel that would cause a natural fire to exhibit more extreme fire behavior.

Many factors influence fire behavior including topography, temperature, humidity, wind speed, and fuel levels. Forest managers can control one of these factors – fuel levels. Management of fuels can modify fire behavior, ameliorate fire effects, and reduce suppression costs, fire intensity, and fire severity (DeBano et al. 1998; Pollet and Omi 2002). Fuels contribute to fire intensity, flame length, spread rates, residence time, and the overall size of the fire. Fuels managers can reduce fire effects by isolating or breaking up large contiguous blocks of fuels and by reducing the quantity of fuels in the forest (Rothermel 1983; DeBano et al. 1998; Agee et al. 2000).

For our purposes, we have classified and monitored fuels at two levels: surface fuels and canopy fuels. Surface fuels include downed logs, woody debris, pine needles or leaves, and understory vegetation. These types of fuels do affect fire behavior, but it is generally thought that ground fires dependent upon surface fuels are controllable (Scott 2003). Canopy fuels are made up of crown bulk density and crown base height. Crown bulk density is a measure of the mass of available canopy fuel per unit volume (Scott and Reinhardt 2001). Stands with higher crown bulk densities are more likely to sustain crown fires, independent of surface fuel loads. Crown base height is the distance between the ground and the lowest live branch with sufficient fuels to carry the fire into the canopy (Scott and Reinhardt 2001). The lower the crown base height, the more likely it is for a surface fire to become a crown fire. Together, crown bulk density and crown base height provide information managers can use to determine how likely a crown fire is to initiate and sustain itself across the landscape.

Analyzing Fire Behavior Data

The primary goal of the Project was to reduce the threat of uncharacteristic high-severity fire to human communities. When the Project began in 2004, the majority of thinning prescriptions implemented were designed to reduce fuels that would also reduce crowning and torching indices. The ASNF started to receive feedback from the Board and community members that some of the projects appeared to result in relatively homogeneous stands of evenly-spaced trees, which were not a representation of historical forest conditions, nor aesthetically pleasing to some. ASNF managers shifted thinning projects to restore a more historic forest structure (clumps and openings). Testing fire behavior scenarios through modeling determined whether or not prescriptions based on multiple objectives also reduced crowning and torching indices. The fire behavior model FlamMap was selected for this analysis. FlamMap is a fire behavior mapping and analysis program that calculates potential fire behavior characteristics (i.e., spread rate, flame length) over a selected landscape under a variety of weather and fuel moisture conditions. The model was populated with spatial data such as topography, slope, and vegetation layers as well as tree and fuels data collected at vegetation plots. Fire behavior was modeled with a 20 ft wind speed of 23 mph, which were the average conditions recorded during the Rodeo-Chediski fire that burned on the ASNF in 2002. While 23 mph wind speeds are common in northern Arizona, they are much lower than sustained winds and gusts (winds 40-60 mph) shown to drive other large fires in the Southwest. This fire behavior analysis is likely to be an underestimate of fire intensity and effectiveness of treatments when compared to potential severe conditions, and would most likely reflect the upper limit of conditions under which prescribed fire could be used. These models are useful in a comparative sense but should not be relied on to provide absolute numbers. A variety of prescriptions and project types are represented in the following analyses. A more detailed explanation of fire behavior modeling is found in Appendix B.

Results and Discussion

Fire behavior and associated forest structural characteristics were assessed at Alpine WUI, Eagar South, Forest Lakes, Greer, and Mineral. Forest structural characteristics were found to be moving in the right direction of desired change between the pre- and post-treatment periods, although not all sites showed a statistical difference. For example, crown bulk density and fuel loads were reduced in all project areas sampled. Crown bulk density was significantly reduced at Alpine WUI ($P < 0.01$), Eagar South ($P = 0.01$), Greer ($P = 0.05$), and Mineral ($P < 0.01$). Fuel loads were significantly reduced at Eagar South ($P < 0.01$) and Forest Lakes ($P = 0.05$). Reductions in these stand characteristics help reduce fire behavior to a desired and more historic fire type for these stands (surface fires) instead of active or passive crown fires.

We also found that crown base height and crowning and torching indices increased at all project areas sampled. An increase in these characteristics represents a reduction in modeled fire behavior. The height to live crown was significantly higher at Alpine WUI ($P = 0.01$), Eagar South ($P = 0.05$), Forest Lakes ($P = 0.02$), and Mineral ($P< 0.01$). Crowning and torching indices were significantly increased at Alpine WUI (crowning: $P = 0.03$; torching: $P = 0.03$), Eagar South (crowning: $P = 0.04$; torching: $P = 0.05$), and Mineral (crowning: $P < 0.01$; torching: $P = 0.04$). Forest Lakes and Greer had no statistically significant changes in torching or crowning indices between pre- and post-treatment periods.

Six project areas were modeled in the fire behavior program FlamMap to determine the overall fire behavior and to visualize the fire type projected to occur under pre- and post-treatment forest conditions. Brookbank was the only area where fire behavior was modeled that did not have enough samples to test for statistical changes in forest structure. At all sites, fire behavior was reduced from an active or passive crown fire to a surface fire in treatment areas on the modeled map. These systems evolved with surface fires that historically occurred as frequently as every two years, which tend to be much more manageable, benefitting vegetation and recycling nutrients previously unavailable in the soil. The Alpine WUI and Forest Lakes sites are near private property and were implemented as WUI treatments that tend to remove a considerable volume of trees and fuels to improve protection of local human communities from the threat of wildfires.

When the Project began, fuels reduction was the primary goal. After viewing these results, the Board expressed concern regarding the lack of statistically significant results for fire-related stand structural characteristics at all project areas. However, biological relevance is an important component when interpreting statistical results. This particular situation highlights this concept. If a quantitative goal in stand characteristic changes was established in the initial monitoring planning phase, the need for using a conservative statistical analysis would have been eliminated. Regardless of the level of statistical significance, all forest stand characteristics and fire behavior models show a trend toward a reduction in severe fire behavior.

The Eagar South site was initiated as a demonstration area to illustrate the shift from fuels-only treatments to multiple-objective treatments, which incorporated wildlife habitat needs and ecological restoration concepts. Previously, there was a perceived conflict between silvicultural, wildlife, and fuels treatments. The Eagar South project was selected to test a multi-objective thinning prescription. Areas were treated for fuel reduction, ecological restoration, and northern goshawk reproduction and prey habitat characteristics. The Board felt it was important to include this project in the fire behavior analysis. At Eagar South, fire behavior was reduced from active or passive crown fire to surface fire over the majority of treated areas. Of all the sites included in this fire behavior analysis, the Eagar South demonstration area was the only site that showed a statistically significant change in all forest characteristics measured. Eagar South illustrates that thinning prescriptions can achieve both fire and fuels objectives while maintaining wildlife habitat. Additional analysis specific to the demonstration area can be found in Eagar South monitoring section.

Figure 5. Projected fire behavior characteristics for pre- and post-treatment conditions in the Alpine WUI project area, treated as part of the White Mountain Stewardship Project

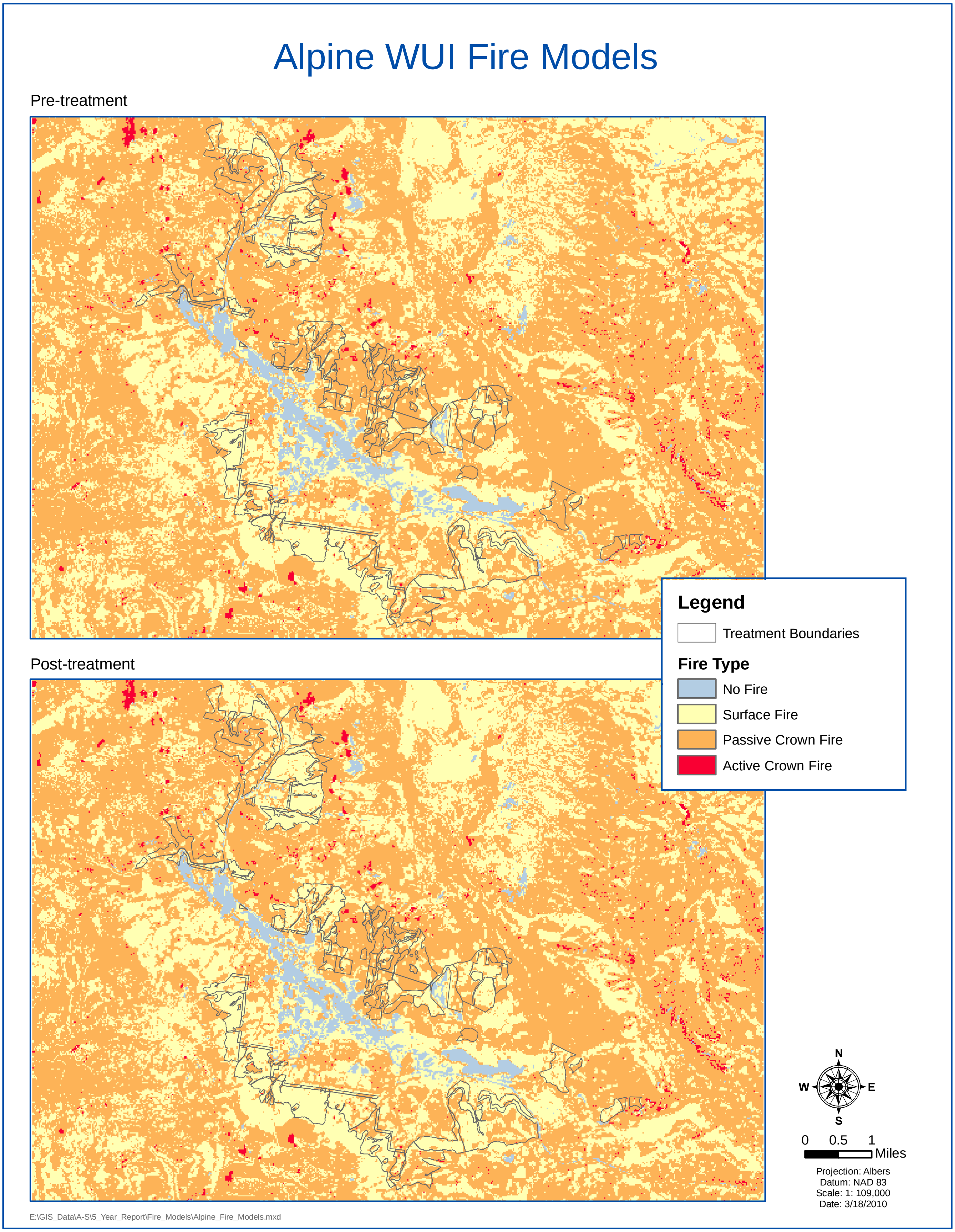


Figure 6. Projected fire behavior characteristics for pre- and post-treatment conditions in the Brookbank project area, treated as part of the White Mountain Stewardship Project

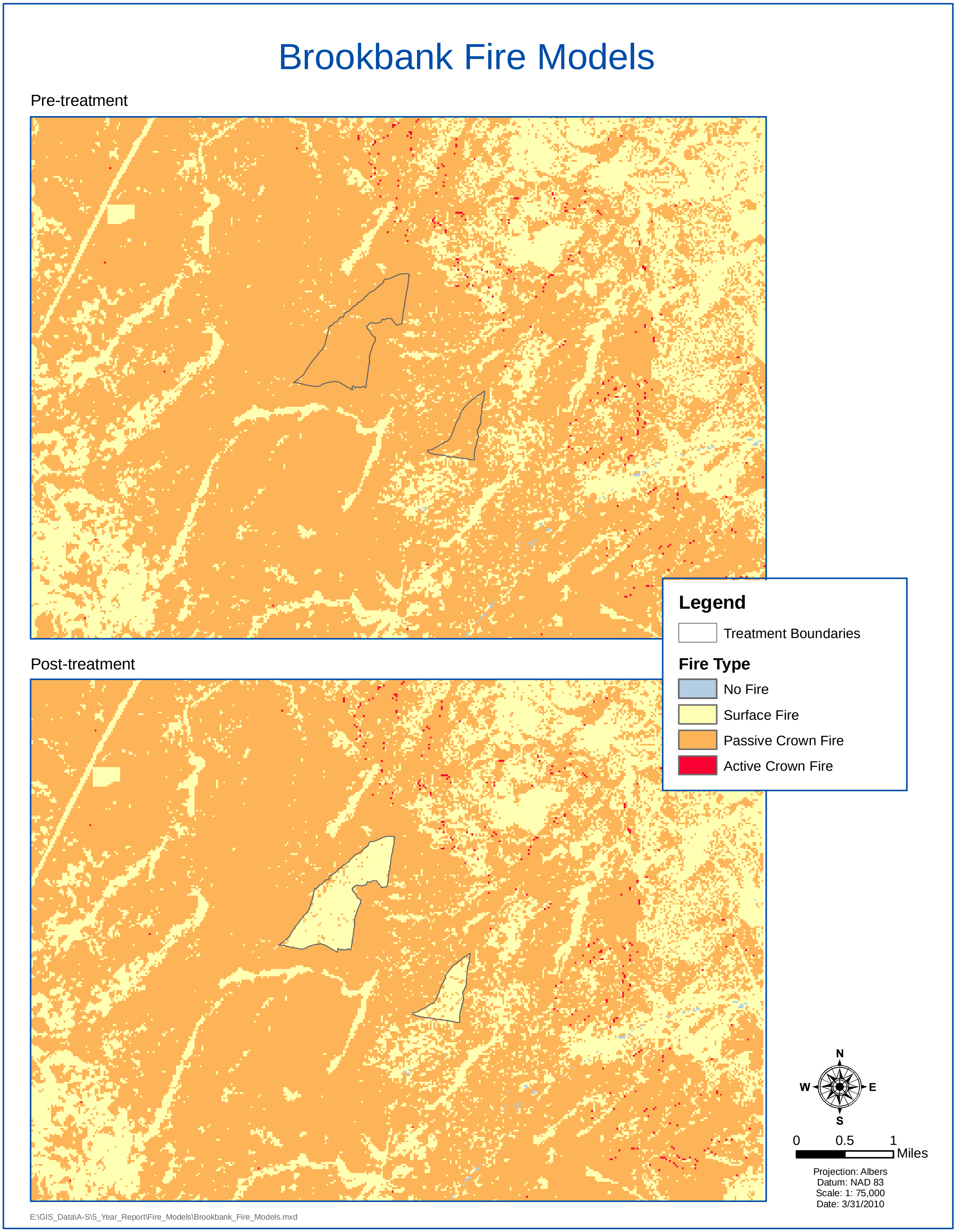


Figure 7. Projected fire behavior characteristics for pre- and post-treatment conditions at in the Eagar South demonstration area, treated as part of the White Mountain Stewardship Project

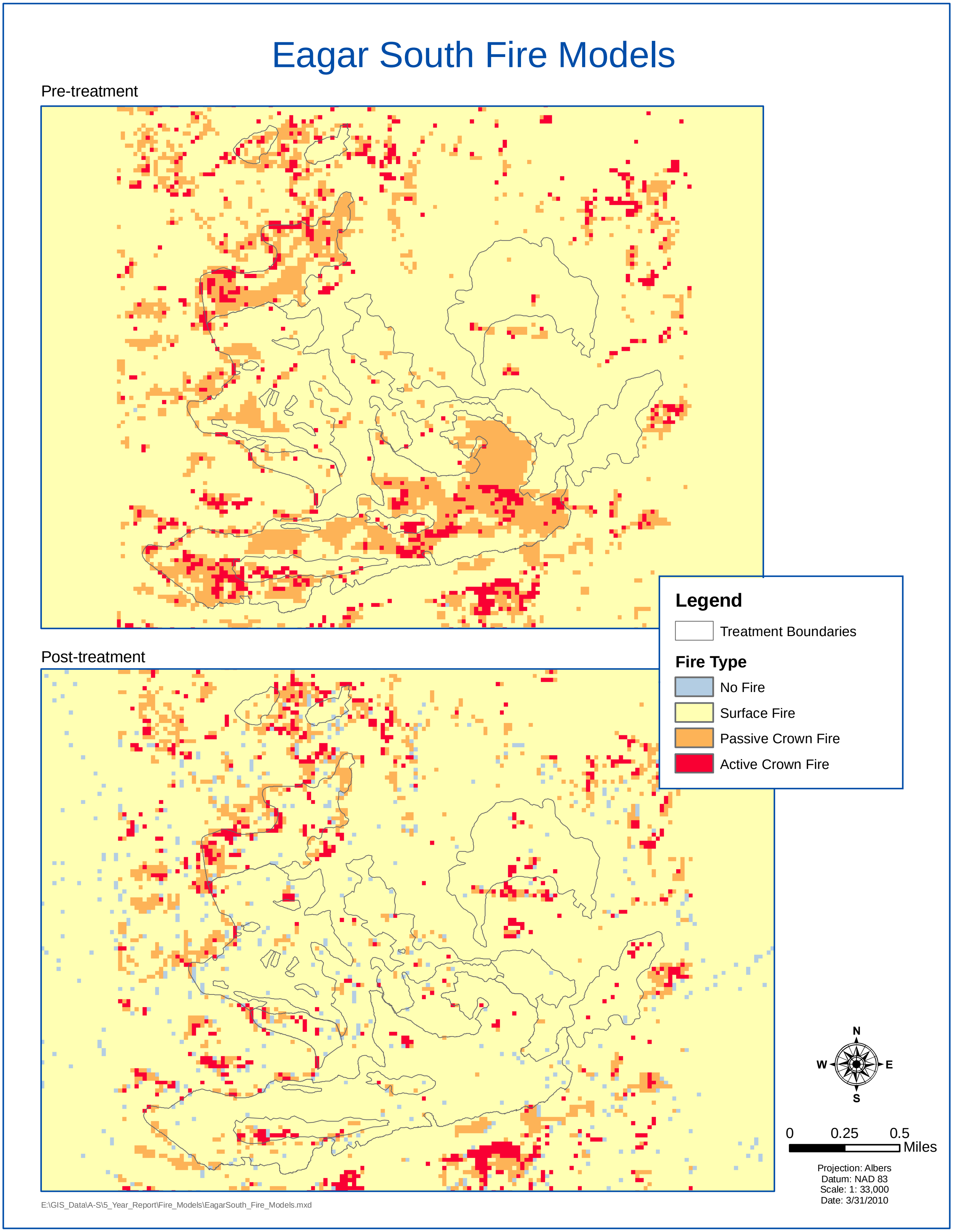


Figure 8. Projected fire behavior characteristics for pre- and post-treatment conditions in the Forest Lakes project area, treated as part of the White Mountain Stewardship Project

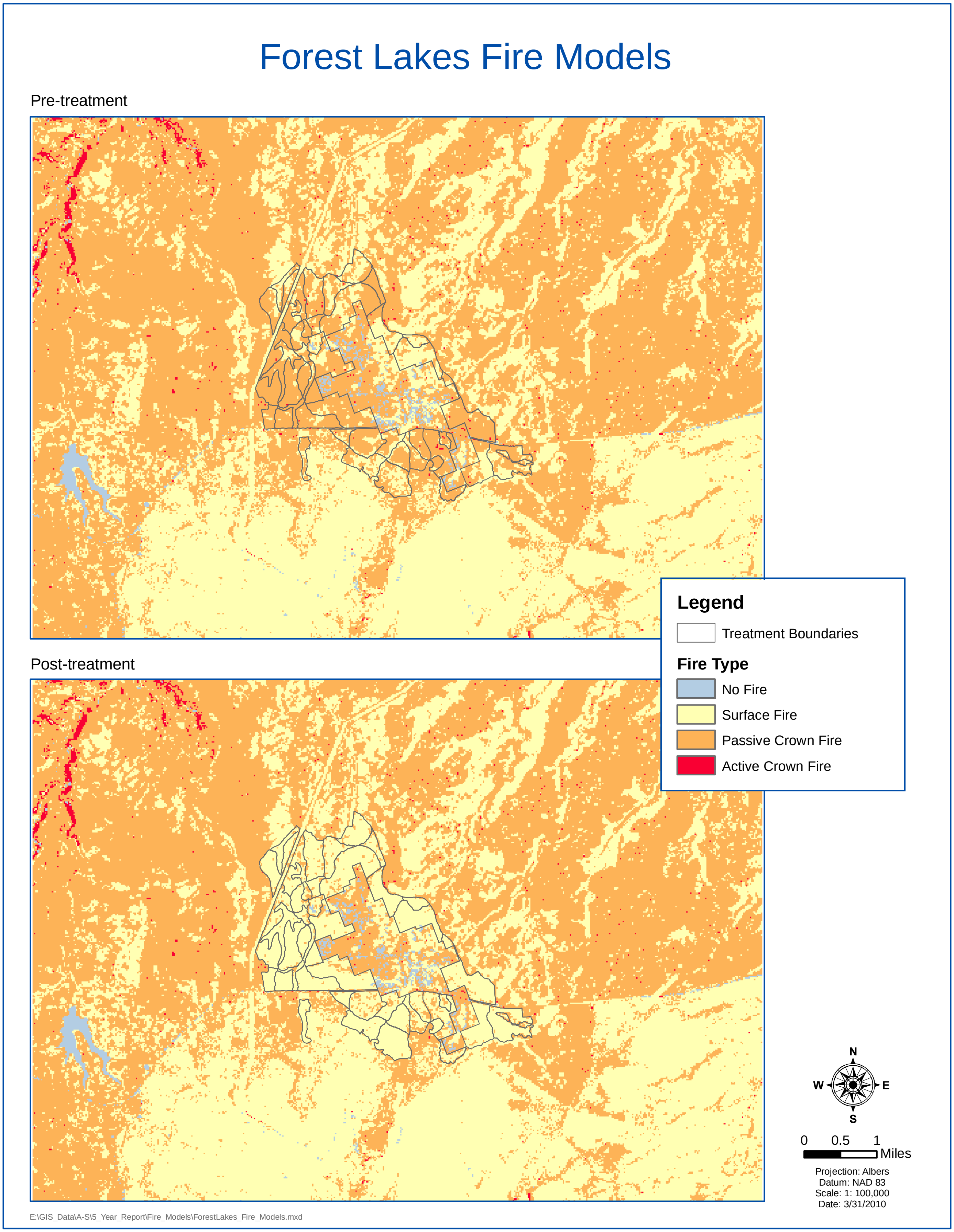


Figure 9. Projected fire behavior characteristics for pre- and post-treatment conditions in the Greer analysis area, treated as part of the White Mountain Stewardship Project

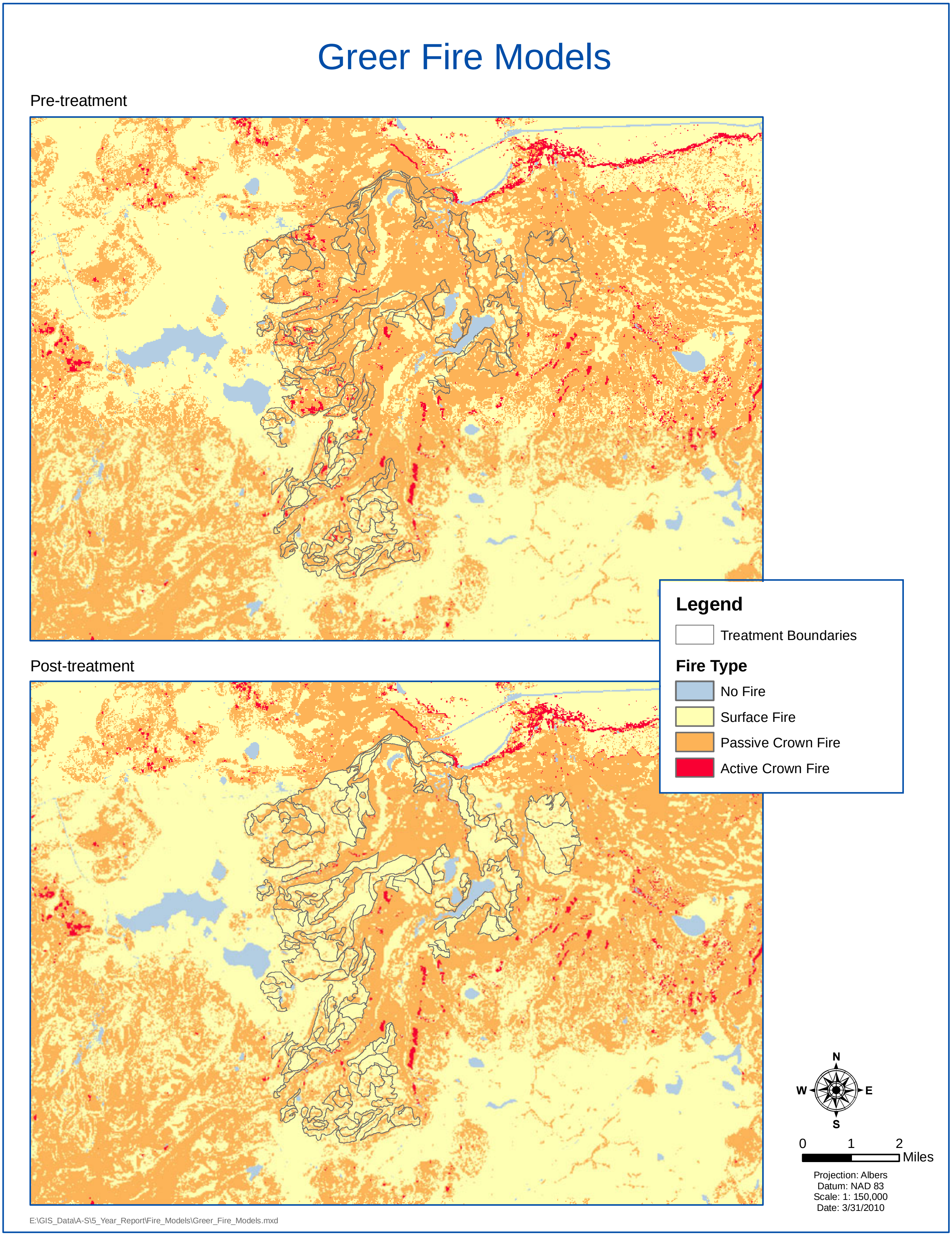
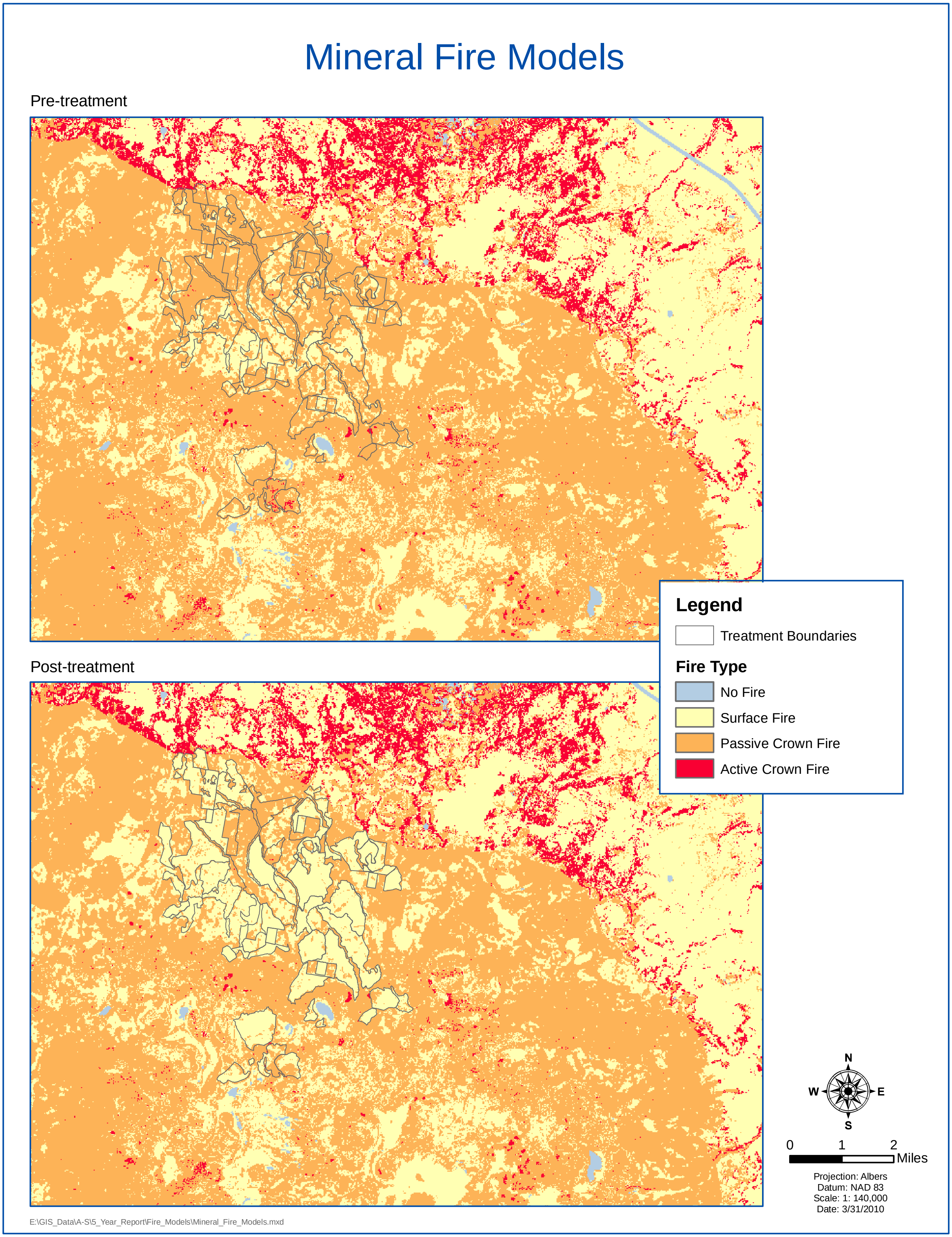


Figure 10. Projected fire behavior characteristics for pre- and post-treatment conditions in the Mineral project area, treated as part of the White Mountain Stewardship Project



Tree Spacing

Overview: As forest managers increase their understanding of the importance and impacts of forest structure, there is a need to verify if treatment prescriptions result in the arrangement of trees that was intended. The Ripley's K statistical test measures the arrangement of trees across the landscape and helps ensure prescriptions are successfully implemented. The analyses conducted for three types of prescriptions used in Project treatments indicate that tree arrangements do meet the intent of the prescriptions.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

Are remaining trees aggregated in a clumpy pattern?

Various treatment prescriptions that include evenly spaced, randomly spaced, and group selection have been implemented over the life of the Project. For prescriptions that include clumps and interspersed openings, the Ripley's K test indicates that this objective was achieved. Similarly, for more evenly-spaced prescriptions, this statistical test indicates success in meeting that objective.

Did forest treatments increase structural heterogeneity across the forest?

Overall structural heterogeneity across a landscape can be difficult to assess and may be subjectively interpreted. The Ripley's K test indicates a high level of structural diversity in sample plots. With the assumption that sample plots represented the natural variation that exists in forest structure across the treatment areas, and given the variety of thinning prescriptions that have been implemented under the Project, it is likely that structural heterogeneity has been achieved in localized areas.

A benefit of a long-term process such as this Project is that treatment objectives can adapt over time based upon input through the collaborative process. As the Project progressed through its first five years, the understanding of the desire for structural diversity has evolved. Thinning prescriptions have shifted from a fuels reduction focus to a restoration focus that promotes structural diversity and includes site-specific objectives that maintain micro-habitat needs (e.g., buffer strips near drainages; additional cover provided near springs and other water sources).

Analyzing Tree Spacing

With the increased implementation of forest treatments across the landscape, there has been a growing interest in emphasizing the creation of horizontal and vertical heterogeneity in forest structure. The concept of a patchy structure made up of small clumps of trees that form larger groups in a matrix of forest gaps or openings has been gaining momentum in ponderosa pine vegetation types. Given the inherent difficulty in measuring this type of forest structure, there has been little examination of how to quantify and statistically test if the structure is in fact different among treatment prescriptions.

To examine tree aggregation patterns, a quantitative assessment of how accurately written prescriptions were implemented on the ground for the various prescriptions was employed by using the Ripley's K function. This function statistically analyzes spatial patterns between pairs of points within *t* radial lag distance. It tests the degree to which the remaining trees are spatially aggregated on sample plots, determining whether or not treatments result in an evenly-spaced, random, or clumpy forest structure. A 2 m (6.5 ft) lag distance with a maximum distance of 100 m (328 ft), half the length of the sample plot, was used for this analysis. Cutting units within three project areas representing evenly-spaced, clumpy, and restoration treatment prescriptions were selected for examination of tree aggregation patterns. A minimum of three subplots were located within each analyzed cutting unit. Each subplot was 9.88 acres (4 hectares; 200 m x 200 m) in size. Every tree, or stem, was mapped in each subplot in a Geographical Information System (GIS) using the Feature Analyst extension from high-resolution aerial photographs; the Ripley's K function was run using program R v.2.8.0 (www.r-project.org).

Results and Discussion

The Ripley's K spatial test is a tool that can be used to quantify the spatial arrangement of trees across the landscape. As treatments include more structural heterogeneity at various scales, this statistical test will help us achieve our desired conditions. This spatial test provides quantitative evidence that the implementation of the written thinning prescription does create the spatial structure that was intended. The following figure shows examples of an aerial photograph, stem map, and spatial test results for three treatment areas. These areas represent each spatial structure targeted: evenly-spaced, randomly dispersed (restoration principles), and clumpy. The first panel shows the aerial photograph of the sample plot. The center panel depicts the stem map created in the GIS environment from that aerial photograph. The third panel is the statistical results of the Ripley's K function for that sample. To interpret this output, the solid line illustrates the observed spatial arrangement of trees within that subplot. The dotted lines show the 95% confidence interval for the observed function. When the observed line is above the 95% confidence interval, it shows that forest structure is clustered at that lag distance. When the observed line is in between both 95% confidence intervals, the trees are randomly distributed. When the observation line is below the 95% confidence interval, it shows that the trees are evenly spaced.

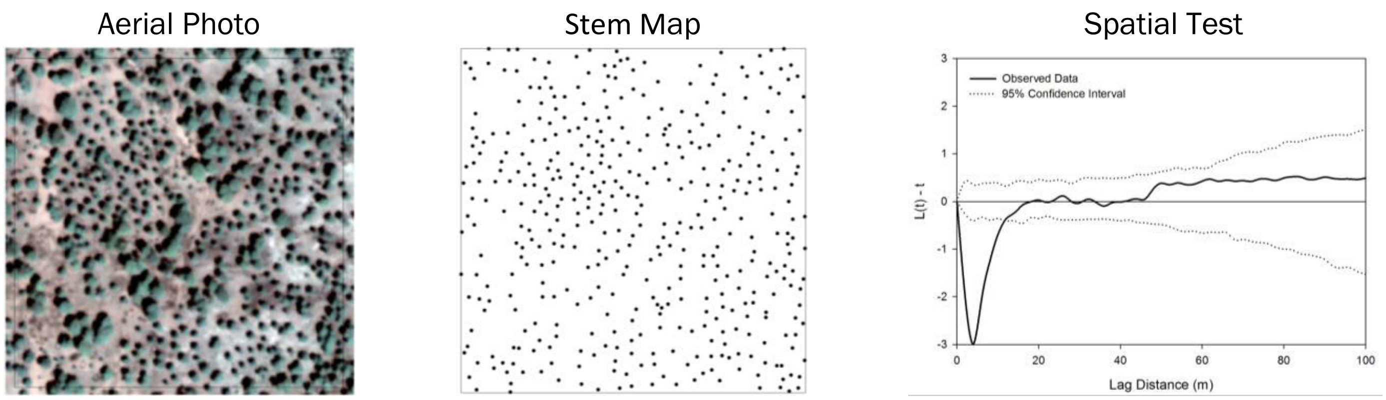
The results panels show that target forest characteristics were achieved with the prescription that was implemented. The Mineral project area illustrates evenly-spaced trees at short lag distances, precisely coinciding with the 21 foot spacing that was targeted by this prescription. The Mineral project area also shows that at larger distances, trees become randomly spaced. At the Eagar South demonstration area, we found that the restoration-based prescription that was determined by the location of remnant evidence of pre-settlement trees did not have a clumpy structure at this site, but that overall trees were randomly spaced on the sampled area. This pattern is also visible in the stem map and the aerial photograph. Of primary concern was the spatial aggregation at patch sizes, which was validated by this statistical test. The northern goshawk treatment exhibited the clumpy structure that was intended and that again at larger scales the trees become randomly spaced. This structure was also visible in the stem map and aerial photograph for this site. Changes in aggregation at different spatial scales helps create the horizontal heterogeneity that is desired across the larger landscape.

As the Project has evolved through time, so have forest structure objectives. Through spatial statistics, such as the Ripley's K function, we can further our understanding of how silvicultural treatments impact the spatial aggregation of the remaining trees on the landscape. Many wildlife species are dependent upon forest structural characteristics that can be quantified using this tool. As evidenced by other ecological monitoring results such as fire behavior, ponderosa pine stands could incorporate a more clumpy structure that also provides openings in the canopy of various sizes and meets multiple resource objectives.

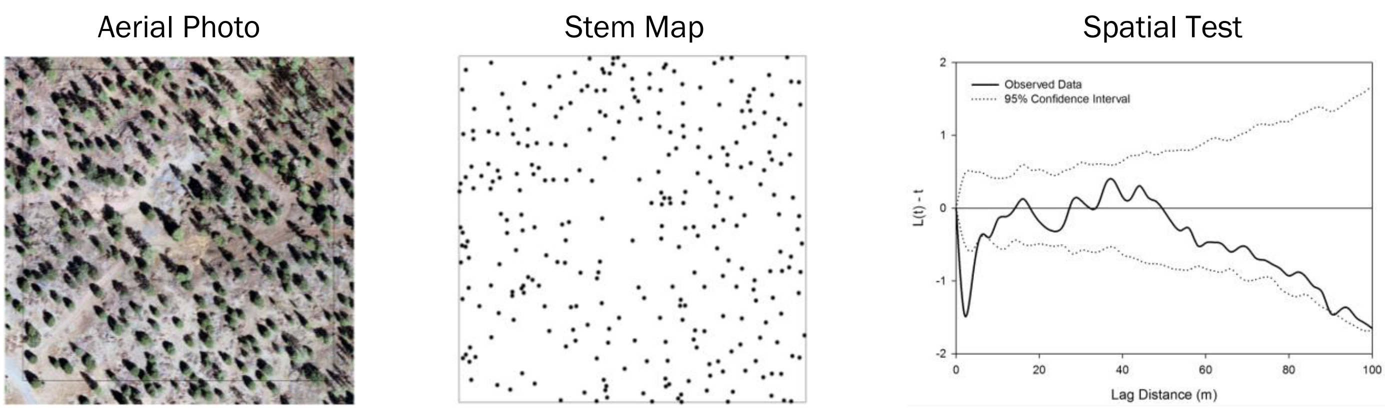
Example of evenly-spaced treatments at Mineral

Figure 11. Spatial structure and level of tree aggregation for three sampled treatments: evenly-spaced, restoration, and clumpy prescriptions

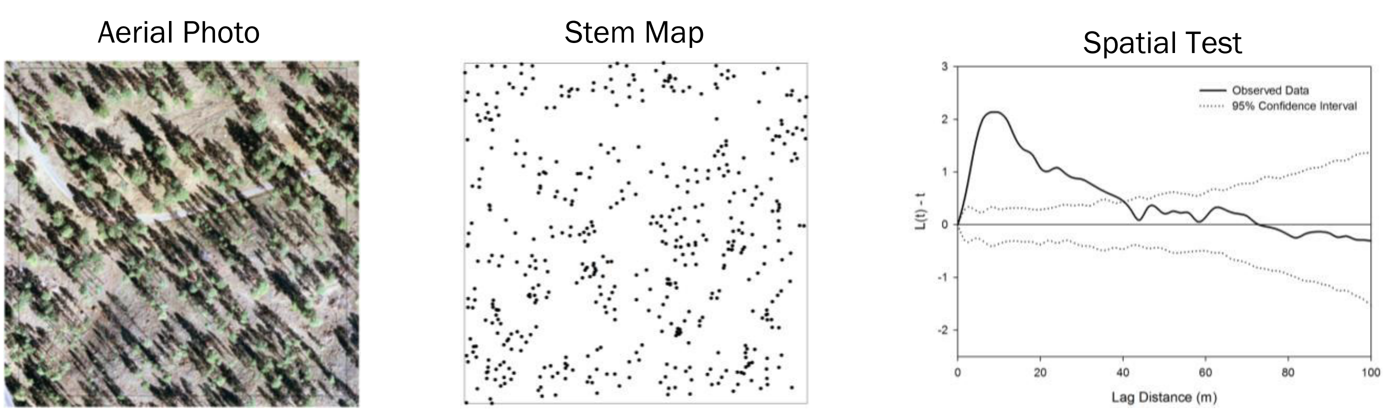
Mineral (Evenly-spaced – 21 ft spacing between trees)



Eagar South (Restoration-based prescription)



Eagar South (northern goshawk guidelines – clumpy prescription)



Wildlife Habitat Connectivity

Overview: Forest thinning treatments have been shown to immediately alter wildlife habitat. Connectivity of suitable patches of habitat that may be available to wildlife species is an important consideration when forest treatments are planned across much of the landscape. Understanding how these treatment layouts affect the connectivity of suitable habitat may help inform the design of future treatments.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

Are patches of dense forest connected?

A large portion of the ASNF is currently dense or overstocked with trees. Forest thinning efforts were targeted at protecting human communities and therefore were patchy across the forest. Connectivity of dense habitat is sufficient in most areas; however, this aspect of forest structure will become increasingly more important as more land area is treated. Currently, dense or untreated forest patches within a planning area are generally left as such because they are inaccessible in some way (on steep slopes or within sensitive soils, canyons, and riparian drainages). Our connectivity analyses highlight the need to begin incorporating higher retention of untreated areas into the planning and layout of treatments during the beginning phase of a project. One area where connectivity has been impacted by forest treatments is in the narrow portion of National Forest land at the western boundary of the Springerville Ranger District, where the Mineral treatments are located. This treatment prioritized fire-risk reduction and implemented an evenly-spaced prescription in the ponderosa pine vegetation type; as a result, connectivity of mixed-conifer habitats was disrupted for species preferring using dense forest cover for movement between these mixed-conifer patches.

Are patches of open forest or pine savannas connected?

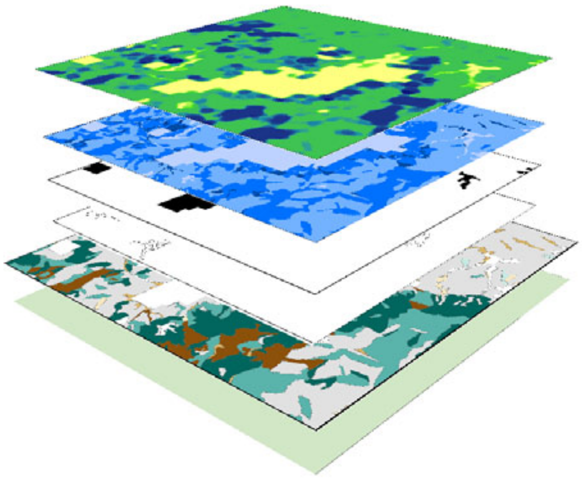
In areas where mechanical thinning and prescribed fire have been used to reduce basal area and mitigate wildfire behavior, treatments have significantly altered forest structure. In these localized areas, habitat connectivity for species that prefer a more open forest structure was suitable. If the connectivity analysis is scaled up to include the entire district or Forest, areas that have been treated are still separated by large areas of dense forest. Future treatments planned in these densely-forested areas will likely improve connectivity of open forests or savannahs across the landscape.

Analyzing Wildlife Habitat Connectivity

Forest structural characteristics are frequently used as a surrogate to define wildlife habitat requirements. Spatial heterogeneity, structural diversity, and temporal dynamics of vegetation are just a few of the metrics used to examine wildlife habitat (Zenner and Hibbs 2000). This variation across the landscape in patches of optimal, sub-optimal, and deficient habitat is what allows species to co-exist and be sustainable over time (Rosenzweig 1981). Restoration treatments are likely to modify wildlife habitat, influencing wildlife population dynamics (Block et al. 2001). Given that forest restoration and fuel reduction treatments are expected to increase in implementation over the coming decades, assessing how these treatments will influence species of management interest and their habitat will assist in planning efforts. In addition, understanding the scale at which these changes occur relative to the species of interest can further the evaluation of potential impacts. Previous research has shown that the concepts of ecological scaling, fragmentation, patch sizes, and the ability of species to move between optimal habitats are important in assessing how species will respond to potential disturbances (Wiens 1989; Kotliar and Wiens 1990; Battin and Sisk 2003). Therefore, habitat connectivity was evaluated at a scale appropriate to the species of interest.

To provide a large-scale assessment of the Project's effects across the landscape on wildlife, a GIS application called PatchMorph (Evan Girvetz; http://arcscripts.esri.com) was used to model habitat connectivity based on post-treatment forest conditions to interpret potential effects on species of interest. There are many assumptions associated with this modeling effort, including adequate identification of suitable habitat available at project areas, accuracy of vegetation spatial layers available, and expert-based predictions of treatment effects on habitat for focal species. Selected species' habitat was modeled to show connectivity of patches identified by experts as optimal to unsuitable habitat based on vegetation characteristics and treatment prescriptions. The model displays levels of habitat connectivity among patches of suitable habitat based upon these assumptions and inputs. Each selected species was modeled at a minimum of two project areas.

Figure 12. Illustration of the spatial layers included in the habitat connectivity analysis for a suite of focal species



Species Selection

A suite of focal species was determined through a collaborative discussion that included biologists from the ASNF, AGFD, and TNC. The suite of focal species was comprised of North American red squirrel (*Tamiasciurus hudsonicus*), Abert's squirrel (*Sciurus aberti*), northern goshawk, Merriam's wild turkey (*Meleagris gallopavo merriami*), and red-faced warbler (*Cardellina rubrifrons*). A literature review was completed for each species to inform model parameters based on the natural history of the species and to inform the habitat suitability characteristics for a variety of forest treatments that have been implemented under the Project. Draft models were developed based on information and attributes gleaned from the literature. These models were then reviewed by species experts and any suggested changes in threshold values or suitability characteristics were incorporated in the finalized models and maps. Full literature reviews of each species that were included in this modeling exercise are located in Appendix C.

PatchMorph

A patch delineation algorithm called PatchMorph was used to characterize functionally connected habitat for a suite of focal species. The PatchMorph algorithm allows for the use of natural history characteristics specific to the focal species to inform the threshold values for habitat suitability, gaps, and spurs in the landscape. In this algorithm, a gap is defined as an area of non-suitable habitat that is included in the patch when it is less than the threshold thickness (Girvetz and Greco 2007; Girvetz and Greco 2009). The gap distance is a measure of the distance across non-suitable habitat that an organism would normally move to access another area of suitable habitat. A spur then is an area of suitable habitat that is excluded from the patch when it is narrower than the specified threshold thickness (Girvetz and Greco 2007). The spur threshold can be thought of as a measure of the minimum thickness of a "core area" of suitable habitat. By utilizing a range of gap and spur distances, PatchMorph creates a configuration of suitable habitat across a range of spatial scales through an iterative process (Girvetz and Greco 2007). By overlaying the range of gap and spur distances, PatchMorph creates a connectivity surface that can be used to evaluate and visually display the functionally connected habitat for a given species (Girvetz and Greco 2007).

For each species analyzed, an extensive literature review informed the model parameters used in this spatial connectivity exercise. Functional habitat connectivity was modeled for multiple species at selected project areas. At each project area, the analysis extent was determined. For each species and project area, the base layers included in the analysis were the analysis extent, stand-level dominant vegetation types, treatment boundaries, private land perimeters, and the assigned suitability values based on expert review. Maps of dominant vegetation types for each analysis area can be found in Appendix D.

Tree Squirrels

Arboreal squirrels are a unique group of small mammals that require large, mature trees for various aspects of their life history and spend the majority of their time in the forest canopy. Many of these species are mature forest obligates and are dependent on mature trees for cavities and canopies for nesting, seeds, access to foraging sites, cover, shaded microclimates for fungal growth and seed storage, and predation escape routes (Koprowski 2005b; Koprowski and Nandini 2008; Leonard and Koprowski 2009; Zugmeyer and Koprowski 2009). Several researchers have also suggested that tree squirrels are excellent indicators of forest health (Carey 2000; Koprowski 2005; Koprowski and Nandini 2008). Furthermore, Patton and Vahle (1986) suggest that mixed-conifer forests are also dependent on small mammals, such as tree squirrels, which effectively disperse viable spores of underground fungi that may be necessary to the survival of conifer species.

Because of their specific habitat requirements, tree squirrels have been shown to be sensitive to habitat fragmentation (Lurz et al. 2008). Habitat fragmentation is a primary threat to the conservation of biodiversity and may lead to endangerment (Koprowski 2005b; Koprowski et al. 2008; Lurz et al. 2008). Many ecosystems have been affected by fragmentation; moreover, forested systems have been subjected to high levels of fragmentation (Koprowski 2005b). In the case of mature pine forests, large-scale fragmentation can result from mechanical treatments (logging, thinning, fuel reduction), uncharacteristic wildfires consuming tree crowns, increases in road densities, and outright loss of habitat. Tree squirrels are in jeopardy worldwide, with approximately 80% of tree squirrel species in need of conservation or legal protection (Koprowski 2005b; Wood et al. 2007; Lurz et al. 2008). In spite of that, population modeling efforts have shown that species such as the red squirrel can recover from low population sizes if factors causing their decline are managed (Lurz et al. 2008). Due to the potential impacts of forest treatments on the habitat requirements of tree squirrels, two species of interest were chosen as focal species for this habitat connectivity analysis. These species include the North American red squirrel and the Abert's squirrel, also known as the tassel-eared squirrel.

Red Squirrels

Natural History

Red squirrels are a diurnal species that are active year-round and defend caches or middens which serve as activity centers within their territory (Boon et al. 2008). Foraging stations and caching sites are frequently associated with large-diameter (>20 inches dbh) trees, snags, and logs (Vahle and Patton 1983). Red squirrels also require canopy cover that exceeds 60% with interlocking branches to create the microclimate necessary to preserve and store cones and to provide potential nesting locations, as well as predator escape routes and access to foraging sites (Patton and Vahle 1986; Goheen and Swihart 2005; Leonard and Koprowski 2009). Douglas-fir dwarf mistletoe (*Arceuthobium douglasii*) infections can form witches' brooms, which have been shown to be a nesting resource for red squirrels in Arizona (Hedwall et al. 2006). Red squirrels also use brooms for foraging, caching, and latrine sites (Hedwall and Mathiasen 2006). Previous research has shown that squirrel density ranges from 1.3 to 1.5 squirrels per hectare (2.47 acres) with a home range of ≤0.56 to 1.03 hectares (1.38 to 2.54 acres; Larsen and Boutin 1994; Goheen and Swihart 2005; Hedwall et al. 2006).

Analysis

For the purposes of the PatchMorph model, the Alpine WUI, Mineral, and Greer treatment areas were used to analyze red squirrel habitat connectivity. These analysis areas contain mixed-conifer vegetation, which is the dominant habitat for this species. The Mineral analysis and prescriptions did not include treating mixed-conifer vegetation; however, treatments in ponderosa pine may affect connectivity between islands of mixed-conifer habitat available for this species. Therefore, ASNF biologists were interested in understanding the potential impacts on habitat connectivity to mixed-conifer species after treatments occurred in interstitial ponderosa pine vegetation. Gap distances ranged from 0-500 m (0-1640 ft) and spur distances ranged from 500-1000 m (1640-3280 ft). Ranges were evaluated at increments of 100 m (328 ft).

Results and Discussion

Our habitat models illustrate limited connectivity of habitat for red squirrels at Greer and Mineral. These models show that overall forest treatments may diminish the connectivity of suitable habitat for this species, even when that species' primary habitat (mixed-conifer) was not a target of forest treatments. Thinning prescriptions may impact the ability for this species to move between mixed conifer patches. The majority of thinning prescriptions implemented in the early stages of the Project represented in the sites we modeled incorporated a low basal area and evenly-spaced retention trees. Because red squirrels require forest structure that includes a higher degree of basal area and interlocking canopies, these treatments are not well suited for this species, even if these treatments occur in predominantly transitional movement zones.

These maps also illustrate the value of treatment layout. Allowing for areas of untreated or higher basal area retention areas creates corridors for movement between larger patches of suitable habitat. For example, the Mineral area is the narrowest portion of the ASNF, with FAIR lands to the south and State land to the north; the vegetation type quickly changes due to the elevational gradient. The layout of treatments in this area may impact the east-west movement of squirrels, leaving only a narrow strip of habitat on ASNF land through which this species could travel. This modeling exercise provides an example of how analyzing habitat connectivity for a selected species in the planning stages could help determine alternatives in location and layout of future treatments. At nearly all sites analyzed, red squirrels were confined to small patches of mixed conifer forests that were interspersed among other less-suitable vegetation types. Understanding how private land and forest treatments may affect remaining movement corridors in an already fragmented vegetation type may inform future planning efforts.

Figure 13. Connectivity among patches of suitable red squirrel habitat in the Greer project area treated under the White Mountain Stewardship Project

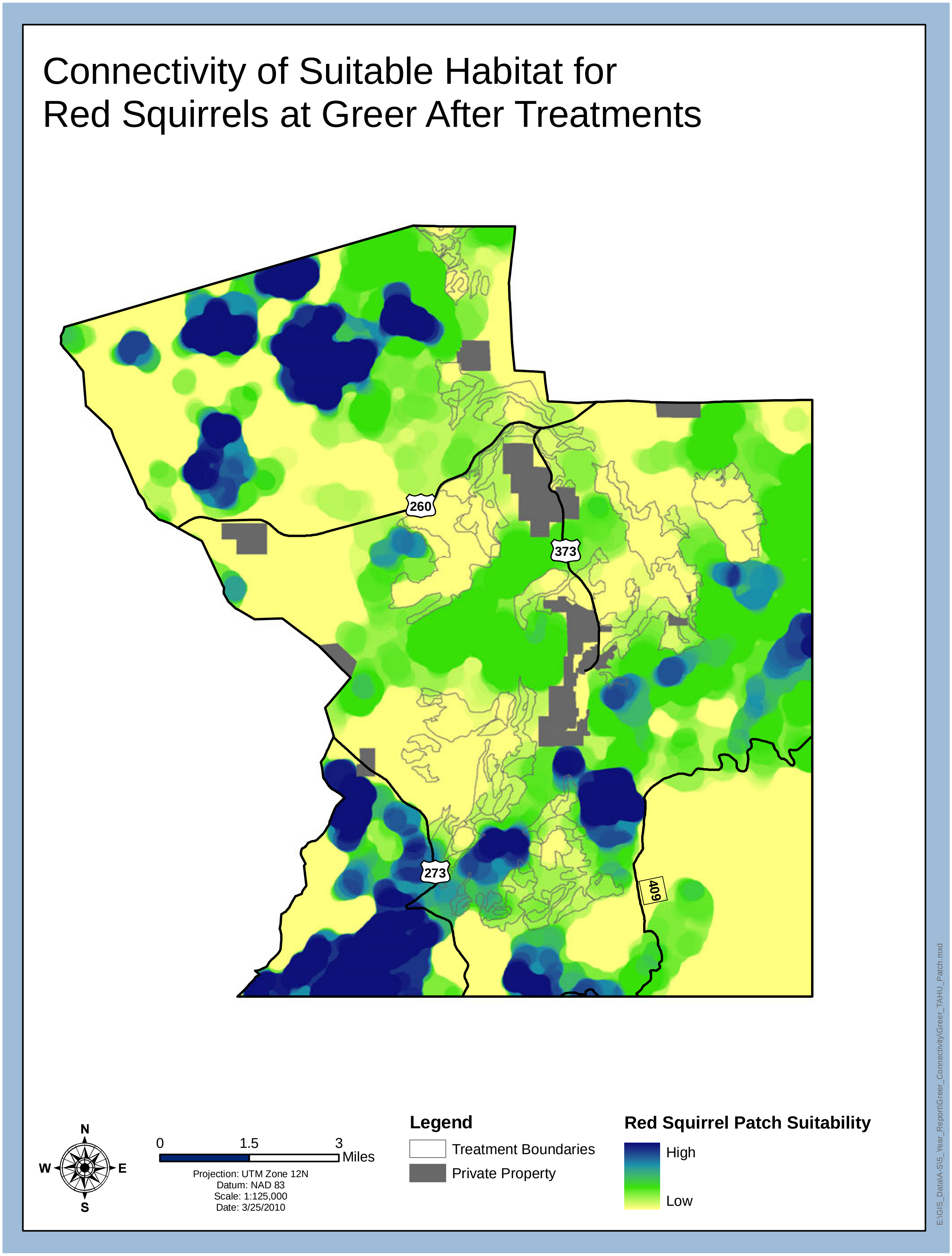
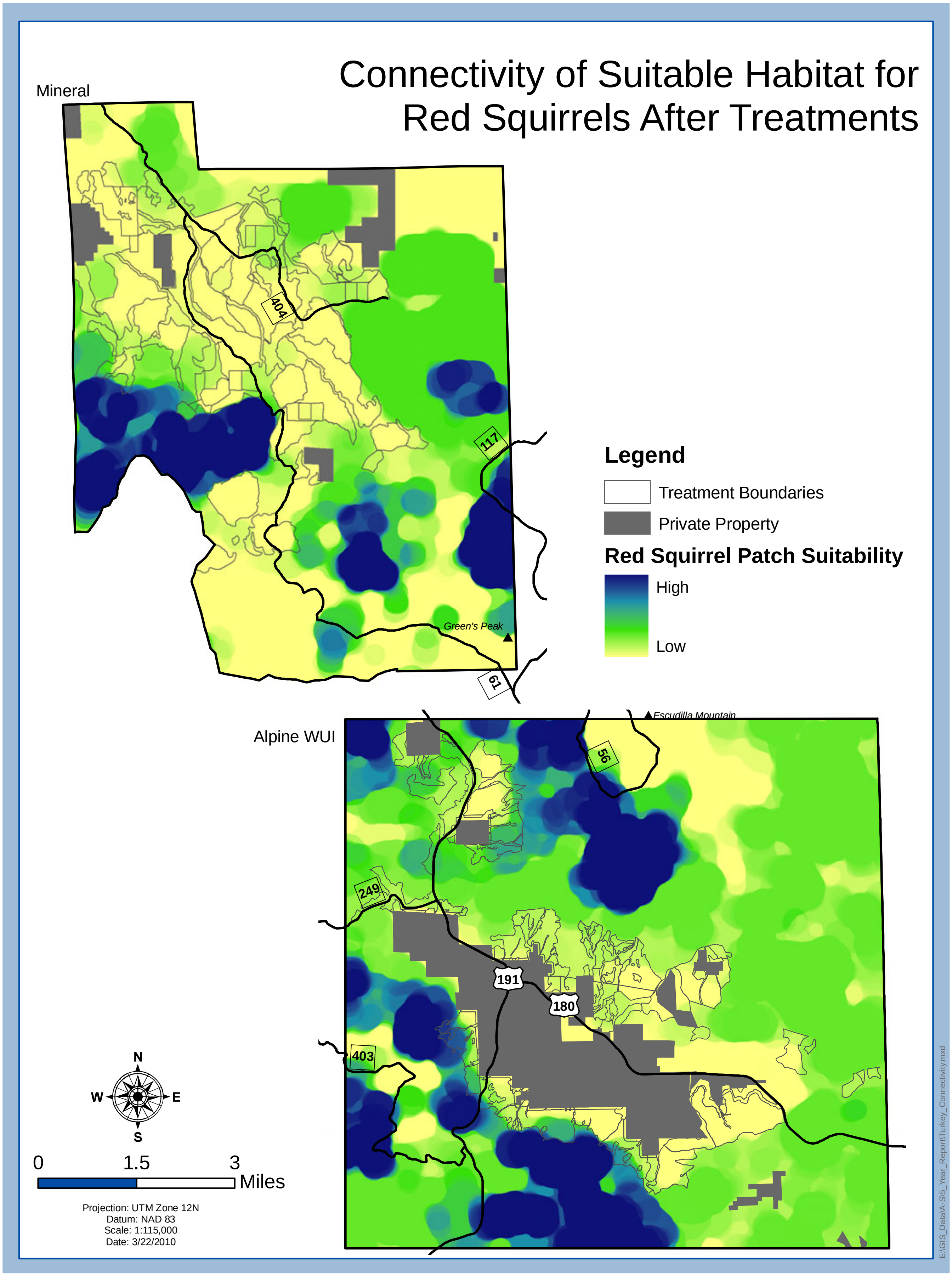


Figure 14. Connectivity among patches of suitable red squirrel habitat in Alpine WUI and Mineral project areas treated under the White Mountain Stewardship Project



Abert's Squirrels

Natural History

The Abert's squirrel is a diurnal species weighing approximately 680-900 grams (1.5-2 lbs.) that requires foraging resources associated with ponderosa pine trees, which include the inner bark of twigs, pollen, seeds, and hypogeous fungi associated with the roots (Burt and Grossenheider 1976; Patton 1984). Like many small mammals, there is a symbiotic relationship between squirrels and the conifer species that comprise their habitat. Squirrels and other small mammals consume the underground fruiting bodies of mycorrhizal fungi (truffles), which are a seasonal food resource that passes through their digestive system unharmed and is dispersed by the squirrel (States and Gaud 1997; Dodd et al. 2003 and 2006; Prather et al. 2006). Previous research has shown that mycorrhizal associations are beneficial to ponderosa pine seedling establishment and survival (States and Gaud 1997). The Abert's squirrel is unique in that it does not store food over winter. High-quality habitat providing foraging resources during the winter is important to their survival (Patton 1984). These squirrels are also dependent on ponderosa pine for nest building sites, cover, rest, and protection from weather and predators (Patton 1984). Abert's squirrels are highly dependent on forest structural characteristics. This species prefers habitat with areas of high basal area, canopy cover, and interlocking branches. High quality habitat for Abert's squirrels can be summed up as a multi-aged stand with a well-defined large tree component (20+ trees/acre >17 inches dbh), a BA of > 153 ft^2/acre, and canopy cover of 50% or more (Dodd et al. 2006). The Abert's squirrel is a common prey resource for the northern goshawk (Dodd et al. 2003 and 2006; Prather et al. 2006), a species of interest and one that is also thought to be affected by forest management activities.

Analysis

For the purposes of the PatchMorph model, the Blue Ridge, Eagar South, Greer, and Mineral treatment areas were used for analysis of Abert's squirrel habitat connectivity. These analysis areas contain mainly ponderosa pine vegetation, which is the dominant habitat for this species. Gap distances ranged from 0-1600 m (0-1 mile) and spur distances ranged from 400-2000 m (0.25-1.25 miles). Ranges were evaluated at increments of 400 m (0.25 miles). A buffer area of 120 m (393 ft) in width was used in treated areas to capture squirrel use of these areas for foraging. Similarly, a 60 m (197 ft) buffer was used in pinyon-juniper vegetation when sharing a boundary with ponderosa pine to capture the use of transition zones by this species.

Results and Discussion

Our model of functional connectivity of Abert's squirrel habitat at Eagar South suggests that treatments had a minimal impact on squirrel habitat. The layout of the treatments in this location allowed for untreated areas to connect larger patches of suitable habitat. Several of the cutting units at Eagar South implemented thinning prescriptions that reduced the suitability of habitat for this species. However, the remaining thinning prescriptions implemented were based on creating a forest structure that consisted of small clumps of trees in larger groups with a relatively high basal area. Individual tree selection emphasized aggregating trees, allowing for interlocking canopy in patches and more open areas that created suitable foraging habitat for squirrels. By implementing this type of forest prescription, much of the area treated under this project maintained moderately suitable habitat for squirrels, allowing this species to move freely between larger patches of suitable habitat while achieving the objectives of the thinning project. Prescriptions implemented at other project areas modeled were focused on evenly-spaced leave trees with low target basal area retention. While these prescriptions were thought to maintain some use of these areas by Abert's squirrels (*N. Dodd, personal communication*), our model suggests that they do reduce the suitability for primary habitat (nesting and foraging) and reduce connectivity among patches of more suitable habitat.

Figure 15. Connectivity among patches of suitable Abert's squirrel habitat in the Greer and Eagar South project areas treated under the White Mountain Stewardship Project

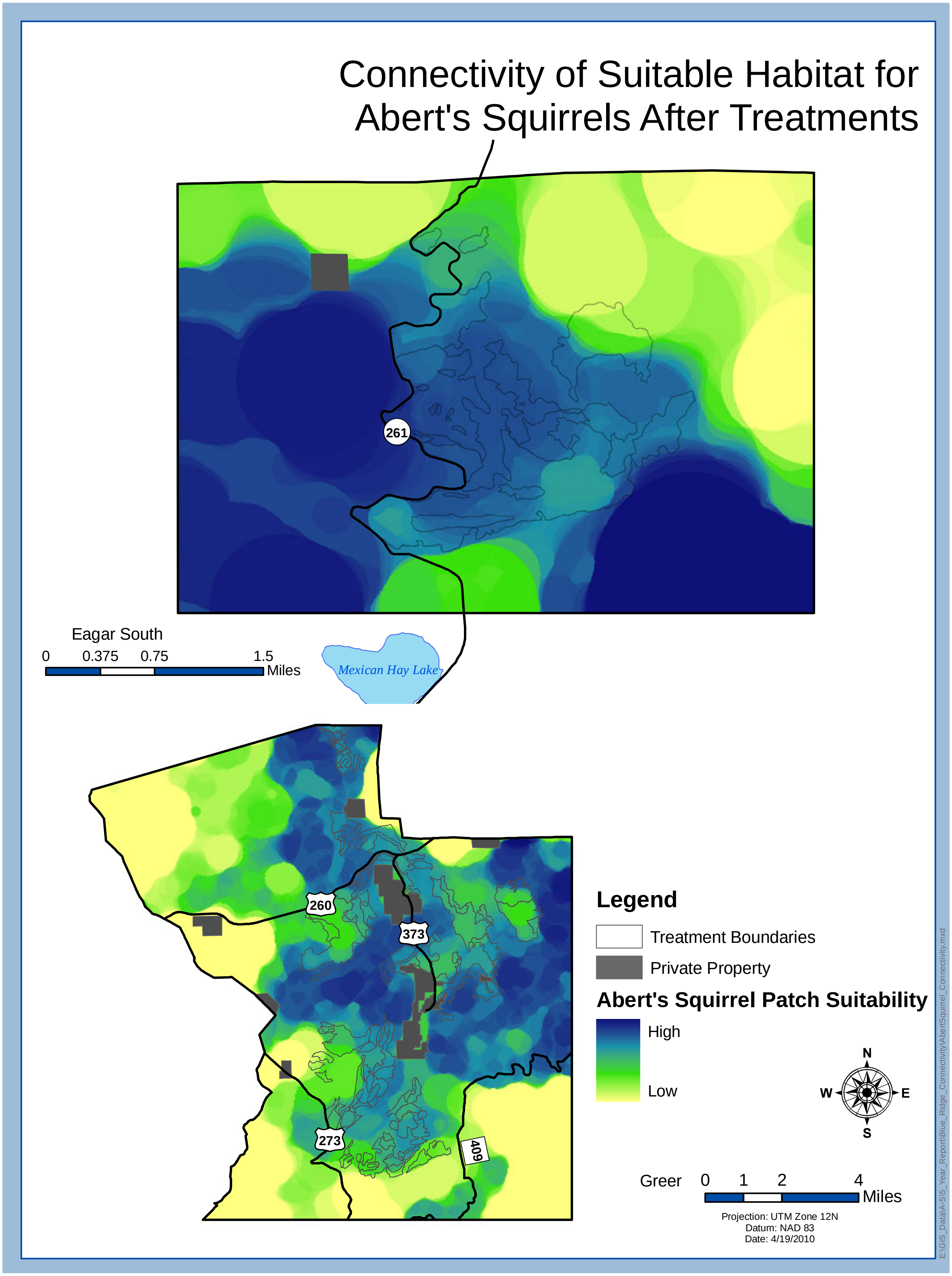
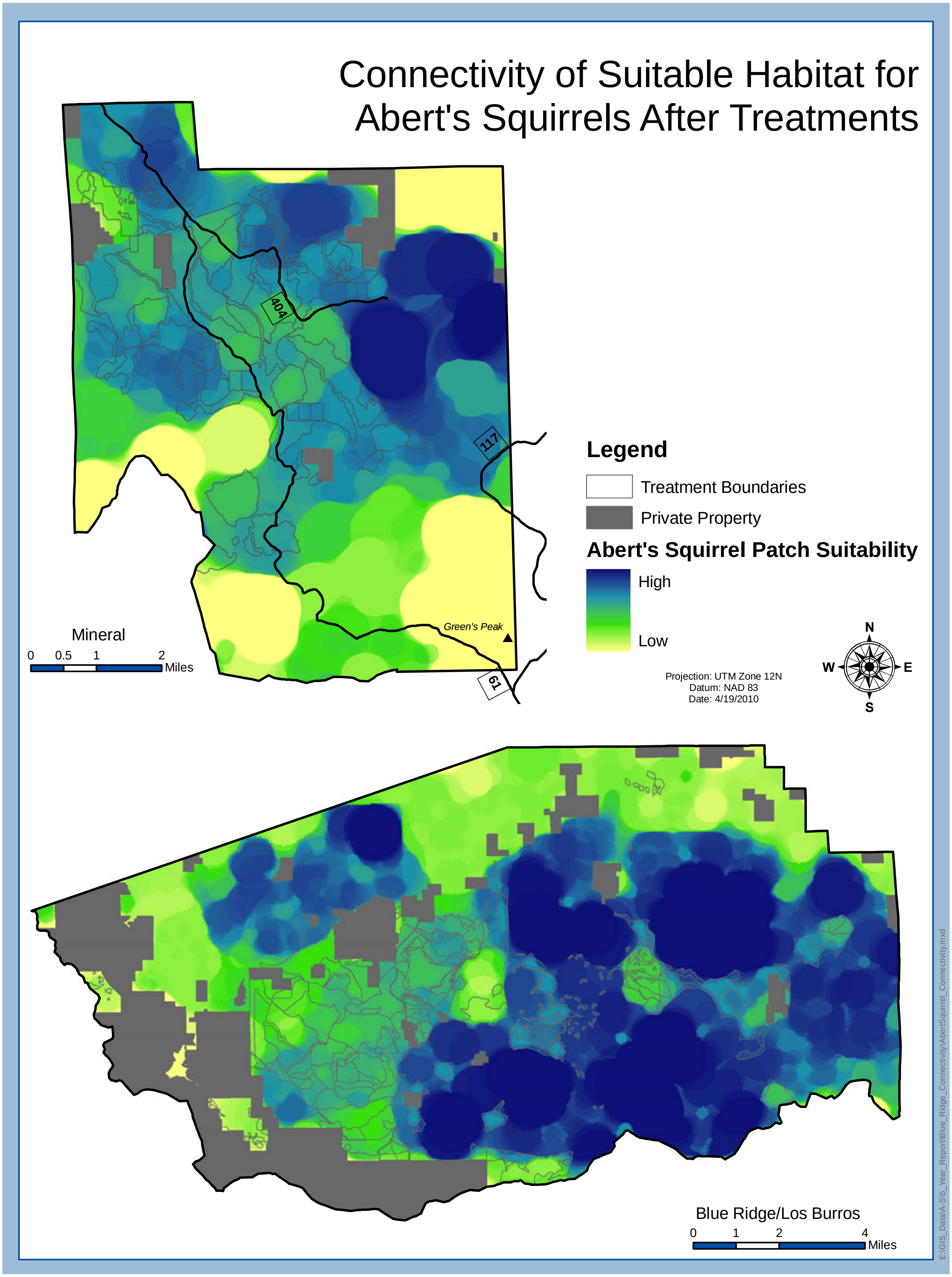


Figure 16. Connectivity among patches of suitable Abert's squirrel habitat in the Blue Ridge and Mineral project areas treated under the White Mountain Stewardship Project



Merriam's Wild Turkey

Natural History

The Merriam's turkey (hereafter wild turkey) most frequently occupies ponderosa pine forest and pine-oak associations, but has been shown to also utilize mixed-conifer forests and pinyon-juniper woodlands. Wild turkeys commonly move to lower elevation pinyon-juniper woodlands seasonally and rely on mast production for winter food resources (Wakeling and Rogers 1994). Wild turkeys are omnivorous and eat a wide range of foods, including grass leaves and seeds, ponderosa pine and pinyon pine seeds, forbs, invertebrates, juniper berries, acorns, and cultivated crops (Scott and Boeker 1975; Hoffman et al. 1993). While this species is considered a habitat generalist, it has a diverse set of specific habitat requirements to meet its basic needs (Hoffman et al. 1993). Wild turkeys require specific habitat characteristics for nesting, roosting, foraging, and loafing. Wild turkey nests are commonly associated with large-diameter ponderosa pine trees in clumpy, uneven-aged stands which provide many nesting options (Wakeling 1991; Lehman et al. 2008). Nests are often on slopes > 40% in areas of high canopy cover (Hoffman et al. 1993; Mollohan et al. 1995). Turkeys also utilize landscape topographic features, rocky outcrops, herbaceous vegetation, or slash to conceal nests (Hoffman et al. 1993; Mollohan et al. 1995). Nest locations often have low horizontal visibility from shrubs, slash, or dead-and-down wood, with ground hiding cover between 1.5 and 6.5 ft high (Mollohan et al. 1995; Spears et al. 2007; Lehman et al. 2008).

Analysis

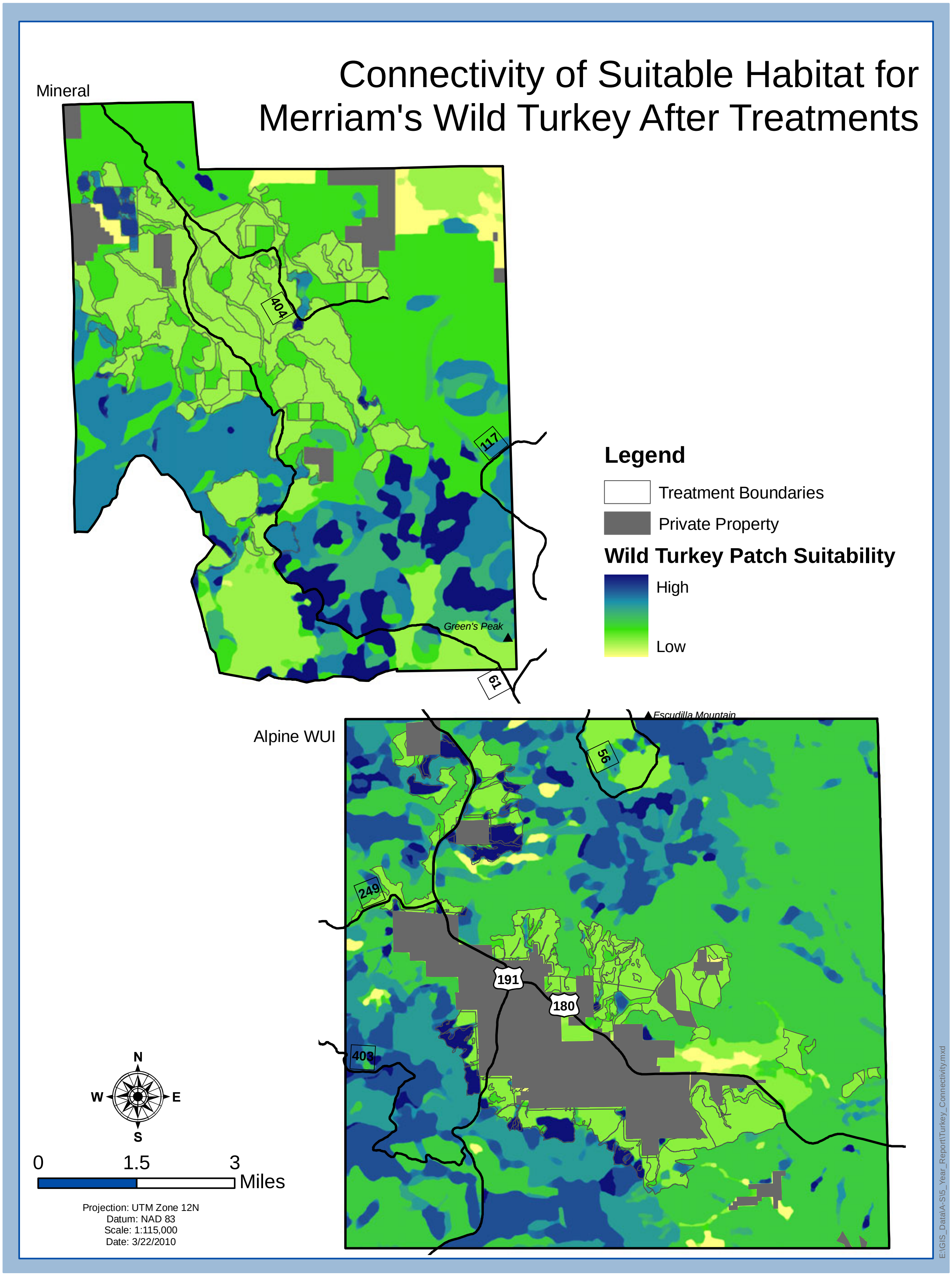
For the purposes of the PatchMorph model, the Alpine and Mineral treatment areas were used for analysis of wild turkey habitat connectivity. These analysis areas contain ponderosa pine, mixed-conifer, and oak woodland vegetation, which is the dominant habitat for this species. Gap distances ranged from 0-150 m (0-492 ft) and spur distances ranged from 50-250 m (164-820 ft). Ranges were evaluated at increments of 50 m (164 ft).

Results and Discussion

Our habitat connectivity model for wild turkey illustrates that forest thinning treatments maintain connectivity between habitat patches. The landscapes surrounding the community of Alpine and the Mineral project area have a high diversity of vegetation types. Because turkeys can utilize a multitude of vegetation types, these areas provide many habitat options for this species. The interaction of a highly variable landscape interspersed with patches of treated and untreated areas creates a complex landscape to model. Our model shows that the area surrounding Alpine retains large patches of suitable habitat for turkeys with all areas functionally connected post-treatment. Similarly, the Mineral project site retains patches of suitable turkey habitat in select treatment areas. The majority of suitable habitat in the analysis extent occurs in untreated areas.

Suitable wild turkey habitat also includes structural characteristics that may be impacted by treatments. Slash, either scattered or in smaller piles, provides loafing and nesting habitat, especially on steeper slopes. Large dead and downed logs provide hiding cover for loafing. Fine fuels, such as needles and small twigs, provide nesting material. Where turkey habitat is a concern, providing direction to leave some amount of slash, downed logs, and fine fuels, particularly on slopes, may help increase habitat suitability. In addition, turkeys often forage at the edges of meadows, but need adjacent cover for protection. Identifying areas to retain higher basal area stands at the edges of meadows could also be included in the planning phase. This modeling effort could be used to identify prescriptions that retain suitable turkey habitat and provide guidance for which prescriptions should be implemented in areas where turkey habitat is of concern.

Figure 17. Connectivity among patches of suitable wild turkey habitat in the Alpine WUI and Mineral project areas treated under the White Mountain Stewardship Project



Red-faced Warbler

Natural History

The red-faced warbler is typically found in mixed-conifer, ponderosa pine, or ponderosa pine-Gambel oak (*Quercus gambelii*) forests associated with moist drainages or heavily-forested canyons (Martin and Barber 1995; Corman 2005). This species is one of a few ground-nesting warblers; as such, it requires an herbaceous layer with enough cover, litter, and downed woody material to conceal nests (Martin and Barber 1995). General foraging behavior includes gleaning for insects in the outer one-third of branch tips of conifer trees, with the majority of foraging taking place <60 ft from the ground (Franzreb and Franzreb 1983). Given the specific forest structural characteristics utilized by the red-faced warbler, a different approach to modeling habitat was used. This analysis examines habitat suitability for this species rather than connectivity. Two objectives of this species-specific analysis are: 1) to determine the impact of treatments in drainages and canyon or slope bottoms; and 2) to illustrate current buffer areas beyond riparian vegetation and in canyons and drainages that provide potential foraging and nesting habitat for this species.

Analysis

Red-faced warbler habitat was not included in the PatchMorph application analysis; relative to forest thinning, habitat suitability was a preferred parameter for evaluation. Therefore, a general evaluation using vegetative layers was incorporated into a GIS. One area of known red-faced warbler detections from the Project's avian surveys was selected for this analysis within the Blue Ridge demonstration project. This area contains ponderosa pine and pine-oak vegetation, interspersed with drainages, canyons, and intermittent or ephemeral streams, meeting many red-faced warbler habitat characteristics. While these habitat characteristics (drainages, slopes, and canyons) are generally not treated when slopes are greater than 30% or contain sensitive site characteristics (i.e., riparian habitat, wet soils, rocky or steep slopes), they are treated on a site-specific basis to remove dense thickets of small ponderosa pine trees to assist in groundwater retention, meadow restoration, and increased stream flows. The selected area was used as an example site to illustrate potential treatment impacts to foraging needs of the red-faced warbler due to the removal of mid-cover vegetation (pine trees from 0 to 60 ft height).

Results and Discussion

The GIS tool, Topographic Position Index (Jenness 2006), uses a U.S. Geological Survey (USGS) digital elevation map to identify the topographic features that meet general habitat needs of red-faced warblers. Previous research has shown that canyons, drainages, and riparian areas are primary nesting and foraging habitat for this species. Within the Blue Ridge demonstration project, several avian transects were established to monitor treatment impacts on the avian community. One such transect was in the area of Thompson Creek where surveyors have detected red-faced warblers at points 8 and 10 along the sampling transect in multiple years. Both points fall within the buffer area (394 ft) that was used to delineate the width of potential habitat surrounding topographic features used by red-faced warblers. This ground-based information helped to validate the buffer distance used in the qualitative assessment.

The topographic model was used to identify potential red-faced warbler habitat. Our analysis area, which included the Blue Ridge and Los Burros project sites, totaled 100,605 acres. Areas that were identified as canyons or drainages and shallow slopes totaled more than 6,000 acres (6% of the total area). Based upon the literature review, buffer areas of 394 ft (120 m) around these features were established to encapsulate potential foraging habitat. This area totaled 50,628 acres (50%) of the analysis area. We assumed that canyon/drainage and slope features and the associated buffer areas would provide a conservative estimate of the potential habitat. To further understand possible impacts from forest treatments within these areas, we selected the topographic features and associated buffered areas that fell only within the treatment units. More than 7,000 acres of buffered potential habitat fell into this category, which was nearly 15% of the identified habitat within the analysis area.

Forest restoration treatments have the potential to directly affect red-faced warbler habitat (Szaro and Balda 1979). Treatments that remove foliage from ground level to 60 ft in height and 30% BA may render previous warbler habitat unsuitable (Szaro and Balda 1979; Franzreb and Franzreb 1983). Restoration treatments also have the potential to improve red-faced warbler habitat if a buffer area up to 150 ft from the outer edge of drainages is created. These buffer areas should incorporate light treatments that may open up the overstory to improve herbaceous and understory growth and retain snags and large downed logs.

This qualitative analysis of potential red-faced warbler habitat has revealed more questions than answers. This analysis indicated there was more potential warbler habitat than expected.

However, there were only a few records in our surveys where red-faced warblers have occupied breeding territories during our surveys. Are the warblers present but undetected, or are the survey transects not positioned to survey in these topographic features since many of these areas are not generally treated? Another factor was that not all areas that fell within the treatment boundary were actually thinned. This makes it difficult to track the potential impacts these treatments may have on red-faced warblers. Furthermore, some prescriptions have the potential to improve and enhance habitat for this species. Additional surveys and targeted monitoring may help address these questions.

Figure 18. Identification of topographic features that may provide habitat for red-faced warbler and a subset of these features identified within the treatment areas which may be affected by treatment implementation at the Blue Ridge and Los Burros project areas treated under the White Mountain Stewardship Project

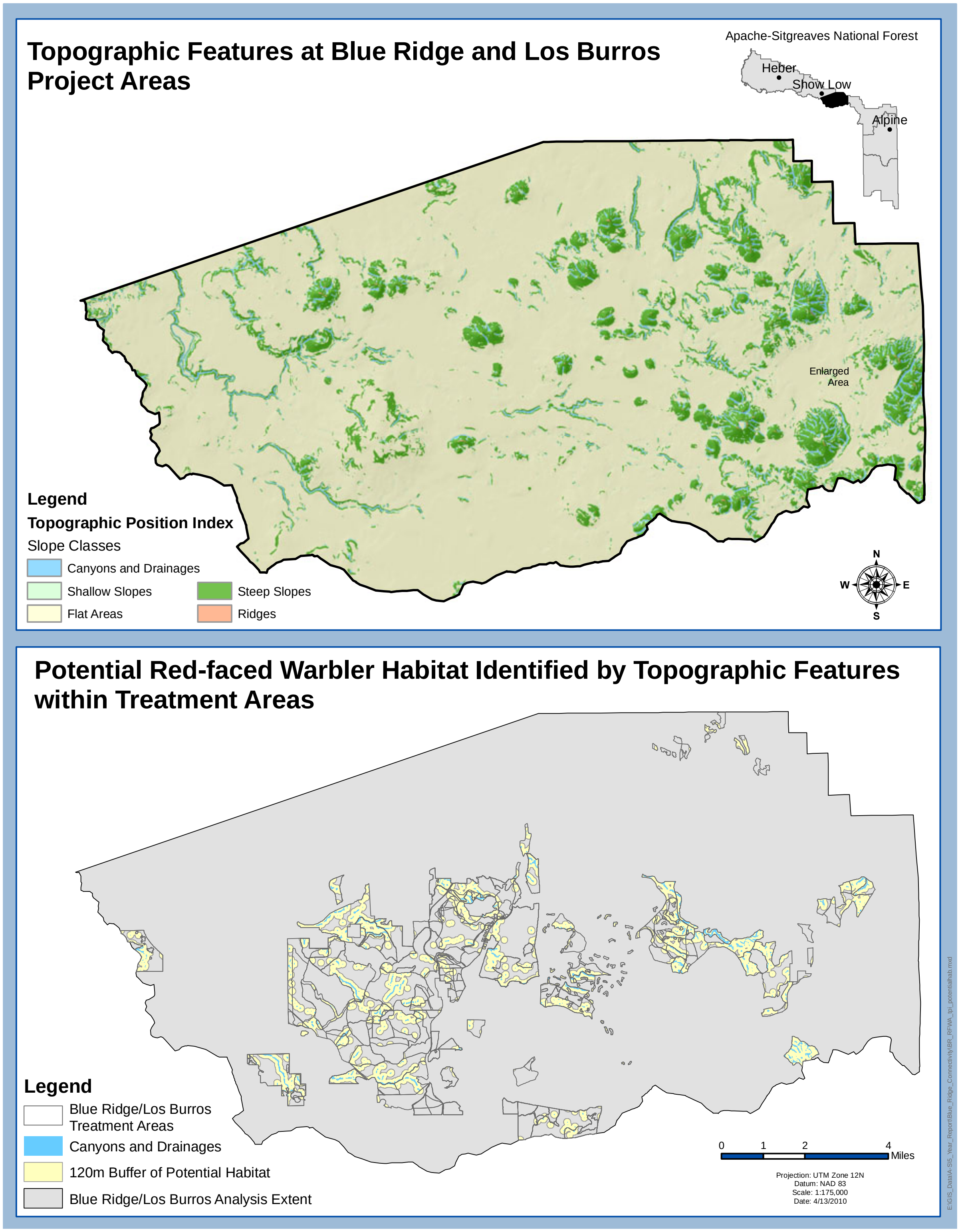
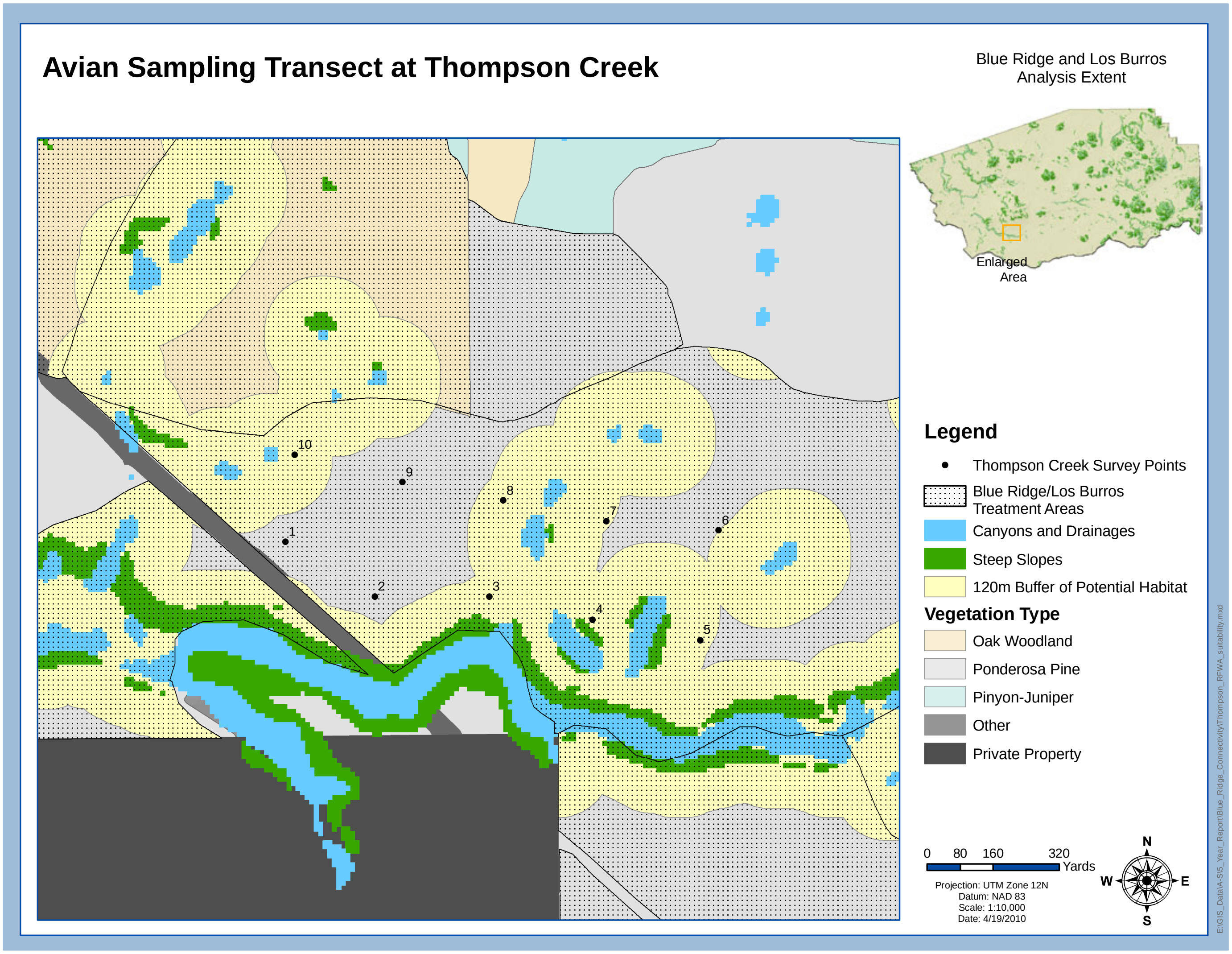


Figure 19. Areas of known red-faced warbler habitat occupancy during multiple years of avian surveys in the Blue Ridge project area treated under the White Mountain Stewardship Project



Point 8 has consistently recorded red-faced warblers in songbird surveys conducted 2007-2010.

Northern Goshawk

Natural History

The northern goshawk is the largest member of the Accipiter family in North America, weighing approximately 2.1 lbs. (Reynolds et al. 1992). In North America, the northern goshawk is a habitat generalist, utilizing all major forest types (i.e., coniferous, deciduous, and mixed). The goshawk, like other accipiters, is morphologically adapted for high maneuverability in forests for hunting (Reynolds et al. 1992). They require about five ounces of food per day and prey on small- to medium-sized birds and mammals (Reynolds et al. 1992). The northern goshawk's short, rounded wings allow them to take prey on the ground or in the air (Reynolds et al. 1992).

The northern goshawk has a Holarctic distribution; in North America it is widely distributed from the boreal forests in Canada to montane forests in the U.S. and Mexico. However, there is concern that goshawk populations and reproduction have been declining in the Southwest (Reynolds et al. 1992). The USFS's Southwestern Region listed the northern goshawk as a "sensitive species" in 1992 (USDA Forest Service 1991). In 1996, a region-wide decision was made to amend all LMPs in Arizona and New Mexico to manage forests for the safeguarding of viable populations of this species. Since this time, there has been considerable debate in the scientific and management community on what the habitat requirements are for goshawks in Arizona.

There are three main categories of habitat for goshawks described in the MRNG (Reynolds et al. 1992): nesting areas (core and alternate nests; approximately 30 acres); post-fledging family areas (PFAs; 420 acres surrounding the nest area); and foraging areas (FAs; 5,400 acres of larger intact habitat surrounding nest areas and PFAs). Each habitat category is made up of varying forest structural characteristics ranging from dense, closed-canopy nesting habitat to more open foraging areas that represent a mosaic of forest structures primarily to meet habitat requirements for the goshawk's multiple prey species.

Analysis

The variety of habitat used by this species is broad in scope, making management and modeling efforts for this species difficult. Due to the complex habitat requirements needed by this species and its prey, connectivity may not be the appropriate metric to address habitat requirements for this species. We chose to delay the modeling effort until more information is available for this species. Prey population studies and monitoring efforts of nests in goshawk treatment areas are currently being conducted in the Eagar South demonstration area to further inform this discussion. Other research in identifying and predicting goshawk habitat is currently underway, led by researchers at Northern Arizona University *(B. Dickson, personal communication).*

Avian Community

Overview: Breeding songbirds are a strong indicator of the overall diversity and health of a forested ecosystem; in addition, survey protocols have been refined over decades of testing and are recognized as successful measures of forest health. Individual species may use specific and unique habitat features that can be assessed or quantified with the presence or absence of these species. An undesirable change in species composition in a post-treatment environment may promote further evaluation or modification of treatment prescriptions to meet desired conditions.

The Board and the ASNF prioritized a songbird monitoring protocol for the Project. The protocol was initiated in 2007; surveys have been conducted each year since implementation. Songbird populations were scheduled to be monitored in four vegetation types: ponderosa pine, mixed conifer, pine-oak, and pinyon-juniper. However, few areas have been sampled in mixed conifer forests to date, and therefore the analysis of this vegetation type was not included in this report.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

Did forest treatments alter avian density?

Forest fuel reduction treatments implemented under the Project altered avian density in ponderosa pine. All species evaluated had higher density estimates in treated areas than in untreated areas sampled. Additional songbird surveys need to be completed in treated pine-oak and pinyon-juniper stands to facilitate the evaluation of changes in density in these vegetation types.

Did forest treatments alter avian composition?

Forest treatments had little impact on avian species composition among pre- and post-treatment periods. In all vegetation types, we detected species in pre-treatment surveys that were not detected during post-treatment surveys. Likewise, the reverse is also true in all vegetation types assessed. The detection of certain species is patchy by nature, but may warrant additional attention in future analysis years if their absence persists.

Did forest treatments move the avian diversity index toward desired conditions?

The avian diversity analysis provides mixed results. In ponderosa pine and pine-oak vegetation types, species richness and evenness are similar among pre- and post-treatment estimates. However, species richness and evenness were reduced in post-treatment estimates in pinyon-juniper vegetation. This reduction in diversity indices in pinyon-juniper is likely due to a small sample size and should be reevaluated when more data are available.

The diversity indices do tell us that forest treatments implemented under the Project are not negatively impacting avian diversity in ponderosa pine or pine-oak habitats. In pine-oak, we found that species evenness actually improved, providing additional evidence that some species are benefiting from forest treatments.

Analyzing the Avian Community

Research has shown that forest fuel reduction treatments can impact songbird habitat in the Southwest. Some species prefer dense canopy forests while others prefer open stands or structural diversity. Currently, the monitoring focus was to evaluate the impacts of the Project on the avian community by comparing bird densities, composition, and diversity indices between untreated and treated areas.

To assess the effects of forest fuel reduction treatments on avian density, composition, and diversity, the ASNF staff and partners surveyed songbirds during the breeding season (late May to late June) using a point-transect protocol. Songbird surveys were initiated in 2007, and are planned to continue throughout the duration of the Project. Point-transects were established in treated and untreated ponderosa pine, pine-oak, and pinyon-juniper stands. Transects generally included ten points, but may vary depending on the topography, stand conditions, and unit size. Points were placed at least 820 ft (250 m) apart. Because forest treatments have focused mainly on ponderosa pine, this is the only vegetation type with enough surveys completed in treated areas to analyze changes in songbird density. Pre-treatment analyses of songbird density in pine-oak and pinyon-juniper were completed to establish a baseline of density estimates for future comparisons with treated areas in those vegetation types. Songbird density was calculated using Program DISTANCE (version 5.0; Thomas et al. 2005). This program adjusts raw count data by the probability of detecting that species, and provides a more accurate density estimate. For example, you are more likely to detect a bird closer to you than one farther away, which would provide a bias estimate of the total number of birds in your sample area. Songbird diversity and composition were calculated using the EstimateS Software Program (V8.2; Colwell 2005). Specific statistical methodologies for each program are detailed in Appendix B.

Results and Discussion

Over all sampling years (2007-2009), a total of 733 points were surveyed ($n = 271$ in ponderosa pine; $n = 246$ in pinyon-juniper; $n = 216$ in pine-oak), accumulating 3,505 detections among 85 species. A minimum of 30 detections was required to estimate the density of that species in each vegetation type under each treatment condition (at least 30 detections in treated and 30 in untreated areas). Many species detected over the course of the surveys did not meet these requirements and were therefore excluded from the analysis. Generally speaking, the species represented in the analysis were the only species that had enough detections to be evaluated.

Songbird Density

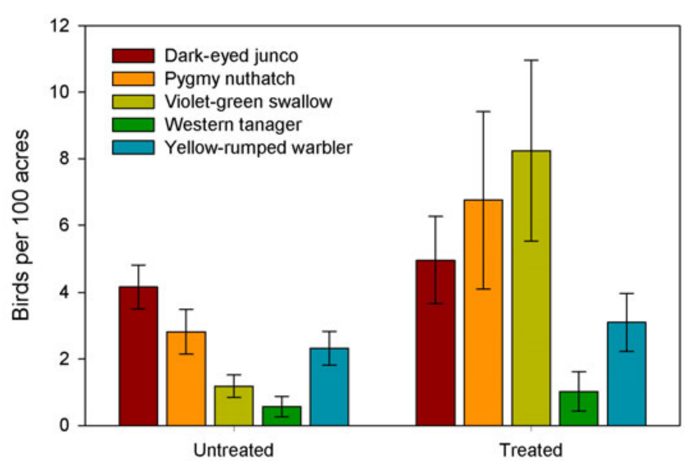
Consistent with previous research, responses to forest treatments among focal species varied considerably (Hurteau et al. 2008; Dickson et al. 2009). Because of the low number of detections in treated areas, changes in density were only assessed in the ponderosa pine vegetation type. In the pine-oak and pinyon-juniper vegetation types, baseline densities were calculated in pre-treatment conditions only for focal species; as treated area samples accumulate, future changes can be assessed.

Ponderosa Pine

The suite of focal species included in the ponderosa pine type that met the minimum number of detections for analysis were dark-eyed junco (*Junco hyemalis*), pygmy nuthatch (*Sitta pygmaea*), violet-green swallow (*Tachycineta thalassina*), western tanager (*Piranga ludoviciana*), and yellow-rumped warbler (*Dendroica coronata*). All species had a higher density in treated areas than untreated areas sampled. The greatest difference in density between treated and untreated estimates was seen in pygmy nuthatch and violet-green swallow populations. Interestingly, these species are secondary cavity nesters and are dependent on the availability of snags with developed nest cavities, some of which were removed during treatment implementation. Dark-eyed juncos are ground foragers, and have been shown to benefit from the removal of fuels and increased growth of the herbaceous understory for nesting and foraging. Western tanagers and yellow-rumped warblers are canopy foragers and utilize a wide range of structural characteristics which may help keep their density levels stable while forest conditions change through time.

Western tanager

Figure 20. Density estimates (individuals/100 acres ± SE) for five focal avian species in untreated and treated ponderosa pine vegetation type surveyed under the White Mountain Stewardship Project



Pine-Oak

The suite of focal species included in the pine-oak vegetation type that met the minimum number of pre-treatment detections for analysis were dark-eyed junco, Grace's warbler (*Dendroica graciae*), mountain chickadee (*Poecile gambeli*), plumbeous vireo (*Vireo plumbeus*), pygmy nuthatch, and white-breasted nuthatch (*Sitta carolinensis)*. The three species more common to forests mixed with conifers and deciduous trees include Grace's warbler, plumbeous vireo, and white-breasted nuthatch. In particular, the Grace's warbler is associated with the pine-oak habitat type. Species found in the pine-oak habitat type would be expected to benefit from the removal of some pine near large oak trees to allow for competition release and recruitment of new seedlings. This analysis was completed to create baseline density estimates in untreated areas. As more surveys are completed in post-treatment areas, changes in density among sampling periods will be assessed further.

Pinyon-Juniper

The suite of focal species included in the pinyon-juniper vegetation type that met the minimum number of pre-treatment detections for analysis were ash-throated flycatcher (*Myiarchus cinerascens*), black-throated gray warbler (*Dendroica nigrescens*), bushtit (*Psaltriparus minimus*), chipping sparrow (*Spizella passerina*), gray flycatcher (*Empidonax wrightii*), and mountain chickadee. Ash-throated flycatchers, black-throated gray warblers, and gray flycatchers are most commonly found in pinyon-juniper woodlands. Bushtit and chipping sparrows are found in pinyon-juniper woodlands, forest edges, or pine-oak woodlands, respectively. These species are likely to benefit from moderate treatment of this habitat type. Maintaining foraging and nesting sites through the retention of large trees will likely improve habitat quality for these species. This analysis was completed to create baseline density estimates in untreated areas. As additional surveys are completed in post-treatment areas, changes in density among sampling periods will be assessed.

Figure 21. Density estimates (individuals/100 acres ± SE) for six focal avian species in untreated ponderosa pine-oak vegetation type surveyed under the White Mountain Stewardship Project

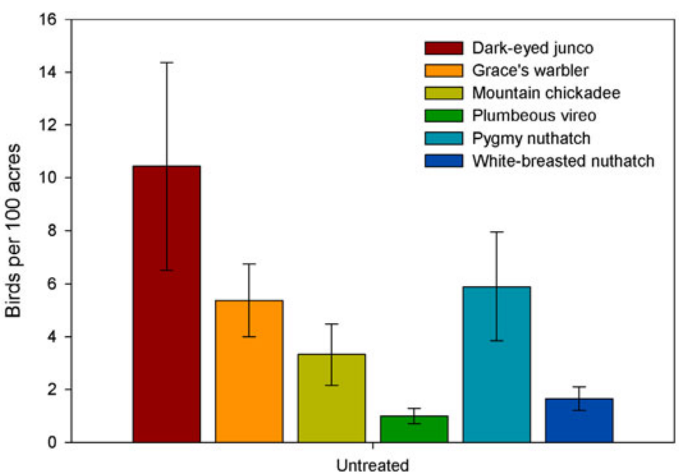
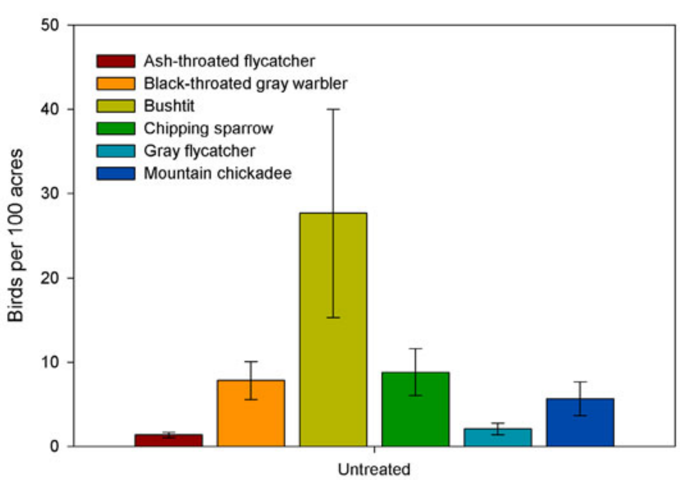


Figure 22. Density estimates (individuals/100 acres ± SE) for six focal avian species in untreated pinyon-juniper vegetation type surveyed under the White Mountain Stewardship Project.



Plumbeous vireo

Songbird Composition

Species composition was difficult to assess for all vegetation types during pre- and post- treatment periods. Most species detected in pre-treatment surveys were also detected in post-treatment surveys for ponderosa pine. In all three vegetation types, there were species detected in only post-treatment or pre-treatment surveys. For ponderosa pine we found that brown creepers (*Certhia americana*), gray flycatchers (*Empidonax wrightii*), olive warblers (*Peucedramus taeniatus*), and Hutton's vireos (*Vireo huttoni*) were absent in the post-treatment surveys. Due to obtaining only one year of post-treatment survey data, drawing conclusions regarding long-term impacts of forest treatments for these species may be premature. Other species were also not detected post-treatment likely due to the patchy nature of their occurrence and distribution. However, changes in occurrence of these and other species will continue to be monitored over the duration of the Project. If monitoring data suggest that an apparent loss of a species in treated areas is not meeting the objectives of the Project, management strategies will be researched and recommended. For a complete list of species detected in each vegetation type, please see Appendix E. These sample sizes will continue to increase as surveys proceed throughout the duration of the Project. Increased sample sizes will allow for the ability to improve the level of robustness for these analyses, and to better determine if there are species consistently seen in pre-treatment conditions that are not consistently observed in post-treatment conditions.

Figure 23. Estimates of mean species richness (First Order Jackknife ± SD) for three vegetation types surveyed under the White Mountain Stewardship Project

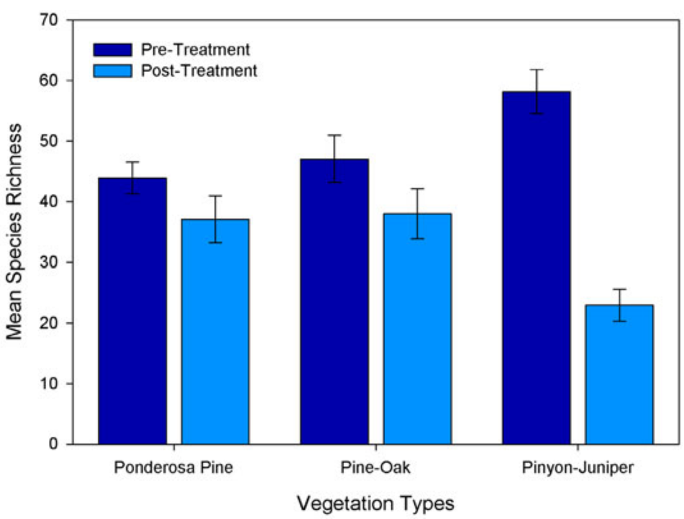
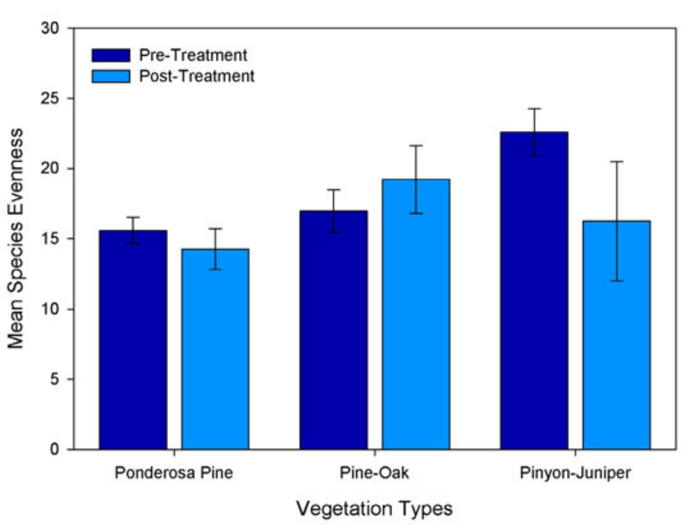


Figure 24. Estimates of mean species evenness (Inverse of Simpson's Index ± SD) for three vegetation types surveyed under the White Mountain Stewardship Project



Songbird Diversity

Species richness (first order jackknife) in this analysis was used as an estimated measure of avian diversity. Estimates of species richness were calculated for each vegetation type independently because of the assumptions of the avian assemblage that may be represented in these surveys. Results from this analysis indicate species richness was higher in pre-treatment areas than post-treatment areas in all three vegetation types assessed. In ponderosa pine and pine-oak vegetation types, there was only a slight decline in the mean species richness estimated from the pre- to post-treatment period, suggesting that forest treatments are not unduly influencing avian populations. The greatest decrease in species richness was found in the pinyon-juniper vegetation type; however, there were very few post-treatment surveys completed in this vegetation type, and the reduction may be due to the small sample size. We recommend that this measure be re-evaluated when more post-treatment areas have been surveyed, as drawing conclusions with limited data is likely to be premature.

Species evenness is a measure of equitability among species' abundance across the areas sampled. Evenness is commonly considered another aspect of diversity, and the measure we used to estimate species evenness also incorporates a measure of dominance instead of richness. The Simpson's index of diversity was used in this analysis, which is a more robust measure of species evenness. Evenness was relatively similar between pre- and post-treatment surveys in ponderosa pine and increased in post-treatment areas in pine-oak vegetation. Species evenness was reduced in post-treatment pinyon-juniper vegetation, again likely due to small sample size.

These results suggest that as changes to forest structure and diversity are made, the avian community will respond to those changes, which should be detected as more data accumulates.

Black Bear

Overview: Black bears are wide-ranging, large mammals that are dependent upon mid-level vegetation for cover, movement, and some food resources. As with other large mammals, when their habitat is retained, many additional species benefit as a result. Bears were selected for study because of the potential impacts the Project's forest treatments may have. These treatments generally increase crown base height (removing mid-level ladder fuels made up of small trees and shrubs), modifying a key vegetation structural characteristic. The Board and ASNF collaborated with the AGFD to initiate a multi-year research project to: 1) determine differences, if any, in black bear selection of treated or untreated patches and resource use within patches; and 2) examine temporal use of selected patches to determine seasonal differences in habitat selection.

The AGFD established the Black Bear Study Area (BBSA) around the Alpine, Greer, and Nutrioso communities and adjacent treatment areas for this project. Research included trapping and outfitting black bears with Global Positioning System (GPS) satellite collars for tracking movements and conducting vegetation studies to compare usage among different habitats. The first three research seasons were primarily focused on obtaining bear movements and vegetation data in pre-treatment conditions. In 2008 and 2009, the first post-treatment data sets were gathered. The study is anticipated to conclude in 2012, with a final report issued in 2013.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

Did forest treatments significantly alter bear movement?

The project is not complete. However, preliminary data indicate that treatments in ponderosa pine vegetation should not significantly alter bear movements. Treatments in mixed conifer vegetation may have an impact if mid-level vegetation is removed.

Do bears avoid or prefer treated areas?

While black bears are a wide-ranging species often moving through a diverse array of habitats, they tend to significantly favor mixed conifer vegetation, especially patches adjacent to meadows and mast-producing species such as oak. If mixed conifer treatments remove a significant amount of mid-story fuels and trees, black bears will likely select untreated areas. Black bears do not appear to select for ponderosa pine in either treated or untreated patches, although both areas may be used by black bears as they move to other preferred habitat types.

Is bear movement correlated with topographic features or forest attributes?

Bear movement is correlated with forest attributes; specifically dense mixed conifer vegetation adjacent to meadows and mast-producing (i.e., oak) patches. Bear movements have not yet been tested for correlations with topographic features.

Analyzing Black Bear Habitat Selection

Fuel reduction treatments generally focus on three key objectives: 1) decrease the amount of dead and down woody material on the ground; 2) increase crown base height by decreasing ladder fuels; and 3) reduce crown bulk density within the canopy. Black bears (*Ursus americanus*) were selected by the Board as a key species for monitoring due to their association with ground- to mid-level cover that is often the target of fuel reduction treatments. They are representative of species that may be affected by these treatments. The Board worked with the AGFD to develop a research project to investigate black bear habitat selection in response to fuel reduction treatments in the Project area. The AGFD designed an experimental study to test the widely-held hypothesis that forest fuel reduction treatments will be avoided by black bears. Specific objectives are threefold: 1) determine differences in black bear selection of fuel reduction treatment areas (patch or selection of specific habitat components); 2) describe habitat selection by season in various stand conditions (within patch or use of habitat components selected); and 3) examine if differences exist in selection of stand conditions during daytime (diurnal) or dawn/dusk (crepuscular) and nighttime (nocturnal) periods. Fuel reduction treatments have yet to be fully implemented; the majority of current data are from pre-treatment conditions. Some post-treatment data have been collected; however, it should be understood that most conclusions are not definitive and are based on incomplete datasets. The project is intended to collect movement data through 2012, with a final report provided to the Board and the ASNF upon completion of the analysis in 2013.

The Black Bear Study Area (BBSA) was located in the forested areas surrounding Alpine, Greer, and Nutrioso, which are encompassed by the Alpine WUI, Greer, and Nutrioso analysis areas. The area is characterized by an elevational gradient ranging from 4,265 – 9,845 ft, with habitat associations characteristic of Rocky Mountain montane and subalpine conifer forests (Brown et al. 1979). Areas above 8,860 ft are predominantly comprised of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), and blue spruce (*Picea pungens*) associations occur between 7,800 and 9,000 ft; ponderosa pine, Gambel oak, and aspen (*Populus tremuloides*) occur at lower elevations (<7,800 ft). The BBSA is almost entirely located within the ASNF.

Beginning in the summer of 2006, black bears were captured and fitted with GPS satellite tracking collars, which were programmed to acquire locations every four hours. Point locations were imported into a GIS program and used to map home ranges. Locations and ranges were stratified by season (spring, summer, and fall). Vegetation sample plots were established within fuel treatment areas and reference (untreated) forest stands to define and analyze habitat use and selection. Pre- and post-treatment locations were compared to determine any changes in habitat selection. A more detailed description of methodologies and statistical analysis techniques can be found in Appendix B.

Results and Discussion

To date, 31 adult bears have been captured and outfitted with GPS collars. Over 4,200 GPS locations (21 individuals) have been obtained for pre-treatment movements and over 4,500 (10 individuals) for post-treatment locations. Radio-collared bears have ranged from western New Mexico to the FAIR. Home range sizes varied by sex with females averaging 29.8 mi^2 (95% CI= 21.7 – 37.3 mi^2), whereas males averaged 74.6 mi^2 (95% CI= 62.5 – 88.6 mi^2). Estimates of maximum distance moved per day varied by sex and seasonal interval. During den emergence, estimated distances moved by males ranged from 1.2 – 6.8 mi, whereas distances moved by females ranged from 0.6 – 4.3 mi. By fall, distances moved by males ranged from 5.6 – 14.3 mi, whereas distances moved by females ranged from 6.2 – 11.2 mi.

During den emergence, the probability of black bear occurrence increased in meadow/grassland and mixed conifer habitats of modest slope (<15°). The estimated odds ratio for meadow/grassland selection was 1.7 times greater than that for mixed conifer habitats. In contrast, for early summer, nearly equal probabilities of occurrence in meadow/grassland and mixed conifer habitats were observed. During this seasonal interval, meadow/grassland and mixed conifer selection were 1.4 and 1.2 times greater, respectively, than for ponderosa pine. Finally, during late fall, the probability of bear occurrence increased in mixed conifer and oak habitats (with increasing slope >15°), and decreased in meadow/grassland habitats. During all intervals, the probability of black bear occurrence increased with distance from roads and decreased with distance from water.

To estimate resource selection by black bears, micro-habitat information was collected at both bear location plots (n = 155) and randomly-generated "available" plots (n = 131). Ants, acorns (*Quercus* spp.), squawroot (*Conopholis mexicana*), grass, and gooseberry (*Ribes pinetorum*) had significantly higher occurrences at bear point locations than available plots. Ants had the largest odds ratio at 13.9, with an observed difference in plot frequency of 38.9% for bear point locations and only 4.4% for available plots. Although not as substantial, acorns and squawroot also had high odds ratios of 6.7 and 5.4, respectively. Grass and gooseberry had smaller, but still significant odds ratios of 2.4 and 1.8. For bear point locations where mast-producing (hard and soft) species were present, soft mast (fruit) production for gooseberry averaged 25,749 berries/acre while hard mast production averaged 47,895 acorns/acre. At reference plots, soft mast production for gooseberry averaged 8,825 berries/acre and hard mast production averaged 20,000 acorns/acre.

Using locations collected in 2006-2009, the AGFD determined how black bears use available habitat types and physiographic features prior to fuel reduction treatments. Some preliminary

post-treatment use data has been collected, but the dataset is not yet complete. Preliminary results suggest that bears appear to be very specific in the selection of habitats, and selection patterns were influenced by bear nutritional status. As the season progressed from early spring through late fall, patterns of resource selection by bears shifted from a disproportionate use of meadows and grasslands to a similarly disproportionate use of oak patches. However, bears consistently used mixed conifer habitats regardless of seasonal interval. The consistent use of mixed conifer habitats highlights its importance to bears. Bears likely prefer mixed conifer habitats because they are often characterized by multi-story canopies, moderate slopes (>15°), and dense horizontal cover. Such habitat types appear to meet requirements for both bedding and foraging sites, particularly when located near water features (LeCount and Yarchin 1990).

As in previous studies (Lindzey and Meslow 1977; Young and Beecham 1986; McLellan 1998; Neilsen et al. 2002), bears displayed a strong avoidance of roads. Avoidance of roads is understandable because nearly all human activity (including forest management) in the BBSA occurs along primary, secondary, and temporary roads. Thus it appears that avoidance of roads by bears is motivated by two factors: 1) general aversion to human activity; and 2) effects of forest management activities that occur at roadsides. The latter is of concern since it is the focus of the AGFD study and represents a disturbance sustained over a greater temporal scale. Forest management practices that reduce structural complexity may degrade the value of habitat to bears, particularly when these treatments occur in mixed conifer habitats. Mid-level structural complexity is a habitat component used by bears for both foraging and protective cover; when management activities reduce either, the focal habitat is degraded to some extent (LeCount and Yarchin 1990). The magnitude of degradation, as perceived by bears, may not be fully evaluated until a full analysis of post-treatment data (both vegetative and movement) is completed.

While the project determines which habitats bears prefer, it also makes note of habitats that were underutilized. Data suggests that bears generally avoided ponderosa pine habitat. Avoidance of ponderosa pine may likely be a result of a lack of structural complexity and food resources within that habitat

Figure 25. Movement variations of two bears near Greer, AZ

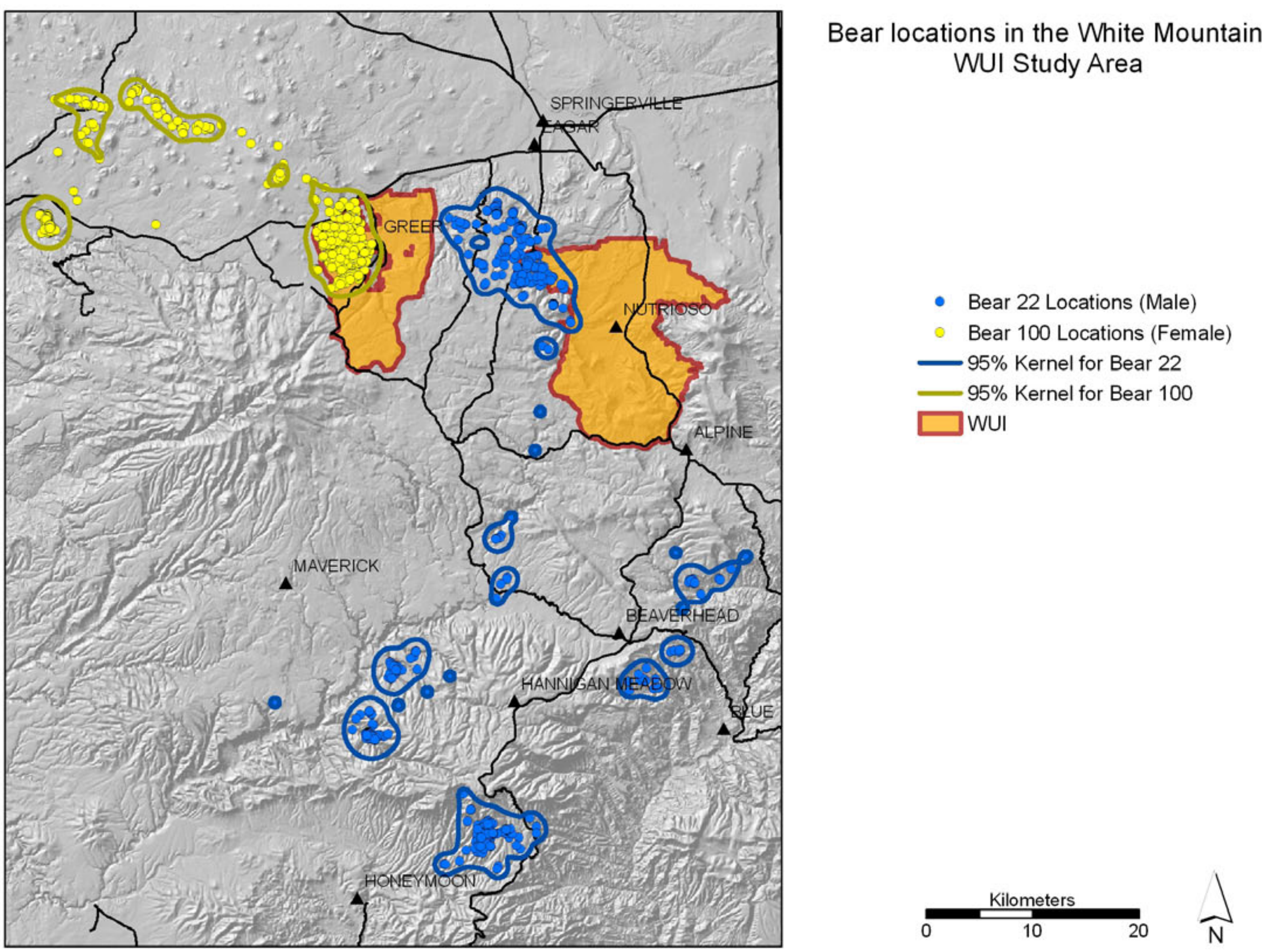
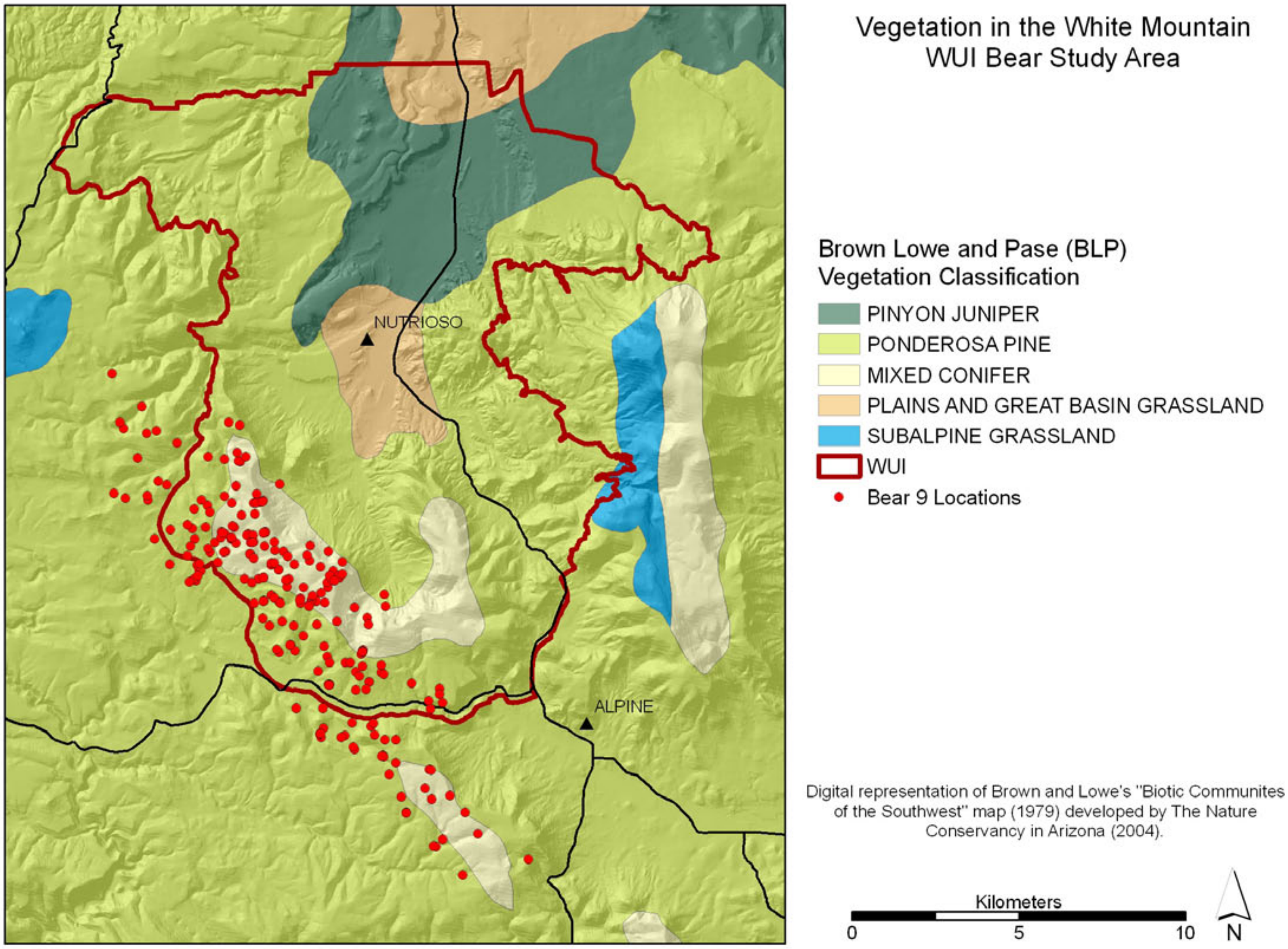


Figure 26. Black bear use of mixed conifer vegetation patches in the Nutrioso area



type. With regards to the former, of the 37 day beds examined, 19 were located in mixed conifer habitat, 11 were located in oak stands, and 7 were located in ponderosa pine. As for the latter, the plot frequency of gooseberry averaged 25.6% in mixed conifer compared to 11.7% in ponderosa pine. Moreover, many of the meadow/grassland point locations visited by bears during den emergence were adjacent to mixed conifer habitats, indicating a favoring of this juxtaposition of forage close to protective cover.

Future Work

The AGFD intends to capture and radio collar 16 more black bears over the next two years. This will ensure adequate post-treatment locations from a statistically-valid number of individuals and provide parity to the pre-treatment sample size. Post-treatment vegetation information will also be collected at both randomly-generated plots and bear-use sites over the next two years to establish the impacts of forest treatments on black bear habitat selection.

Radio-collared and tagged bear

Soil Compaction

Overview: Mechanical equipment used to thin small-diameter trees under the Project has the potential to disturb and compact soil resources, depending upon the treatment intensity, type of equipment used, soil properties, and soil moisture at the time of treatment. Soil compaction reduces water infiltration, increases runoff and erosion potential, inhibits root growth, and reduces overall site productivity. In general, soil compaction may be spatially minimized by concentrating heavy equipment on defined skid trails and roads. The equipment used in the Project is generally lighter than larger machinery traditionally used in logging, but is crossing more ground more often due to the need to collect targeted trees individually or in small bunches for delivery to landing sites.

Soil compaction monitoring was conducted in 2007 and 2008, measuring changes to three indicators: soil disturbance classes, soil bulk density, and soil surface resistance. In most cases, increases were seen in soil bulk density and soil resistance post-treatment. Changes were categorized as insignificant, moderate, or significant. Significant impacts were often localized and found on roads, skid trails, and landings. The soil penetrometer, used to measure surface resistance, proved to be problematic and gave unreliable results on thin, already compacted and/or rocky soil (Disturbance Class 3); data on those soils were found to be inaccurate and therefore discarded. ASNF staff recommend using a different penetrometer for future monitoring efforts.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

Did forest treatments result in compacted soil?

In 69% of the treatment monitoring areas, often receiving one-time crossings by equipment, soil compaction had either minimal or no effect (less than a 5% increase in soil bulk density and surface resistance). In 16% of the monitoring areas, mostly found in existing moderately-disturbed sites (roads, landings, skid trails), a 24% increase in soil bulk density was recorded, signifying an unsatisfactory increase. In general, equipment usage across the landscape did not significantly impact soil resources. Long-term monitoring of site productivity will allow managers to determine appropriate plant and soil recovery time.

Analyzing Soil Compaction

Analyzing soil compaction helps the ASNF understand the effect mechanical treatments have on soil layers, which in turn influence the rate of plant growth, erosion capacity, and water infiltration. Mechanical treatments have various degrees of impact. The ASNF monitored the impacts of equipment operation in a random sample of pre- and post-treatment areas to understand the level of compaction across the landscape using an approach that measured changes in soil disturbance classification, soil bulk density, and surface resistance.

Monitoring sites were selected at random, with the goal of sampling 10% of all cutting units in selected treatment areas. Sites were selected for monitoring in both 2007 ($n = 9$) and 2008 ($n = 6$) in the Alpine, Greer, and Mineral analysis areas. Each site is analyzed for its percentage within four Disturbance Classification categories, allowing for comparisons between

Table 9. Soil disturbance classifications and descriptions

Disturbance Classification	General Description
0 – Undisturbed	No evidence of past equipment use; no wheel tracks or depressions; no soil displacement; litter, duff, and forest floor layers present and intact
1 – Minimal disturbance	Faint wheel tracks; compaction slightly greater than natural; slight depressions evident but are <5 cm depth; burning evidence light; duff and forest floor layers present
2 – Moderate disturbance	Wheel tracks or depressions are 5-10 cm depth; surface soil partially mixed with subsoil; moderate burn evidence—duff charred or consumed; forest floor layers partially intact or may be mixed with subsoil
3 – Heavy disturbance	Wheel tracks or depressions >10 cm depth; forest floor layers missing; evidence of soil removal, gouging, and/or piling; duff and litter removed completely; roots do not penetrate; surface soil has been displaced

Example of Disturbance Class 0 (undisturbed)

Example of Disturbance Class 1 (minimal disturbance)

Example of Disturbance Class 2 (moderate disturbance)

Example of Disturbance Class 3 (heavy disturbance)

different classifications at the same general site. The ASNF uses the Region 1 Visual Disturbance Classification Guidelines, which describe four different categories distinguishable by visual observation in the field. Table 9 describes the characteristics of each of the four disturbance classes. The percentage of area within each disturbance class at every monitoring site was recorded for both pre- and post-treatment periods.

Once pre-treatment disturbance classifications are documented, soil compaction is analyzed at multiple sample points within each disturbance class for each monitoring site. Soil compaction is analyzed by: 1) changes in soil bulk density; and 2) changes in surface resistance to penetration. An increase in soil bulk density indicates that movement of air and water within the soil has been reduced, and that the soil may be less favorable for plant growth or be more likely to erode. Within the monitoring sites, a total of 64 bulk density samples were taken post-treatment. An average from samples taken from Disturbance class 0 provided the baseline reading; other disturbance class readings were measured as a departure from that baseline figure. Bulk density is measured utilizing a slide-hammer bulk density sampler which outputs soil density readings in g/cm^3.

Surface resistance is an indicator of how much soil resists vertical penetration. The more compact the soil, the higher the level of resistance. Soil resistance is measured by kilopascals (kPa) and is measured using a CP 40-II electronic cone penetrometer. A total of 162 samples were taken from six units monitored (nine readings per disturbance class per site; not all sites may have examples of each disturbance class). The averages of each disturbance class were calculated. The penetrometer proved to be incapable of measuring areas of heavy soil compaction (Disturbance Class 3) due to its inability to probe below the immediate soil surface; or, if able to break through, gave unreliable and inaccurate data. This data was excluded from this analysis.

Soil bulk density and surface resistance are measured under pre- and post-treatment conditions. To monitor sites that have already been treated (thus no pre-treatment sampling available), points are selected in areas that are outside harvested units and within harvested units.

The differences between pre- and post-treatment (or unharvested/harvested) measurements for bulk density and resistance are then calculated; a threshold table determines if these calculated differences result in satisfactory, impaired, or unsatisfactory impacts.

The result is a summary of overall disturbance in the sampling sites by harvesting operations. Impaired and unsatisfactory results were followed up with analyses by ASNF staff, and recommendations were provided for future Project activities.

Table 10. Standard thresholds for compaction and soil disturbance

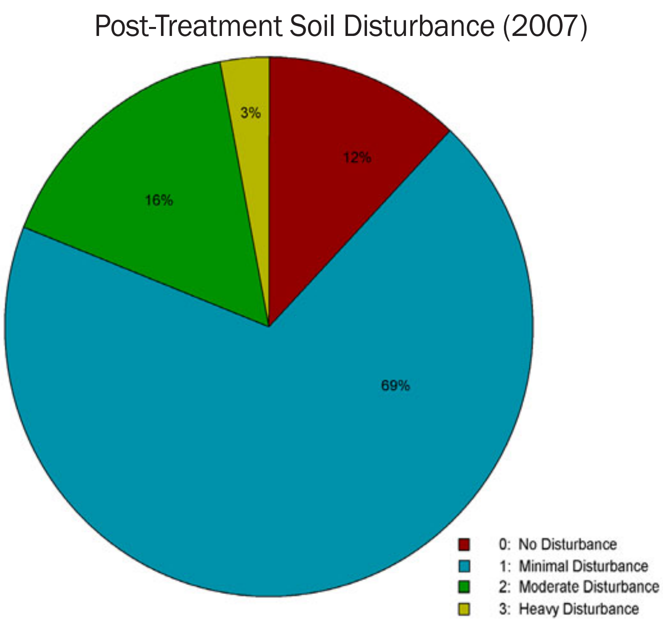
Index	Satisfactory	Impaired	Unsatisfactory
Bulk Density	Slight Increase (1-5%)	Moderate Increase (5-15%)	Significant Increase (>15%)
Infiltration	Slight Decrease (1-10%)	Moderate Decrease (10-50%)	Significant Decrease (>50%)
Penetration Resistance	Slight Increase (1-10%)	Moderate Increase (10-50%)	Significant Increase (>50%)
Aerial Extent	Slight Distirubance (1-5%)	Moderate Disturbance (5-20%)	Significant Disturbance (>20%)

Results and Discussion

Disturbance Classifications

Disturbance classifications for sampled analysis areas indicated that the majority of sites were classified as Disturbance Class 1 (minimal disturbance) both in pre- and post-treatment conditions. Combining Disturbance Classes 0 and 1, 81% of all monitoring sites were found to have minimal or no disturbance after treatments. Alternatively, 19% of the treatment monitoring sites were classified as moderately or heavily disturbed.

Figure 27. Average post-treatment disturbance classifications at all units sampled

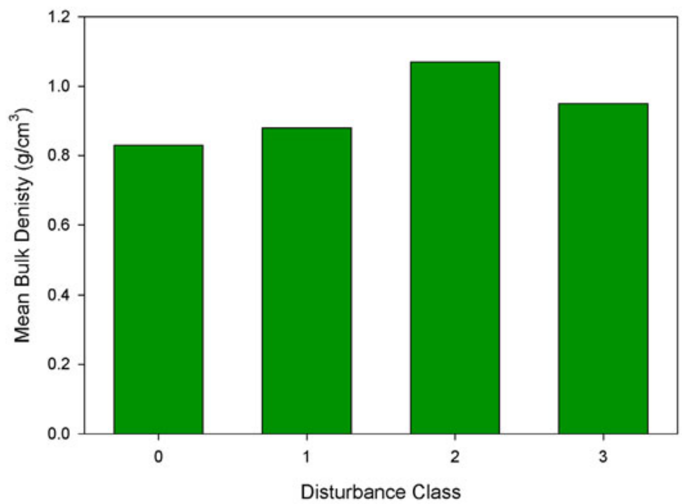


Soil Bulk Density

In general, harvest operations appear to have limited and localized effects on soil compaction. A majority of the sampling units showed minimal erosion, with soil displacement within acceptable guidelines. From the baseline readings in Disturbance Class 0, there was a slight increase (5%) in bulk density reading taken at points within Disturbance Class 1 (69% of the total monitoring area), which ranked as satisfactory. A 24% increase occurred at points within Disturbance Class 2 (16% of the total monitoring area), which ranked as unsatisfactory. A moderate increase (12%) occurred at points within Disturbance Class 3 (3% of the total monitoring area), which ranked as impaired.

ASNF soil scientists noted that most Disturbance Class 2 soils, the classification receiving the unsatisfactory ranking, were found on main skid trails and locations where equipment turned around. Other locations include flat terrain which facilitates equipment access and movement.

Figure 28. Average soil bulk density in each disturbance class for all post-treatment samples



Surface Resistance

Surface resistance readings using the selected penetrometer were only viable for samples taken in soil Disturbance Classes 0, 1, and 2. A total of 54 readings were taken at six different monitoring sites (nine readings per site). The following table describes the pre- and post-treatment penetrometer reading results, averaged across all samples at two soil depths. The penetrometer readings indicate that most compaction occurs in the first 10 cm, but appears to lessen in depth thereafter.

In summary, most impacts to soils appeared to be localized and concentrated in Disturbance Classes 2 and 3. Disturbance Class 1 soils, covering 69% of the treatment and monitoring areas, were generally found in areas that received one-time crossings from equipment. A slight increase in compaction occurred, but on an overall scale, management has controlled the soil disturbance in these areas. Class 2 soils were found throughout the landscape on main skid trails, turnaround areas, and areas where more equipment movement occurred. Class 3 soils were found on landings, major skid trails, and temporary access roads. With a 3% overall coverage of the monitoring areas, this is a relatively low-level impact and one to be expected in treatment areas. Rutting was evident in some areas (Greer A and Mineral A, Unit 10). In the future, the ASNF soil staff recommends concentrating monitoring within Class 2 and 3 soils, including monitoring those areas for soil and plant recovery rates. A different soil penetrometer may assist in obtaining readings in rocky or heavily compacted soils.

Table 11. Surface resistance and percent change at six monitoring sites; average readings in soil Disturbance Classes 0, 1, and 2, in kilopascals (kPa); 2008

Treatment Status	Soil Depth 0 – 5 cm (kPa)	Soil Depth 10 cm (kPa)
Pre-treatment	772	1516
Post-treatment	1343	1833
Percent Change	74%	21%

Photographs illustrating minimal soil compaction at Brookbank analysis area.

Pre-treatment


Post-treatment

Best Management Practices

Overview: Best Management Practices (BMPs) refer to standards developed to minimize adverse impacts from various management activities on water quality. The use of mechanical equipment and the creation of temporary roads and skid trails have standards imposed to ensure limited or no impact on soil erosion or streambank stability. The ASNF staff mandated that the contractor adhere to BMP standards and designed a protocol to monitor both the implementation of these standards and the effectiveness of BMPs on soil and water quality. General results indicate that 60% of the management actions measured ranked out as "effective;" 24% as "effective at risk;" and 16% as "not effective."

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

Did contractors adhere to Best Management Practices?

Implementation monitoring was sporadic. While all contract activities incorporated BMPs, with the contractor required to adhere to these standards and guidelines, data on whether or not these practices were implemented was insufficient. Recommendations were made to increase the consistency and level of contract oversight on implementation of BMPs.

Do Best Management Practices result in maintenance of water quality standards and guidelines?

For the three years that monitoring data was available (2006, 2007, and 2009), 60% of the actions implemented were found to be "effective;" 24% "effective at risk;" and 16% "ineffective." In cases where "ineffective" or "major effect" findings were observed, most instances were due to operations conducted in wet conditions, resulting in rutting of roads; placement of skid roads in sensitive or erosive soils (slopes and riparian areas); and landing reclamation. Earlier closures for wet weather conditions, additional contract oversight specific to water quality issues, and continued training/education of operators was recommended to improve these situations. Where monitoring results indicated "at risk" or "ineffective" results, it was unclear if the ASNF modified or increased the level of site-specific monitoring after the risk was identified.

Analyzing Best Management Practices

Best Management Practices (BMPs) are the primary mechanism to measure and achieve water quality standards embedded within the federal Clean Water Act (Sections 208, 319) and the state-regulated process which oversees compliance with federal standards. BMPs are intended to control non-point sources of pollution and to reduce to the maximum extent possible the level of this pollution from these sources.

The ASNF designed a Best Management Practices Evaluation Program (BMPEP) in 2005 for all mechanical treatments on the Forest, including the Project, based upon site-specific conditions and feasibility. These BMPs were incorporated into every task order. Evaluation of BMPs includes: 1) assessing whether or not the correct BMPs were applied to each project; 2) determining if all BMPs were implemented; 3) if BMPs were effective in meeting water quality standards; and 4) if BMPs were adjusted when needed. Onsite evaluations within the BMPEP protocol helped to answer the above questions. The BMPEP assesses 23 BMPs in eight different categories as shown in Table 12.

Onsite evaluations are the core of the BMPEP. Evaluations were conducted on sites where BMPs were implemented and were based upon stated objectives. Both the implementation and effectiveness of individual BMPs at the sites where the practices have been applied were tracked by ASNF staff. Visual estimates and measurements of conditions were scored according to criteria for their level of effectiveness. Sites were selected both randomly and for specific sites based upon current conditions. For example, all sites where Meadow Protection standards applied were sampled, whereas skid trails were randomly sampled. The implementation portion of the monitoring program is completed prior to the effectiveness monitoring. Effectiveness evaluations were generally monitored after the practices had been exposed to various hydrologic effects. The exceptions were the BMPs that must be evaluated at the time of implementation, including Timber Sale Administration, Streamside Management Zones (SMZs), and Stream Crossing BMPs.

In order to improve understanding of BMPs by the contractor, the ASNF held a workshop in April 2007 to review treatment prescriptions, project objectives, road use, construction, and maintenance, resource protection, and BMP implementation. ASNF staff shared their expertise with the contractor and sub-contractors working on all Project treatments. With projects already underway, examples of both effective and ineffective operations were discussed. The workshop improved communications between ASNF staff and operations at the treatment level to meet site-specific needs and objectives.

Implementation monitoring was designed to answer whether or not BMPs were in fact implemented. In this case, four ratings apply: 1) activity exceeded contract requirements; 2) activity met contract requirements; 3) activity was a minor departure from

Table 12. Categories for assessing Best Management Practices implemented in the White Mountain Stewardship Project

Best Management Practice Category	Practices Evaluated Within Each Category
Streamside Management Zones (SMZs)	Streamside zone designation Streamcourse and aquatic protection Slash treatment in sensitive areas
Skid Trails	Tractor skidding design Erosion control on skid trails
Landings	Log landing location Log landing erosion control
Timber Sale Administration (erosion prevention/control)	Erosion prevention/control during operations Erosion control structure maintenance Acceptance of erosion control measures before sale closure Modification of timber sale contract
Special Erosion Control/Revegetation (disturbed lands)	Special erosion prevention on disturbed land Revegetation of areas disturbed by harvest activities
Meadow Protection	Meadow protection during timber harvesting Slash treatment in sensitive areas Tractor operation limitation in wetlands and meadows
Stream Crossings	General guidelines for location and design of roads Stabilization of road slope surfaces and spoil disposal areas Road slope stabilization and construction practices Control of road drainage Construction of stable embankments
Temporary Roads	Stream crossings on temporary roads Obliteration or decommissioning of roads

contract requirements (implemented substantially, but with minor shortcomings); or 4) activity was a major departure from contract requirements. Based upon the results of the implementation questions, each site was given a composite rating which indicates "implemented," "implemented with minor departure," or "not implemented."

Effectiveness monitoring was designed to answer how effective the practices undertaken were in maintaining water quality standards. Effectiveness was assessed by making measurements or visual estimates at the site of BMP implementation. Parameters were selected based upon site-specific objectives for each individual BMP. Given the multiple parameters measured, various types of forms and responses were completed. Initially, measurements determined whether or not the practice was "effective" (meets criterion); "effective at risk" (a minor departure from being fully effective); or "not effective" (objective not met). All measurements were then compiled into a database which then evaluated the magnitude, duration, and extent of effects of the BMPs, and further summarized each of the eight categories as having "minor," "moderate," or "major" overall effects on water quality.

Results and Discussion

The ASNF monitored BMPs in 2006, 2007, and 2009 on a sample of Project existing task orders. In 2006, all implementation forms were rated as "effectively implemented." In 2007, however, implementation was tracked by a form provided to the Timber Sale Administrator (TSA), which asked simply if specific BMPs were implemented or not. Very few responses were received (no specific numbers provided in 2007 or 2009 reports). BMP implementation occurred on each task order; however, it is difficult to determine the degree to which BMPs were implemented. Therefore, an analysis of implementation is not available for those years.

For effectiveness monitoring, the 23 practices in the eight categories detailed above were monitored randomly at multiple analysis areas. In 2006, 53 practices were monitored at different task orders within four project areas (Alpine, Greer, Little Springs, and Mineral). In 2007, 55 practices were monitored in different task orders within seven project areas (Alpine, Dutch Joe, Greer, Hilltop, Little Springs, Mineral, and Woods Canyon). In 2009, 90 practices were monitored within four project areas (Brookbank, Heber/Overgaard, Trap Springs, and Water Springs). As described above, measurements in all eight categories were given one of three rankings ("effective," "effective at risk," and "not effective").

In assessing the definition of the three rankings, "effective at-risk" is typically used to represent practices that are generally "effective" but have minor departures within an overall "effective" ranking. Data indicate that in general, a majority of measurements rank as "effective" (60%) and "effective at-risk"

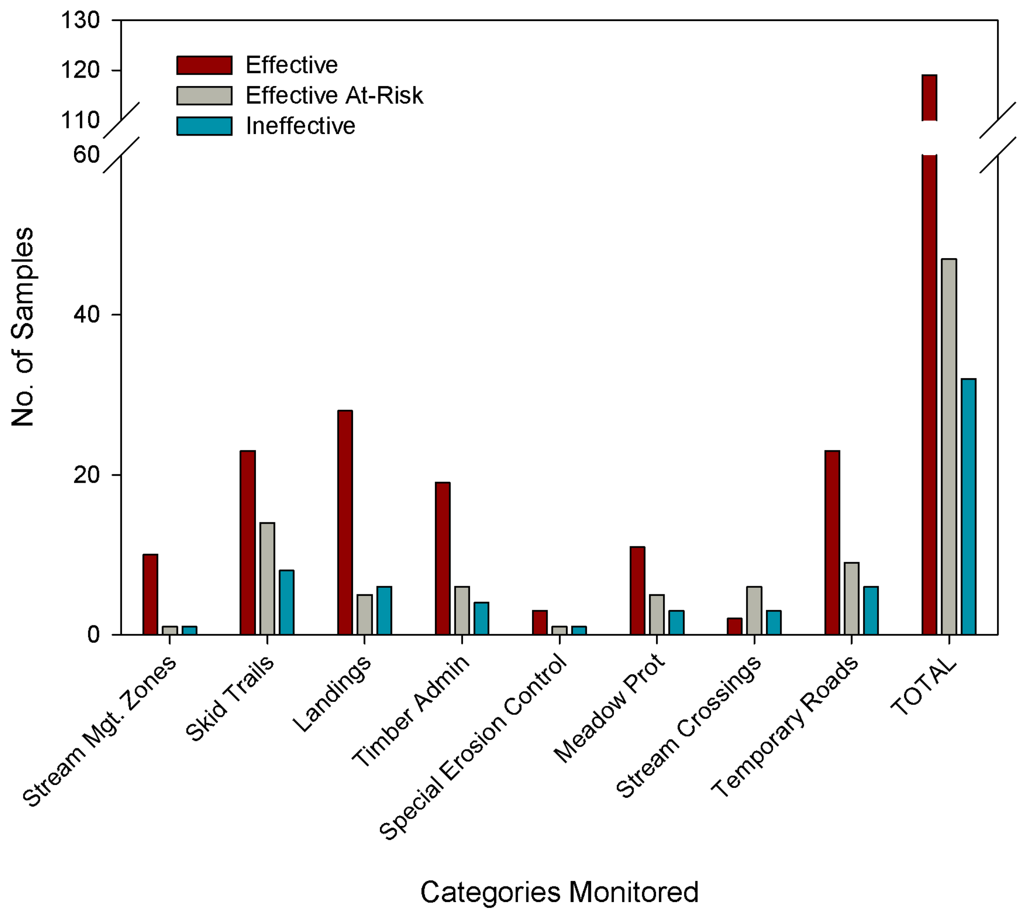
(24%), for a total of 84%, with 16 % ranking as "ineffective."

In the first four years of monitoring BMPs for the Project, site-specific evaluations indicated that in most cases, water quality standards were maintained and BMPs were implemented. While the majority of BMPs were ranked at "effective," deficient rankings that seemed to indicate trends or patterns in BMP effectiveness should be tracked. Deficiency scores included those found in the creation of skid trails on slopes of 30-35% or near drainages, operating under wet conditions and on steep slopes, lack of water bars on skid trails, cut-slope failures, and ruts in roads (primarily due to operating in wet conditions).

Recurring themes in deficiency ratings seem to include poor planning of skid trails, operating during wet conditions, operating on steep slopes, and stream-crossing impacts. Site-specific ineffective measurements could be further classified as an action that occurs in a high-risk area (i.e., drainage, steep slope) or in a low-risk area (i.e., level ground removed from stream channel) in order to determine if an increased level of monitoring is warranted. Recommendations from the ASNF staff for the next five years monitoring include:

- Determine low-risk and high-risk areas, and adjust monitoring to appropriate conditions;
- Improve planning of temporary roads and skid trails;
- Improve active oversight by the timber, contract, and monitoring staff for both implementation and effectiveness, as well as oversight during operations; and
- Improve diligence on closing areas from mechanical operations in wet weather.

Figure 29. Summary of rankings for BMP measurements in 2006, 2007, and 2009



Eagar South Demonstration Area Results

Overview: The ASNF designed the Eagar South demonstration area to integrate fire-risk reduction concepts with multiple resource objectives, including forest restoration principles and the most recent interpretation of northern goshawk management guidelines. The ASNF developed silvicultural prescriptions, tree marking guidelines, and monitoring questions through a collaborative effort with members of the NRWG and the Board. The Eagar South demonstration area is part of the Project; as such, it is included within the overall monitoring effort. However, due to the demonstration classification of the project, additional monitoring questions were formulated by the collaborative group. Results of these specific monitoring questions are included in this section, with results of general Project monitoring for Eagar South included in other ecological analysis sections. Treatment has occurred in the first of three phases; the second phase is scheduled for layout and marking in the summer of 2010. Project-specific monitoring of post-treatment effects only pertains to the first treatment phase.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

Many Eagar South monitoring questions were integrated within the general Project monitoring program, including wildlife habitat connectivity, stand structure, overstory and understory vegetation, fire behavior, and public perceptions, and are included elsewhere in this report. The following questions are specific only to the Eagar South demonstration project and are discussed in this section:

Did treatments improve habitat for northern goshawk prey species?

Of the eight primary prey species studied, first-year survey results show that Abert's squirrel was the only species showing a significantly lower density in treated areas. No statistically significant difference between treated and untreated areas was found in chipmunk densities. Golden-mantled ground squirrels showed a significantly higher density in the treated areas than the control. While initial observations of Steller's jay, northern flicker, and hairy woodpecker showed slightly higher densities in treated areas, certain factors preclude associating these increases with treatments. Mourning doves and rabbits were not found in high enough numbers to statistically test differences in densities. Specific recommendations include leaving more downed woody debris for small mammal habitat and evaluating the basal area within clumps and the size of groups to determine if alternatives could achieve similar resource objective goals, while maintaining denser clumps or larger groups for Abert's squirrel.

Did northern goshawks continue to occupy existing nests in the Eagar South demonstration area?

Yes. The first phase of Eagar South treatments included treatments within a nest area and PFA of a northern goshawk pair. Treatment concluded in 2008 just prior to nesting season; the goshawk pair used that nest, and fledged two young successfully in both 2008 and 2009. Monitoring the nest in subsequent years will determine if that nest-site use was due to site fidelity or site conditions.

How many trees greater than 16" dbh were removed across the treatment area?

A total of 538 trees greater than 16" diameter at breast height (dbh) were removed across the 1,093-acre treatment area. This averaged 0.49 trees per acre.

What was the difference in costs for treatment layout and marking efforts between Eagar South and other typical fire-risk reduction treatments?

The ASNF compared the layout and marking costs of Eager South and the Mineral analysis area, and found that costs were similar, with Eagar South totaling $67.44 per acre, and Mineral totaling $68.34 per acre. Despite a learning curve for incorporating goshawk guidelines at Eagar South, the time spent in the field determining the prescription very quickly decreased to have parity with other fuel reduction treatments.

Was the volume of material removed different from other Project treatments?

From 2004-2007, the volume removed across the entire project area ranged between 11.3 – 58.8 tons per acre, with an average of 30.6 tons per acre. The Eagar South Grapevine project averaged 31 tons per acre removed, nearly equal to the overall Project average.

Analyzing Eagar South

Several aspects of Eagar South monitoring were integrated within the standard Project monitoring protocols. Please see the ecological monitoring sections on wildlife habitat connectivity, stand structure, understory vegetation, and fire behavior for results and discussion. This section will describe only the monitoring results for the above questions.

Ecological Monitoring at Eagar South

Northern Goshawk Prey Study

The AGFD initiated a study in 2009 to compare relative abundance of the most commonly-reported northern goshawk prey in the Eagar South treatment area to an equally-sized control site in a nearby untreated forest (Frary and Ingraldi 2010). Eight focal species or species-groups were surveyed: Abert's squirrel, chipmunks (*Tamias* spp.), golden-mantled ground squirrel (*Spermophilus lateralis*), rabbits (both cottontail [*Sylvilagus* spp.] and black-tailed jackrabbit [*Lepus californicus*]), Steller's jay (*Cyanocitta stelleri*), mourning dove (*Zenaida macroura*), northern flicker (*Colaptes auratus*), and hairy woodpecker (*Picoides villosus*).

Abert's squirrel density was estimated using feeding-sign index counts (Dodd et al. 1998) conducted at 256 points each in treatment and control sites ($n = 512$), spaced evenly along 1837 ft transects. Index counts were conducted over a five-day period in late April 2009.

The AGFD placed Sherman live-traps at 256 points along 328 ft transects in both treatment and control areas ($n = 512$) in June and August 2009 to survey for chipmunks and golden-mantled ground squirrels to calculate relative abundance based on catch-per-unit-effort and mean number of individuals trapped per day.

The four avian species were surveyed once a month during the breeding season (May-July 2009) using point count surveys along linear transects. A point count station was placed every 656 ft. Six transects with six count stations each were established in treatment and control sites ($n = 72$). Point counts were conducted within three hours of sunrise by a single observer to maximize detection and reduce observer bias. Density estimates were calculated using the average number of detections per survey divided by the total area surveyed.

Cottontail and jackrabbit abundance was surveyed using nighttime spotlight counts along roads in treatment and control areas. Surveys also included a preliminary effort to assess the feasibility of pellet counts along transects.

Based on the initial year of surveys, the AGFD's preliminary findings conclude that treatments appear to have positively affected the abundance of golden-mantled ground squirrels and negatively affected the abundance of Abert's squirrels. Golden-mantled ground squirrels clearly responded to a reduction in tree density, basal area, and canopy cover, and were found most often near downed trees, stumps, and rocky hillsides. Conversely, treated areas appear to represent low quality habitat for Abert's squirrels. In the control site, squirrel sign was common and widespread; in the treated site, squirrel sign was limited to the edges of treatment areas adjacent to nearby untreated, dense stands. Abert's squirrels are a primary food resource for the northern goshawk, particularly in winter. While all the research has been conducted in the summer, the apparent absence of squirrel sign in the core of treated areas may cause a shift in foraging areas and prey availability for goshawks. Furthermore, additional research may be warranted to determine the impacts of treatments on winter prey availability.

Abundance of chipmunks was similar between the two sites; however, chipmunks were only found where dead woody debris was present. This was particularly apparent in treated sites; chipmunks were absent where all or the majority of woody debris was removed during treatment.

Table 13. Preliminary results from surveys of northern goshawk prey in Eagar South demonstration area, 2009 (Frary and Ingraldi 2010)

Species	Treated	Control (untreated)	Calculation
Abert's Squirrel	0.05 squirrels/ha	0.32 squirrels/ha	Significantly higher density ($p < .001$) in control/untreated site
Chipmunks	18 captures/day	24 captures/day	No significant difference ($p = .228$)
Golden-mantled Ground Squirrel	23 captures/day	3 captures/day	Significantly higher density ($p = .002$) in treatment areas
Steller's Jay	2.8*	1.4	Higher density in treatment area
Northern Flicker	3.4	2.0	Higher density in treatment area
Hairy Woodpecker	1.2	0.6	Higher density in treatment area
Mourning Dove	0.1	0.1	Rare at both sites
Rabbits (Cottontail and Jackrabbit)	Five (5) total detections over five survey nights; observed few rabbit pellets in both control and treatment sites		Rabbit densities likely very low in both sites

* Avian density figures per 100 acres

The AGFD considers the avian surveys to be inconclusive due to factors that have not yet been analyzed. Factors include the potential for a greater probability of detecting species in treatment areas due to increased visibility and ability to hear sounds from greater distances where forests were more open. In addition, treatment areas occurred in relatively small patches interspersed within untreated patches, which were often aspen, fir, and spruce stands, offering a diversity of habitat. This became problematic when attempting to assess which species were actually using treatment areas when individual birds were heard and not visually observed.

The AGFD plans on continuing this study in 2010 to assess temporal variation in relative abundance of prey species and to address factors that arose in the preliminary analysis. Minor modifications to avian survey methods may be incorporated to allow for a more informative measure of avian species response to treatments. More specific management recommendations will be included in the final report to be submitted in December 2010.

Northern Goshawk Nest Occupation and Reproduction

ASNF biologists and silviculturalists visited the nest area to observe northern goshawk activity throughout the nesting season in both pre-treatment and post-treatment periods. Observations of young in the nest and exhibiting fledging behavior were recorded.

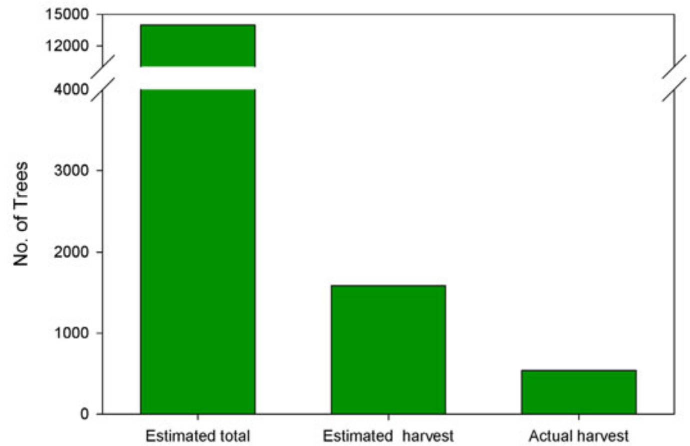
The Eagar South (Grapevine) territory was established in 1999 and has been monitored annually since that time. While establishing this nest territory, the goshawk pair seemed to successfully nest approximately every other year. Prior to treatment, this territory was occupied and produced young in both 2006 and 2007. Treatments in the first phase of Eagar South, including the territory's PFA, were conducted during the winter of 2007-2008. In the spring of 2008, two young fledged from the nest site. In 2009, at least one young fledged, but later in the year than 2008. This may have been due to weather conditions during the nesting period, with 18" snow accumulation at the same time the nesting pair was preparing the nest, thereby delaying the nesting cycle. The pair has returned in the spring of 2010, and has been incubating eggs which were thought to have hatched in late May. The nest will continue to be monitored to determine if and when the chicks fledge.

Large-Tree Removal

Prior to marking the prescription, 72 Common Stand Exam (CSE) plots were placed randomly across the 1,093-acre treatment area. Trees were individually counted and placed in diameter class categories for each plot. This sampling effort allowed the ASNF to estimate the total number of trees >16" dbh across the treatment area. Upon finalizing the prescription, but prior to marking, the number of >16" dbh trees that would be removed from the project area was estimated. To ground-truth this estimate, the location of each individual tree >16" dbh was mapped using a GPS during the tree-marking phase.

The CSE plot estimate of total trees >16" dbh across the entire 1,093-acre treatment area was calculated as 13,961, with a sampling error of 20%. Therefore, the total estimated number of trees >16" dbh ranged from 11,169 – 16,753. The number of >16" dbh trees that would be removed, given the prescription parameter, was estimated (prior to actual marking) at 1,587 (11% of total). However, upon the final marking on site and mapping of each individual >16" dbh tree to be removed, a total of 538 trees were actually marked for removal (4% of total tree estimate), which resulted in an average of 0.49 trees per acre. There were four treatment units monitored for >16" dbh tree removal. Unit 1 removed 118 trees; Unit 2 removed 28; Unit 3 removed 30; and Unit 4 removed 362 trees. Unit 4 was a pre-settlement restoration prescription with a 1:1 replacement tree to remnant evidence ratio. The >16" dbh trees removed from this unit were not of pre-settlement age (determined by core samples); they were located in areas with high growth potential, which was represented by deep soil with high moisture availability. Most were described as encroaching into meadows.

Figure 30. Trees greater than 16" dbh harvested in Eagar South demonstration area



Administrative Monitoring at Eagar South

Treatment Layout and Marking Costs

The interpretation of the management recommendations for the northern goshawk implied a more complex treatment layout and marking exercise than typical fuel reduction treatments. Identifying the necessary leave-tree clumps representing a variety of structural stages, identifying openings, and mapping the location of large trees to be harvested could have resulted in more time and expense than other forest treatments. The collaborative working group requested the ASNF track time and expenses in designing and marking this first phase of Eagar South, and then compare results with a different, more typical fuel reduction project. Unit A of the Mineral analysis area was selected for comparison due to their similarity in size. In addition, both areas were marked in 2007, allowing for identical costs in paint and labor. As a result of this analysis, costs associated with treatment layout and marking were similar between Eagar South and Mineral.

Table 14. Treatment layout and marking costs for Eagar South demonstration area and Mineral Unit A, 2007

Treatment Area	Acres	Person-Days	Labor Costs	Paint	Cost per Acre
Eagar South	1,093	294	$57,362	$16,485	$67.44
Mineral (Unit A)	1,191	238	$65,783	$15,607	$68.34

Volume Removed

ASNF staff records the removal of tons per acre for most Project treatments through contract administration. Between 2004 and 2007, the tons per acre material removed in all Project treatments ranged from 11.3 to 58.8 tons per acre, with an average removal of 30.6 tons per acre. Eagar South (Phase 1 Grapevine Unit) averaged 31 tons per acre removed, which is slightly higher than the average across the entire Project area.

Discussion

The Eagar South project demonstrated that incorporation of multiple resource objectives (fuel reduction, wildlife habitat, and watershed protection) can be accomplished. Treatment layout and marking costs were similar to other, less complex fuel reduction treatments. Volume removed (tons per acre) was also similar. Predicted fire behavior was reduced from active or passive crown fire to surface fire types across the landscape. As reported in the fire modeling results section, Eagar South was the only Project treatment area to show statistically-significant changes in all forest and fire behavior characteristics sampled.

The AGFD provided preliminary recommendations based upon its first-year surveys on northern goshawk prey populations, cautioning managers to not over-generalize the results described above. Regarding the decrease in Abert's squirrels, the AGFD suggests that treatments increase overall basal area within clumps, or leave trees more clumped. Since chipmunks were found primarily in association with downed woody debris, the AGFD suggests leaving downed woody debris in more patches across the landscape to encourage colonization by small mammals.

Both small mammal and avian species will continue to be monitored in 2010, with final results, conclusions, and recommendations completed and provided by the AGFD in late 2010 or early 2011.

Northern goshawk post-family fledging area (PFA) post-treatment at Eagar South

Economic Monitoring Results

Local Economic Impacts

Overview: The Board prioritized five general measurements for the economic monitoring program. Four of these priority indicators involved understanding the direct economic effects of the Project on the local economy, specifically to determine: 1) businesses that purchased or processed the wood removed from the Forest by the Project contractor; 2) the number of jobs directly and indirectly tied to the Project; 3) the amount of expenditures made by Project-associated businesses both locally and regionally; and 4) cross-commuting information. These indicators were monitored and analyzed annually by a consultant contracted by the ASNF. Summaries are provided in this report; the annual economic reports detailing these and other measurements are available on the Board's website.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

How many wood-product businesses either purchase or process Project materials?

In the four years for which economic data is available, twenty separate businesses purchased or processed materials produced from the White Mountain Stewardship Project.

Where are these firms located?

The firms are primarily located within the White Mountains region. Occasionally, an individual business may be located out of the region, but local businesses provide the majority of markets and processors for Project materials.

What are the expenditures by these businesses, both locally and regionally?

For the four years of economic data available, total annual expenditures from all businesses that are related to Project-associated costs (local and non-local combined) range from $18,491,940 to $22,611,663, with an average of 67% of that amount spent locally in the White Mountains.

How many jobs, both direct (basic) and indirect (non-basic and effects from multiplier), are attributed to the Project?

In the four years where data is available, the total number of jobs, both direct and indirect, attributed to the Project in the White Mountains ranged from 296 to 358 per year, with an average of 319 (226 direct and 93 indirect) jobs provided per year, 2005-2008.

Do employees live where they work? If not, which local communities benefit the most from the Project?

Most employees do not live where they work. Snowflake-Taylor and Springerville-Eagar provide most of the employment opportunities for Project-related jobs; however, employees tend to live within all communities across the White Mountains, keeping this income at least within the greater White Mountain region.

Analyzing Local Economic Impacts

One of the primary objectives of the Project was to facilitate and encourage private industry and investment in markets, products, and processing of materials made available through this stewardship contract with the overall goal of reducing the treatment costs borne by the U.S. taxpayer. In addition, such investment would help create employment, sustain future forest management activities, and improve forest health conditions.

Sawtimber-based industries declined in the 1990's, largely due to concerns by interest groups on large-diameter tree harvesting. At the same time, fire suppression and other past management practices allowed for increased growth and build-up of small-diameter trees.

The use of forest materials by private industry necessitated a paradigm shift towards building an infrastructure able to utilize small-diameter material. Businesses able to purchase or use this type of wood product were limited at the time when the Project was initiated. Forest Energy, Inc., a wood pellet manufacturing plant, and Walker Brothers, a harvesting operation business, partnered to produce Future Forests, LLC, and became the Project's contractor. This partnership had the capacity to harvest, and then process (and add value to), some of the wood removed from Project treatments. The contractor worked with local business networking entities such as the Northern Arizona Wood Products Association (www.nawpa.org) and the Southwest Sustainable Forests Partnership (www.littlecolorado.net/SWSFP/Index.html) to locate and sell additional material to offset some of the treatment costs.

Of the multitude of economic information that could be gleaned from this Project, the Board prioritized understanding the impacts of the Project on employment, expenditures within the local area, markets or businesses purchasing available wood fiber, and the primary locations of employment compared to the residency of employees. An added measure was included in 2009, which determined the income generated to the local tax base; that analysis follows the local economic impact information in this section.

To answer the Board's questions, the Board and ASNF determined that an outside contractor with professional economic expertise, conducting annual surveys, would be the most appropriate method for acquiring this information. In 2005, the ASNF contracted with Lay J. Gibson, Ph.D., University of Arizona, to monitor and analyze these economic indicators annually. Dr. Gibson provided this service for three years until his retirement. In 2008, the ASNF contracted with McClure Consulting, LLC to replicate these analyses on an annual basis.

In 2005, Dr. Gibson met with the contractor, Future Forests, LLC, to determine which businesses purchased material from Project treatments. He developed a written survey to be provided to all businesses. Survey results detailed each business's employment situation (full-time, part-time, and seasonal employees) and residency; percentage of sales made to individuals or firms in the White Mountains; expenditures in ten categories made either locally or outside the region; and the portion of their business production based on purchases from Future Forest, LLC. Analyses included summaries of the above data, as well as the identification of potential means to enhance the local economic benefits by evaluating industries that could provide goods and services that are currently purchased outside the region. Annual reports describing the methodology, survey questionnaire, and the full suite of analyses are available on the Board's website.

Results and Discussion

Businesses Associated with the White Mountain Stewardship Project

Material provided by Future Forests, LLC were categorized into four types: clean chips (often used for pellet manufacturing); dirty chips (commercial-grade pellets, biomass); roundwood (5" to 9" diameter trees); and sawtimber (9" diameter trees and greater). From 2005-2008, 20 businesses used these materials, representing a diverse industry base, including manufacturing (pellets, pallets, moulding, furniture, and small lumber), energy production (biomass), livestock bedding, and soil fertilizers.

Table 15. Businesses purchasing wood material from Future Forest, LLC directly tied to the White Mountain Stewardship Project, 2005-2008

Business	2005	2006	2007	2008
APC Pallets (Phoenix)			X	
APC Lumber (Eagar)				X
Arizona Log and Timberworks (Eagar)*	X	X	X	X
Cooley Forest Products				X
Forest Energy Corp. (Show Low)	X	X	X	X
Future Forest (Pinetop)	X	X	X	X
Mountain Top Wood Products (Snowflake)		X	X	
Moulding Accents (Snowflake)			X	X
Nutrioso Logging (Nutrioso)		X	X	X
Reidhead Bros. Lumber (Nutrioso)	X	X	X	X
Reidhead Bros. Re-manufacturing Plant (Springerville)	X	X	X	
Snowflake White Mountain Power/Renegy (Snowflake)	X	X	X	X
Round Valley Wholesale Lumber (Eagar)	X	X	X	X
Snowflake Lumber Moulding (Snowflake)	X	X	X	
Southwest Forest Products, Inc. (Phoenix)	X			
TriStar Logging, Inc. (Snowflake)	X	X	X	X
WB Contracting (Eagar)	X	X	X	X
Western Moulding (Snowflake)		X		
Western Renewable Energy (Eagar)	X	X		
Winner's Circle Soils, Inc. (Taylor)	X	X	X	X

*Shading indicates businesses utilizing or purchasing material each year of the White Mountain Stewardship Project through 2008.

Table 16. Employment directly and indirectly associated with the White Mountain Stewardship Project

Project Year	Basic FTE[a]	Indirect FTE[b]	Non-Basic FTE[c]	TOTAL
2005	152	90	77	319
2006	144	85	73	302
2007	141	83	72	296
2008	190	112	56	358
Average	156	93	70	319

a Basic = Employment primarily producing goods sold outside region, bringing in new dollars
b Indirect = Multiplier effect for basic jobs (Basic x 0.591)
c Non-Basic = Employment primarily producing goods sold within region, re-circulating dollars
All numbers rounded to nearest whole number

Employment

Employment in rural western communities has undergone major shifts over the past several decades. Traditionally dependent upon resource extraction (i.e., logging and mining), many communities have shifted to become more dependent upon tourism, retirees, and professional services (Rasker et al. 2004). In many communities, however, resource extraction and products derived from adjacent public lands still comprise an economic sector that provides diversity among employment opportunities and income generation. As such, the Board place priority on understanding the impact of the Project on jobs within local communities.

Economic base theory includes the concept of a job producing some good or service that is sold either within or outside (or exported out of) the local region. Jobs that produce goods sold outside the region bring in outside dollars, and are considered "basic" jobs. Basic jobs bring in new dollars that are re-invested within the community, and therefore have a multiplied effect, as a "basic" job employee supports themselves as well as additional workers in this multiplier process. Research on the economic sector specific to forest product industries provides a numerical multiplier factor of 1.591, meaning that one full-time basic job, on average, supports 0.591 of another "indirect" employee. A "non-basic" job is considered to be directly associated with the Project, but one that produces goods sold within the White Mountains, therefore not bringing in new dollars to the region. Examining all three types of employment, economists can calculate the full impact of the businesses included in this analysis. Table 16 summarizes the number of full-time equivalent (FTE) jobs in the categories of Basic, Indirect, and Non-Basic for each year of the Project, 2005-2008.

Expenditures

Expenditures are defined as the goods and services used or provided by the firms associated with the Project. In 2005, data were collected only on local expenditures. In 2006, the protocol was modified to collect data on both local and outside/external expenditures in order to evaluate potential opportunities for businesses to expand to provide goods and services locally. Expenditures were grouped into ten categories: raw material (wood products), hauling, petroleum products, mill equipment, mill parts, heavy equipment, heavy equipment parts, electricity, vehicle parts/tires, and transport equipment. Each business calculated the amount of expenditures for each category spent within and outside the White Mountains. For each year, the categories with the highest expenses were raw materials, followed by hauling, mill and heavy equipment/parts, and electricity. Table 17 summarizes the total expenditures, the portion of expenditures within the White Mountains, and the percentage of local expenditures out of the total.

Employment Cross-Commuting

The annual economic analyses determined the level of cross-commuting within the forest product industries that are directly associated with the Project. Cross-commuting is described as the comparison between places of employment (location of business)

Table 17. Expenditures by businesses for products associated with the White Mountain Stewardship Project

Year	Total Expenditures	Local Expenditures Only	Percentage of Local to Total
2005*	No data	$ 12,125,000	No data
2006	$ 22,611,663	$ 15,969,116	71%
2007	$ 20,025,783	$ 11,055,463	55%
2008	$ 18,491,940	$ 14,105,070	76%
Average	$ 20,376,462	$ 13,313,662	65%

* Initial year of analysis only requested local expenditure data

and residency of employees. It can also help determine the extent to which employment in one location impacts communities throughout a region. In all four years of analysis, it was observed that the Snowflake/Taylor and Springerville/Eagar areas employ more workers living outside those communities than any other community within the region. In effect, Snowflake/Taylor and Springerville/Eagar "export" jobs, while other communities such as Show Low, Heber-Overgaard, and Pinetop-Lakeside "import" jobs – their residents bring their employment dollars into their community of residence. Overall, however, the Project's cross-commuting data suggest that jobs are not generally exported outside the White Mountains region, and that the entire region benefits from both exported and imported jobs.

Within one year, economic analyses indicated that the Project was already showing a positive impact on jobs, products, markets, and expenditures within the White Mountains region. The 2005 study provided a baseline for future comparisons, and subsequent years' analyses indicated relatively similar numbers, with an increase noted in 2008, despite the general economic recession and the loss of two industries associated with the building market.

Several of these local firms solicited and received grant monies to assist in developing a new manufacturing process, or to transition from sawtimber-based production of goods to creating products using primarily small-diameter wood. For example, the USFS Forest Product Laboratory (http://www.fpl.fs.fed.us/) offers a Woody Biomass Utilization grant program, which awards proposals up to $350,000 for projects that incorporate the use of lower-value material removed from fuel reduction treatments. This program helps to create markets, improve business practices, offer technical expertise, and provide financial support for emerging businesses tied to forest restoration activities. Such grant programs help offset risks involved in creating new products; often these grants can help businesses purchase operational or mill equipment or create business or marketing plans.

In general, these studies indicate the following:

- Along with contributing to forest health and community safety from the threat of wildfire, the Project also positively adds to the economic diversity of the White Mountains;
- The range of businesses and products created from the Project shows a diverse and varied use of materials, and in some cases, innovation in new industries is evident;
- Economic benefits are spread out across many of the White Mountain communities;
- The expenditures made by businesses associated with the Project are substantial, particularly within White Mountain communities; and,
- Expenditures and jobs increased in 2008 despite the global economic recession, suggesting a level of long-term sustainability due to diversity of products and businesses.

These annual economic surveys and analyses provide information on the impact of the Project that the Board prioritized. The continuation of these surveys should be integrated into the entire suite of Project monitoring. An analysis of goods and services that are currently purchased elsewhere should be conducted, with recommendations of potential business growth opportunities provided to local and regional business development groups, for these groups to seek out businesses that could expand or relocate to the region. Future economic monitoring could include a return-on-investment (ROI) analysis, which would include factors such as the effect of the contribution of grant funds to the overall Project and the calculation of sales of the manufactured or processed wood products created from the wood fiber sold to these businesses.

Region-wide Tax Revenue

Overview: From the five general measurements prioritized by the Board for economic monitoring purposes, one monitoring question relates directly to determining the effect of the contract on the general tax base for local/county governments. The Northland Pioneer College's Small Business Development Center offered to analyze this aspect of monitoring using some of the information from the annual economic analyses; data from the Project contractor; and economic multipliers from the U.S. Bureau of Economic Analysis. Navajo County data were the source for calculating estimates, but final figures are inferred to represent tax revenues shared by both Navajo and Apache counties, as both share similar economic conditions. Total revenue to the White Mountains regional tax base anticipated at the end of the Project period is estimated at $6,782,390.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

What is the overall value of the Project (including multiplied effects) to the general tax base of the region?

This analysis, conducted by Mark Engle, Director of the Small Business Development Center of Northland Pioneer College, estimated tax revenue generated from the Project from county property tax, school district revenue, sales tax from capital equipment purchases, sales tax from average per capita consumption, local (municipal and county) sales tax, and tax generated from indirect employment using multipliers. Adding these figures together, the total expected revenue for Navajo and Apache counties over the ten-year cycle of the Project is $6,782,390, making the White Mountain Stewardship Project one of the largest economic development projects in the region.

Analyzing Region-wide Tax Revenue

While the annual economic surveys in the previous section determined annual economic expenditures, jobs, and their multiplied effects on the local economy, additional factors not evaluated in that analysis include: 1) taxes generated from these business's expenditures; 2) taxes and revenue derived from employees as residents within local communities paying property and sales taxes and as families with students in the school system; and 3) property and sales taxes generated from indirect jobs created by the Project using industry-specific multipliers. Such an analysis can help counties better understand the effects of an economic development project in their region and are of considerable interest to county governments. In this analysis, tax revenues generated by the Project were estimated on sales of wood products; capital expenditures by businesses purchasing Project material or providing sub-contracted thinning services for the Project; property taxes generated by employers residing in the county; school revenue generated by the average family; sales tax generated by average per capita expenditures in the county on consumable goods and supplies; and sales and property taxes generated by employees from indirect (use of multiplier effect) jobs.

To understand how the Project affects the local tax base for the region, Engle (2010) used information on jobs obtained from the annual economic monitoring analysis and from employment and payroll information from the Project's contractor. Research on estimated per capita capital expenditures and consumption of local goods, housing costs and property tax figures, average number of school-age children per family, and other factors were incorporated. In addition, this analysis included the effect of revenue generated by the Project on other jobs and earnings using a multiplier obtained from the U.S. Bureau of Economic Analysis Regional Input-Output Modeling System (RIMS II) calculated from averaging the North American Industry Classification System (NAICS) codes for logging, sawmills, and miscellaneous wood manufacturing.

Actual information on these economic factors was obtained for years 1-3 (2006 – 2008) of the Project. For years 4-10 (2009 – 2015), projections in each revenue category were based upon actual figures, averages, and anticipated economic trends and treatment projections. The original data, including gross contributions, net calculations, and revenue generated per year (2006-2015), can be found in Appendix F. A summary of the data is provided in Table 18.

Results and Discussion

From actual figures calculated in 2006, 2007, and 2008, and projecting revenue for the remainder of the Project period (2009-2015) using actual and estimated treatment increases and economic trends, the Project provides an annual average of $678,239 to the White Mountain region, for a total of $6,782,390 for the entire ten-year period. This is one of the White Mountains region's largest economic development projects, comparable to the largest industrial projects within the region, including the Snowflake Paper Mill and the power plants for Arizona Public Service, Salt River Project, and Tucson Electric Power in terms of jobs added and impacts on taxes and regional communities (*M. Engle, personal communication*).

Actual and projected revenue from the Project appears to play a value-added role in the White Mountains regional economy. Employment in the wood-product industry provides higher-than-minimum wage positions in this rural region, offering mid-level wages for heavy equipment operators, loggers/sawyers, mill operators, and manufacturing jobs. This economic sector diversifies the region's employment opportunities by offering jobs that are not characterized by primary employers such as government, health care, and tourist-based industries. While the economic effect of the Project is small compared to the total White Mountains economic base, it provides a niche for people seeking to live and work in this region that fits the average educational level of its residents.

This analysis on regional tax revenue does not include the financial inputs from the federal government portion of the Project. The analysis only includes impacts from sub-contractors, end wood users, businesses and employees providing goods and services to the contractor, and indirect impacts from these sectors. USFS staff time and labor associated with planning, marking trees, burning residual material, contract oversight, and monitoring are not included. It is estimated that this segment could represent another third of the total amount for employment and other economic impacts (*M. Engle, personal communication*).

It is recommended that these calculations be re-analyzed near the end of the Project period when actual data for future years (2009-2015) are available in order to validate projections made from this analysis and to calculate revenues based upon actual data. In addition, the inclusion of USFS and contract costs into the analysis is also recommended.

Table 18. Regional economic tax revenue projections from the White Mountain Stewardship Project

Revenue Category	Range of Annual Tax Revenue ($)	Average Annual Tax Revenue ($)	Ten-Year Total Tax Revenue ($)	Data Sources
Economic Contributions: - Property tax of businesses - Federal / State school appropriations - Local and county sales tax from local capital purchases by businesses.	**198,530** (2006) – **527,732** (2015 projection)*	**441,675**	**4,416,750**	Wood product sales; payroll estimates; student enrollment; local capital purchases
WMSP Direct Employees: - Local and county sales tax from consumable purchases - Property tax	**41,576** (2006) – **99,783** (2015 projection)	**87,942**	**879,420**	Average consumable purchases per capita; local sales tax capture rate estimate by Navajo County 2008; property tax per capita
Indirect Employment: - Multiplier effect on employment - Multiplier effect on earnings	**70,264** (2006) – **168,633** (2015 projection)	**148,622**	**1,486,219**	BEA RIMS II; Arizona NAICS codes for Logging, Sawmills, and Miscellaneous Wood Manufacturing
TOTAL	**310,370** (2006) – **796,148** (2015 projection)	**678,239**	**6,782,390**	

* Projections included estimates by Contractor based on recent treatment increases, actual figures, and projected averages and actual figures and trends from Navajo County data

Social Monitoring Results

Overview: To assess general social perspectives on forest management, the Board relied on using a social assessment conducted by Timothy W. Collins, Ph.D., in Navajo County in 2005, on social perspectives of forest management after the 2002 Rodeo-Chediski fire. This assessment surveyed over 500 households on general beliefs, knowledge, and support of various forest management activities and the importance of forest health to a resident's lifestyle and home purchasing decisions. The Board and ASNF contracted with Dr. Collins to conduct a similar assessment for Apache County. For comparison purposes, the survey was identical. However, these assessments did not specifically mention the White Mountain Stewardship Project; they were focused on general forest management. As a result, social data on awareness of the Project, other than anecdotal experiences, does not exist.

Incorporating Project-specific questions into a follow-up social survey to be conducted in the latter half of the Project period will be determined by the Board. The original survey report is available on the Board's website.

Informal actions to increase public awareness of the Project undertaken by the ASNF and Board include developing a "stakeholder's report," a full-page color newsprint insert published annually in the regional White Mountain Independent newspaper, which reaches approximately 9,500 readers. Annual reports to Congress are developed and highway signs depicting the White Mountain Stewardship Project title have been created and placed at strategic locations throughout the ASNF.

White Mountain Stewardship Project Monitoring Questions and Answers to Date:

Do people understand and support large-scale mechanical and prescribed fire treatments?

The 2005-2006 Navajo and Apache county social assessments of 722 households found that 94% of survey respondents indicated their support of mechanical treatment and 92% indicated their support of prescribed fire.

Do people recognize or differentiate USFS treatments from other agency forest treatments?

The assessments found that respondents ranked the White Mountain Apache Tribe higher than the USFS in their performance of forest management. Most respondents were nearly neutral on USFS management performance, but agreed that the White Mountain Apache Tribe "does a good job managing forests." This survey was conducted in the beginning phases of the White Mountain Stewardship Project when very few acres had been treated around communities at that point.

Are people aware of the White Mountain Stewardship Project?

The assessments did not specifically address understanding of the Project; therefore, baseline numbers are not available. However, the ASNF and Board publish a full-page color newspaper insert every year that highlights the Project and reaches an estimated 9,500 readers annually. It is recommended that a future social survey in the latter half of the Project period include this question.

Do people believe that forest treatments reduce the threat of wildfire?

The assessments found that 70% of survey respondents believed that forest restoration reduces the threat of wildfire to their community and neighborhood.

Do people have an understanding of forest and fire ecology?

The assessments found that surveyed households have a good basic knowledge of the ecological benefits of fuel treatments, forest restoration, and prescribed fire, with relatively less knowledge of the evolutionary role of fire in ponderosa pine ecosystems and of the association between fire suppression and subsequent increases in wildfire magnitude. Respondents answered correctly on various forest ecology questions 80% of the time, indicating a high level of awareness of forest and fire ecology.

Analyzing Social Impacts

A door-to-door survey sample was obtained for Navajo County residents living in the Show Low-Pinetop-Lakeside area, reaching 1,050 households. For Apache County, 969 surveys were mailed to random full-time and part-time residences owning U.S. Postal Service post office boxes. A total of 772 surveys for both counties were returned, resulting in a 38.2% overall response rate. For details on the methodology, please refer to Appendix G. The

Table 19. Results of social assessment on knowledge of fire ecology, Navajo and Apache counties, 2006

Ecological Awareness Survey Questions*	Sample Size			Mean**		
	Navajo County	Apache County	Total	Navajo County	Apache County	Total
Prescribed fire is a restoration tool	553	206	759	.94	.95	.94
Restoration benefits wildlife	554	206	760	.88	.85	.87
Restoration helps reestablish native plants	555	205	760	.83	.83	.83
Large fires result in part from suppression	554	207	761	.73	.84	.76
Restoration reduces threat of wildfire	553	206	759	.71	.68	.70
Ponderosa pine forests are not fire dependent	554	206	760	.56	.72	.60

* Ranked in order of highest average "correct" answers
** Standard deviations found in full report, available on Monitoring Board website

actual survey form is available on the Board's website under the link entitled "2006 Dr. Collins Social Assessment Presentation."

Results and Discussion

Of the survey questions pertaining to perspectives on forest management and management approaches, and general knowledge of forest and fire ecology, survey findings indicate a relatively high level of awareness, knowledge, and support for mechanical forest treatments, prescribed fire, and general forest and fire ecology.

Perspectives on Forest Management

One question asked respondents for their level of agreement or disagreement with the performance of the USFS, the Bureau of Indian Affairs (BIA) and White Mountain Apache Tribe (WMAT), local government, and private property owners. Answers to the statement that the entity in question "does a good job managing forests" were placed on a scale from "completely disagree" (calculated as -2) to "completely agree" (calculated as +2), with "0" used to represent "neutral." Of particular interest to the Project was that the USFS had a total average ranking of -0.1 (close to neutral) and the BIA/WMAT averaged a ranking of +0.79 (closest to "agree"). Survey fill-in responses indicated a higher level of awareness of BIA/WMAT forest treatment projects near Pinetop-Lakeside, which had a relatively higher visibility than most USFS treatments at that time.

Perspectives on Forest Management Approaches

Respondents were asked two survey questions directly relating to their level of support for prescribed fire and mechanical fuel reduction; a "0" score indicated the respondent is "against" the practice; a "1" score indicated the respondent "supports" the practice. On average for both counties combined, mechanical fuel reduction received a level of 94% in support; prescribed fire received a level of 92% support. In voluntary write-in sections about fuel reduction treatments, respondents cited concerns with whether or not the approach would be guided by industry profits or ecological/aesthetic goals and the desire to only focus on small trees, maintaining large, mature trees. Concerns expressed regarding prescribed fires included fires escaping control and effects of smoke on air quality and health; these two reasons were the primary responses as to why an individual was "against" the practice of prescribed fire. One respondent indicated he does not like burning due to an impact on his personal health; despite that concern, however, he recognized prescribed fire as "important to maintain forest health."

Knowledge of Fire Ecology

A category designed to assess knowledge of forest and fire ecology asked respondents to answer "yes" or "no" to six general statements, with scores given as "1" for correct answers and "0" for incorrect answers. Table 19 depicts total answers received for Navajo and Apache counties with the mean correct response rate for each county and the aggregate average.

Survey response indicates that the highest number of "correct" responses was attributed to the awareness of the use of prescribed fire as a forest restoration tool. The lowest "correct" response rate, attributed to understanding the fire-dependency of ponderosa pine forests, showed that over half of the respondents (60%) scored correctly, despite the question posed in the negative tense. Respondents have relatively less knowledge of the evolutionary role of fire in ponderosa pine systems and of the association between fire suppression and subsequent increases in wildfire magnitude.

The survey also included several questions that were not correlated directly to ASNF treatments or the Project. Responses to questions related to the respondent's value of place, home-buying decisions related to the forest environment, private property fire hazard reduction efforts, and socio-economic characteristics can be found in the full report, available on the Board's website.

Three general conclusions were drawn by the author of the survey: 1) residents value the White Mountains forest environment more than any other aspect of place-related values; 2) over half, and in many cases, more than half, of all respondents have a basic knowledge about fire ecology and forest treatments in the White Mountains forests; and 3) respondents overwhelmingly support the use of mechanical fuel reduction and prescribed fire.

In addition, several preliminary or tentative conclusions were provided, and indicate a suite of questions suitable for follow-up surveys to obtain more concrete results. First, full-time residency is a predictor of actively decreasing fire hazards on one's property. In general, part-time residents implement fewer fire safety measures and maintain more hazardous properties than full-time residents. Second, while residents generally understand fire hazard treatments and have some understanding of forest and fire ecology, these qualities do not directly translate into less hazardous or more ecologically-sensitive household behaviors. This may support the assertion that sufficient knowledge of fire hazards and forest-related ecological awareness may not be enough to motivate household decisions on reducing fire threats at home. Third, while households support forest treatments in the general White Mountains region, they are ambivalent about cutting trees near their own homes due to a personal association with a suite of values with local forest environments. It appears to be relatively easy for individuals to support forest management in the abstract White Mountains region, but more difficult to recognize their own property's trees as a potential fire threat.

In summary, this social assessment indicates a high level of support for forest treatments in the White Mountains area, but not a high level of awareness of the various treatments that occurred on the ASNF prior to 2005. However, it should be noted that Project treatments did not start until late 2004 and early 2005, and that ANSF forest treatments under the Project have increased from pre-Project levels. Dr. Collins indicates that any resistance to forest thinning and prescribed burning will likely be localized, temporary, and represent a minority of White Mountains residents. The assessment recommends that public outreach programs should rely on scientific knowledge about forest ecology and highlight the positive environmental aesthetics of existing forest treatments.

Given that the population growth in the White Mountains is anticipated to continue, ongoing social research and outreach on the Project is recommended. The Board and ASNF should plan to re-survey a random sample of Navajo and Apache county residents to repeat a social assessment near the end of the Project cycle (2012 or 2013). A rigorous review and evaluation of the survey questions should occur to keep key questions that can be compared with the original survey, and to develop appropriate questions to gauge awareness of the Project.

Other Social Outreach Programs

The ASNF and Board developed the following outreach efforts to increase general awareness of the Project, but have no data pertaining to outcomes of these efforts:

Annual Stakeholder Report

The ASNF's public information staff develop a full-page color newspaper insert every year to be provided in one edition of the local White Mountain Independent (the newspaper of official public record in the White Mountains region). Titled the "Apache-Sitgreaves National Forests Stakeholder's Report," the insert incorporates various themes that represent key activities for the Project that occurred over the previous year. The first insert, published in 2006, focused on general facts of the Project. In 2007, the second insert focused on initial treatments with an outline of monitoring activities. The third insert, in 2008, provided more detail on monitoring activities and findings to date. The 2009 insert focused on adaptive management. Using the Eagar South project as an example, information was provided on how the experiences gained in the first few years of the Project allowed for adjustment of treatments to include multiple resource objectives, such as wildlife habitat enhancement and ecological restoration. This insert is printed in one Friday edition of the White Mountain Independent, generally scheduled for a summer release to capture more readers that may be visiting or are only summer residents. The newspaper's average circulation is approximately 9,500 (*J.F. Rivera, personal communication*). In addition, 1,000 extra reprints are ordered for the ASNF and its partners to distribute within and outside the community.

Annual Report to Congress and Briefing Papers

ASNF staff complete one-page briefing papers and short documents summarizing acres treated, costs, and general monitoring findings for Congressional submission and for public outreach. Interested readers are encouraged to contact ASNF staff to receive the most recent briefs.

Signs

Large signs appropriate for visibility at highway speeds were placed in strategic locations on each Ranger District of the ASNF where Project treatments occur.

Case Study

In 2007, the Northern Arizona University's Ecological Restoration Institute commissioned a study to evaluate the Project, focusing on the collaboration effort of the Project and its monitoring and management approaches. The report, titled "Case Study of a Community Stewardship Success: The White Mountain Stewardship Contract" (Abrams and Burns 2007) can be found in its entirety on the Board's website.

The report describes how the process undertaken by various business, community, conservation, and government stakeholders in the White Mountains region arrived at a positive collaborative framework that established broad-based support for the first large-scale, multi-year stewardship contracting program on any National Forest system lands. The report examines agency, community, and wood-product utilization capacities, and details "lessons learned" that may be either site-specific (therefore difficult to translate) or valuable to communities and forest programs elsewhere. Key among these lessons are the findings that communities can play new and indispensible roles in preparing National Forests for stewardship projects; that there may be a need to structure work on a socially-defined "zone of agreement" that can be anticipated to be modified over time; and that a collaborative framework can be used to address challenges and opportunities as they arise. The report details how forest stakeholders in the White Mountains region were able to "transition from stalemate to stewardship" through several years of open discussion and capacity building. This effort is now seen as a model for increasing the scale of forest restoration and stewardship of public forests.

The First Five Years:

What Have We Learned?

In May 2007, a human-caused wildfire was ignited and quickly spread on the Black Mesa Ranger District, threatening private property and local infrastructure. The Vincent fire, as it was called, burned in an area typical of today's present forest conditions – dense stands of small trees interspersed within larger, mature trees. The small trees carried flames into the canopies of the large trees, becoming an active crown fire, and many stands were burned completely. Moving northeast, the fire reached a White Mountain Stewardship Project area that had been treated just the year before, in 2006. This area had been selected for treatment to protect an adjacent parcel of private land. Upon reaching the treated area, the fire dropped to the ground, becoming characteristic of those that regularly burned in this area for thousands of years, burning lightly through grasses and shrubs, releasing nutrients, and rejuvenating the forest soil and groundcover. The adjacent private property was protected. Firefighting costs were reduced, and the risk to firefighter's lives was virtually eliminated.

The White Mountain Stewardship Project is a manifestation of a vision held by Congress and the USFS that the use of public funds to facilitate private investment as a long-term solution to address a public land issue would eventually lower public costs; provide economic benefits to communities; and improve land health. When evaluating the White Mountain Stewardship Project as a whole, tracking tangible costs and benefits across all aspects of the Project was just one part of the picture. Placing a value on intangible aspects of the Project, such as reducing the risk to firefighters or protecting private property, was challenging but necessary. While we may not be able to estimate in dollars these and other benefits, including these topics in the discussion has provided a perspective on the Project as a whole.

How do we calculate the total benefit to our local communities or our wildlife resources when forests are treated to reduce potential wildfire threats? What are the benefits associated with the aesthetic value of a forested environment to communities or with the protection of a town's watershed and municipal water supply? How do we determine the costs of uncharacteristic wildfires that may not have occurred because of these forest treatments, where managers now have the ability to use unplanned fire events to benefit natural resources? How do we ascribe a value to the increased level of social trust generated between stakeholders that may allow large-scale forest restoration to occur? Putting a price tag on these and other benefits can be challenging, but all were benefits that have allowed the Project to transpire and to achieve multiple objectives.

In tracking and analyzing the Project, we found that it has generated both costs and benefits on a large scale. The pathway taken to turn costs into assets was neither linear nor simple. Costs borne by the U.S. taxpayer became positive outcomes enjoyed by employees, businesses, and local municipalities in one relatively small geographic area. The following section highlights many of the findings from the Project's monitoring effort. Lessons learned from each monitored aspect are summarized, and we provide a list of recommendations to be considered in the remaining five years of the Project. Discussions on the intangible costs and benefits are included, and we hope the reader gains an understanding of how the ASNF, the Board, and the Project contractor perceive Project outcomes as a whole.

Evaluating Project Administration

The White Mountain Stewardship Project was an attempt to test the mechanism of stewardship contracting on a ten-year project that guaranteed a long-term supply of wood to generate private business investment in wood products and to build a sustainable market, reducing the need for further government financial assistance. Until recently, no other National Forest had attempted to use stewardship contracting for a ten-year period.

The Project has generated much interest by other National Forests, forest stakeholders, and communities that depend on National Forest lands as a driver for their local economy. It has attracted national attention, receiving visits from USFS Regional and Washington Office representatives; Forest Supervisors; the U.S. Department of Agriculture; members of Congress; environmental or conservation organizations; and businesses ranging from local to international. The exposure of the Project has helped generate an atmosphere in which broader forest restoration projects could occur. As an example, stakeholders and National Forests across northern Arizona have embarked on a much larger collaborative effort, the Four Forest Restoration Initiative, which aims to restore 2.4 million forested acres within parts of the Apache-Sitgreaves, Coconino, Kaibab, and Tonto National Forests over the next 20 years.

As described in the Administrative Results and Economic Results sections costs for and benefits from the Project were high. The Project benefits communities that are within watersheds of Project treatments where the risk of uncharacteristic wildfires has been reduced for a certain time period. These communities can continue to derive economic benefits from tourism and recreational use. Financial beneficiaries include wood processors, local businesses, and municipal governments generally located within the White Mountains region. Other beneficiaries include private landowners who own land adjacent to or embedded within National Forest land; wildlife species whose habitat needs depend on a more open forested environment; and the general public who live, visit, or recreate within the forest.

Lessons Learned

A long-term stewardship contract, the initiation of which can be very complex, does create an umbrella contract where individual task orders obligate funds for treatment implementation. Task orders are a less complex administrative procedure that can be completed in a matter of days instead of the weeks or months required for separate contracts. This reduction in time dedicated to contracting mechanisms ultimately reduces the internal administrative costs by the Forest Service. However, a long-term stewardship contract does commit both the contractor and the associated National Forest to a process that carries funding and budgetary risks.

Currently, no process exists where additional funds for any long-term stewardship contract can be appropriated by Congress above and beyond normal budgets. A National Forest's Regional Office receives a set budget, and must allocate funds from that budget to the stewardship contract. Allocating limited regional resources to a large contract with thousands of acres committed each year has impacted other programs and projects. Other aspects of budgeting that a National Forest must consider include ongoing support from the region, incorporation of the contract over multiple years, and bonding in case minimum requirements are not achieved. Under stewardship contracting legislation, National Forests are obligated to set aside funds in case of contract cancellation by the USFS to pay the contractor for the remaining minimum acreage over the life of the contract. These contracting requirements place a burden on the USFS to set aside a large amount of allocated monies that cannot be used in annual budgets. Only by Congressional action can this contracting issue be resolved.

Upon initiation of the stewardship contract, the Board began a monitoring program designed to answer a variety of questions that pertain directly to the forest manager and contractor. While these questions were simple and direct in nature, they were focused on determining both the quantitative and the qualitative nature of the Project. One aspect was to evaluate whether or not the Project reduced overall taxpayer costs, thereby realizing one of the original objectives of a long-term stewardship contract. Overall, Project costs fluctuated annually, likely due to the task orders and type of treatment applied to each task order. While contract costs for specific types of treatments have not decreased, the ASNF and the contractor still gained efficiencies in operations. Often conducting a total removal harvesting operation for partial-removal costs, the ASNF has seen a greater value for its investment. The contractor has developed markets for most of the wood fiber created by treatments; at the present time, demand exists for at least 15,000 acres of wood fiber annually. In addition, with the initiation of a four-year agreement to purchase residue by SWMP for electrical generation from biomass in late 2009, it is anticipated that much of the piles of residue accumulating from treatments will be removed, thereby negating the need for ASNF to conduct follow-up burning of these piles.

Another factor that helps decrease overall costs is the stability gained in using the same contractor throughout the contracting period. Forest silviculturists have worked directly with the operators in the forest cutting trees to help them understand the desired post-treatment forest structure. When confident that harvesters could implement the thinning prescription from a written description and the resulting forest condition reflected the intent of the prescription, a designation by description, or designation by prescription format was implemented. These types of prescriptions remove many internal costs associated with site preparation and tree marking. Including this type of flexibility in project implementation has allowed for increased efficiencies on the part of the contractor and streamlined administrative costs for the ASNF.

The contractor and the USFS have indicated that an essential factor in the stewardship contracting process is the need for flexibility and open communication by both parties (*D. Walker and R. Cole, communication to Board*). The contractor becomes a partner with the USFS. For example, he communicates his specific equipment needs to process wood on site given his current buyers and their needs; in turn, the USFS informs the contractor what is allowed at any project site as a result of the area's environmental analysis. Project efficiency and effectiveness can be enhanced when the contractor and agency work closely together on every project.

Recommendations

- Continue tracking internal Forest Service administrative costs on an annual basis.
- Analyze what business niches would be helpful to expand wood products markets to process and add value to material that is currently underutilized.
- Utilize designation by description / prescription implementation formats where appropriate to further reduce administrative costs.
- Review contract language to determine if adjustments can be made to adapt to improved methods of calculating costs to better reflect cost reductions.

Evaluating Ecological Impacts

Monitoring ecological impacts from the Project was the most complex and challenging aspect of Project monitoring. Sample sizes were inadequate to make inferences at the desired scale of changes and effectiveness of treatments. This became especially difficult when there were multiple treatment prescriptions, each having different results on the ground. Additionally, modifying only parts of a landscape generally incurs gradual changes at various scales; inferring impacts after a few years of treatments does not indicate what may transpire in the long-term, as forests grow and change over time.

In general, while the Project has treated slightly over 35,000 acres, these treatments have created a patchwork pattern that has affected a much larger forested landscape. Using the Vincent fire as an example, a crown fire was virtually stopped once it reached treated areas, preventing an intense fire from reaching other untreated areas. In essence, from a relatively homogeneous stand of ponderosa pine forest, the Project has created a mosaic of diverse forest conditions. We hope to learn from our current and future ecological analyses how this landscape continues to change in the size, shape, and value of habitat types.

Lessons Learned

In general, ecological monitoring indicates an increase in vegetation structural diversity across the landscape and a reduction in uncharacteristic wildfire threat to communities surrounded by completed treatments. While we have been able to identify trends in forest structure, monitoring data were largely insufficient to address some of the questions asked by the Board five years ago. Specific objectives and monitoring questions had to be scaled down to appropriately match the data that were collected. There has been a considerable transformation in the understanding of ecological monitoring by the Board. The analyses contained within this report have helped Board members make decisions regarding future Project monitoring. A key insight was to understand the level of inference that could be made from the monitoring protocols developed by the ASNF in the beginning phase of the Project. Some monitoring aspects will and should continue for the duration of the project to obtain a long-term and statistically-robust dataset. However, the Board has expressed interest in revising the ecological monitoring plan to focus in on some key information that was missing and to enhance monitoring protocols to reduce uncertainty in monitoring results.

One of the primary objectives of the Project was to reduce the risk of large, high-severity wildfires to communities, private land parcels, and Forest infrastructure. Because the threat of wildfire was the driving force behind the contract, most Project treatments were planned to address fire and fuels reduction. The Eagar South demonstration area, the first project in the contract thus far to have a predominantly wildlife habitat and ecological restoration focus, was a turning point in the Project. We found that fire behavior goals could still be accomplished under these treatments. The Eagar South demonstration area was controversial at the time, but the Board supported experimenting with different forest treatments to meet multiple objectives. Modeling changes in fire behavior showed that the potential for passive or active crown fire was reduced under all prescriptions implemented to date (evenly-spaced, clumpy, northern goshawk guidelines, and restoration-based). The results from Eagar South indicate that forest managers should have the ability to design treatments to meet multiple resource objectives and incorporate site-specific conditions as warranted.

Forest thinning prescriptions have been shown to directly impact wildlife populations, wildlife habitat, and habitat connectivity. Through the wildlife connectivity models, we found that the layout of treatment units directly affected connectivity for species dependent on specific habitat requirements. It was also apparent that untreated areas, in general, still maintain some level of connectivity. However, the size, shape, and connectivity of untreated patches may become increasingly restricted as additional areas are treated. For future planning efforts, it may be beneficial to model habitat connectivity for selected species during the planning of treatment prescriptions and selection of treatment units. Slight modifications in treatment layout and design could still meet fuel reduction goals while providing a meaningful increase in the level of connectivity for specific habitats and associated species.

The Project has generally focused on treatments in WUI areas and ponderosa pine vegetation for the first five years. While we have identified trends in wildlife responses to treatments in pine forests, the Project will soon be expanding to include more treatments in pinyon-juniper and mixed conifer forests. The three years of songbird surveys completed in ponderosa pine forests showed an increase in densities in treated areas and a slight decrease in species diversity. These results highlight the need to retain and enhance a variety of vegetation types to provide habitat for those species impacted by treatments. Ponderosa pine systems are also very well studied; however, not as much information is available for pinyon-juniper woodlands and mixed conifer forests in Arizona. The Project provides an opportunity to further understand how treatments in these vegetation types may impact wildlife and their key habitats. An ongoing study that exemplifies this was the black bear research project conducted by the AGFD. Based on black bear movements and habitat use, preliminary data indicates that bears may not be selecting for ponderosa pine habitat, whether treated or untreated, within the Black Bear Study Area. It does appear that this species may not be affected by treatments in ponderosa pine vegetation. Black bears tend to favor mixed conifer habitat with more cover, selecting feeding areas (e.g., open meadows) based upon adjacency of that cover. Effects to this species may change when treatments shift to incorporate more mixed conifer areas. Treatment prescriptions may need to incorporate movement corridors and leave higher-density stands along preferred feeding areas.

Over the first five years of the Project, there has been a paradigm shift from focusing on fuels reduction treatments to incorporating more ecologically-based restoration principles. Monitoring data have indicated that multiple objectives for fire behavior, forest structure, and wildlife habitat can be integrated together, which additionally serve to promote social agreement in supporting these types of forest treatments.

Recommendations

- Revisit monitoring plan and update goals, objectives, and questions. Determine what gaps in knowledge still exist, and develop a focused monitoring plan to address these outstanding issues for the final five years of the Project.
- Evaluate and modify vegetation plot data collection protocols to ensure the data will meet monitoring needs. The existing protocol was not sufficient to detect changes in vegetation across entire cutting units or project areas for some of the factors of interest (i.e., snags or understory cover).

- Improve the process of collecting ecological monitoring data by evaluating existing data forms and modifying forms to facilitate and enable a more efficient analysis process.
- To facilitate vegetation composition and structure analyses, increase independence of data collection from USFS Common Stand Exam protocols.
- Given fire behavior model results on all treatment prescriptions, continue testing and exploring different prescriptions that promote structural heterogeneity in forest stands and vegetation components (i.e., snags, downed logs, herbaceous growth).
- Develop a more robust method of analyzing differences among treatments with and without diameter caps.
- Use wildlife connectivity models in the environmental analysis process prior to establishing treatment prescriptions and placement.
- Expand wildlife connectivity models to include more species and incorporate more detailed habitat suitability values as feasible.
- Use vegetation growth models to determine optimal treatment re-entry periods and to analyze fire behavior under future vegetation conditions.
- With expert input and through a transparent communication process, develop a northern goshawk habitat suitability model that reflects the most current understanding of its ecological and biological needs. Determine what data are needed in order to better analyze treatment effects on this species.
- Repeat Abert's squirrel population index surveys in the Mineral treatment area to compare differences from the ASNF's 2004-2006 survey effort.
- Target specialized avian sampling in canyons and drainages to further understand treatment impacts on red-faced warblers.
- Based upon findings within the BMP analysis, increase contract oversight in risky conditions (e.g., wet soil).

Evaluating Economic Impacts

One of the overarching goals of the Project, and for stewardship contracting in general, was to use a long-term contract mechanism to facilitate private business investment in utilizing public land resources, with the end result being an ecologically and economically sustainable private enterprise network that achieves multiple benefits on public land. Evaluating if and how the Project met the Board's goals was a high priority monitoring objective. Annual economic surveys focused directly on businesses associated with the Project, whether it was the contractor or a business purchasing raw materials from the contractor and creating a value-added product. In conjunction with administrative monitoring, the Board wanted the ability to compare economic gains with administrative and contract costs.

In comparing administrative costs with economic benefits, it was quite clear that a stewardship contract of this magnitude had high levels of both. Expenditures by businesses within the region, the creation of products that were sold outside and within the region, jobs created, and tax revenue generated all create dollars that were recycled within the community, providing more indirect benefits. Most of these benefits were realized within the White Mountains region, while the costs were largely assumed by the federal government representing the entire United States populace. Determining the merit of this type of public financing process was beyond the scope of this report; however, it bears pointing out that the number of acres treated per year has increased, with relatively stable annual payments. This indicates a trend towards realizing the goal of transferring the costs from the public sector to the private sector. In addition, business expenditures alone within the region surpass contract payments annually.

Lessons Learned

The White Mountain Stewardship Project would not have been possible without some type of wood products industry. Initially, there was considerable concern from stakeholders about industry driving the treatments to maintain jobs and economic benefits. The Board recognized that ecological restoration and reducing the threat of wildfire would not be possible without a partnership between the contractor and the USFS. The ongoing discussion between the ASNF, the Board, and the contractor has struck a balance between placing an emphasis on ecologically-based treatments and the development of industry that is sustainable based upon the fiber these treatments produce. For the first four years of the contract (2004-2008), 20 businesses purchased materials from the contractor. Nearly half of those businesses were customers for all four years, and the majority of businesses purchased materials for multiple years of the Project. The contractor has built a demand for small-diameter wood products over these first five years without compromising the ecological integrity of the treatments.

The ASNF and the contractor have estimated that approximately 40% of all the material harvested from the forest was comprised of residual material (branches and needles, also termed slash) left over after pulp and stems were utilized. Depending on task order requirements, at times the slash was hauled offsite or it may have been piled for burning at a later date. For the first five years of the contract, managing slash has been a challenging economic variable in the attempt to decrease overall Project costs. Slash can be sold to power plants to produce biomass-generated electricity, but oftentimes the cost of transport and hauling was higher than the income it produces from electricity generation. As a result, the contractor worked diligently to sell slash as often as possible. In December 2009, Snowflake White Mountain Power, a biomass power company, agreed to purchase material, including residue often left in piles, for biomass energy production from project sites located on the western side of the ASNF where transportation of this material is economically viable. Specific data on the outcome of this recent development are not yet available. A factor that other potential forest restoration projects may want to evaluate is to determine if markets are sufficient for all types of forest material, including slash, to minimize treatment costs; or at least if there is a high level of investment interest in these materials prior to developing a contract. A second factor other project collaborators may want to consider is evaluating the need for an independent marketing specialist that devotes time to develop markets for under-utilized material.

The Project has stimulated local economies and provided tangible community benefits. With an average of 319 jobs created (226 direct jobs; 93 indirect jobs), the Project has been one of the largest economic development programs within the White Mountains region. Combining all of the estimated investment and income generated by the Project to date, over $40 million has been contributed to the White Mountains economy, superseding the overall costs of the contract, which have been estimated at approximately $30 million. While this assessment compares two seemingly different funding aspects, it does indicate that an investment by the federal government may achieve results in a localized area that spur growth in private enterprise and businesses.

Recommendations

- Continue with annual economic monitoring effort and evaluate the need to expand this analysis to include a return-on-investment (ROI) assessment that broadens the economic factors analyzed.
- Explore ways to research potential opportunities to expand markets to purchase under-utilized wood material.
- Evaluate non-local expenditures by businesses to determine if a local business could fill these needs, keeping more income in the White Mountains region.

Evaluating Social Impacts

When the Project was initiated, the Rodeo-Chediski wildfire was still relatively fresh in most residents' minds. A social assessment undertaken during this time period clearly indicated that most residents appreciated the need for forest management, including both thinning and managed fire. This assessment was conducted in Navajo County, and the Board expanded the survey to include Apache County, using the same format for comparison purposes. However, the original Navajo County survey was designed prior to the initiation of the Project, and as such, no questions pertained directly to the Project or to stewardship contracting. Given the impact of the Rodeo-Chediski fire on the perspectives of the general public, the Board felt that this survey would suffice to gauge public support for the Project, despite knowing that questions pertaining directly to the Project would not be included. Along with this survey, the Board implemented a variety of outreach efforts, including highway signage and newspaper articles.

Lessons Learned

Given a limited monitoring budget, the Board made the choice to expand upon an already-existing social assessment that pertained to forest management in general, which indicated a high level of support, awareness, and knowledge of forest management issues. However, given the recent occurrence of the Rodeo-Chediski fire and the enormous effect that fire had on the people living in the White Mountains, at the time the Board believed that these perspectives would be maintained well into the future. In addition, the Board also decided that a follow-up social assessment would best occur near the end of the Project period to allow as many treatments around communities to occur as possible. As such, the Board obtained very little data specific to social perspectives of the Project as a stewardship contract undertaken by the ASNF. It was telling, however, that the ASNF has received virtually no negative feedback on Project treatments other than concerns voiced about the aesthetic value of an evenly-spaced homogeneous prescription.

Other social outreach efforts were not measured to establish comparative indicators of any changes in social perception or awareness of the Project. While over 9,500 copies of the annual newspaper insert were distributed throughout the region, it is unclear if that figure represents the number of people who read and absorb the information provided.

Recommendations

- Develop a social assessment for the latter part of the Project period (i.e., 2013-2014), using baseline assessment questions for comparative purposes and adding questions specific to the Project to obtain some level of understanding of public perception of the Project.

White Mountain Stewardship Project Conclusions

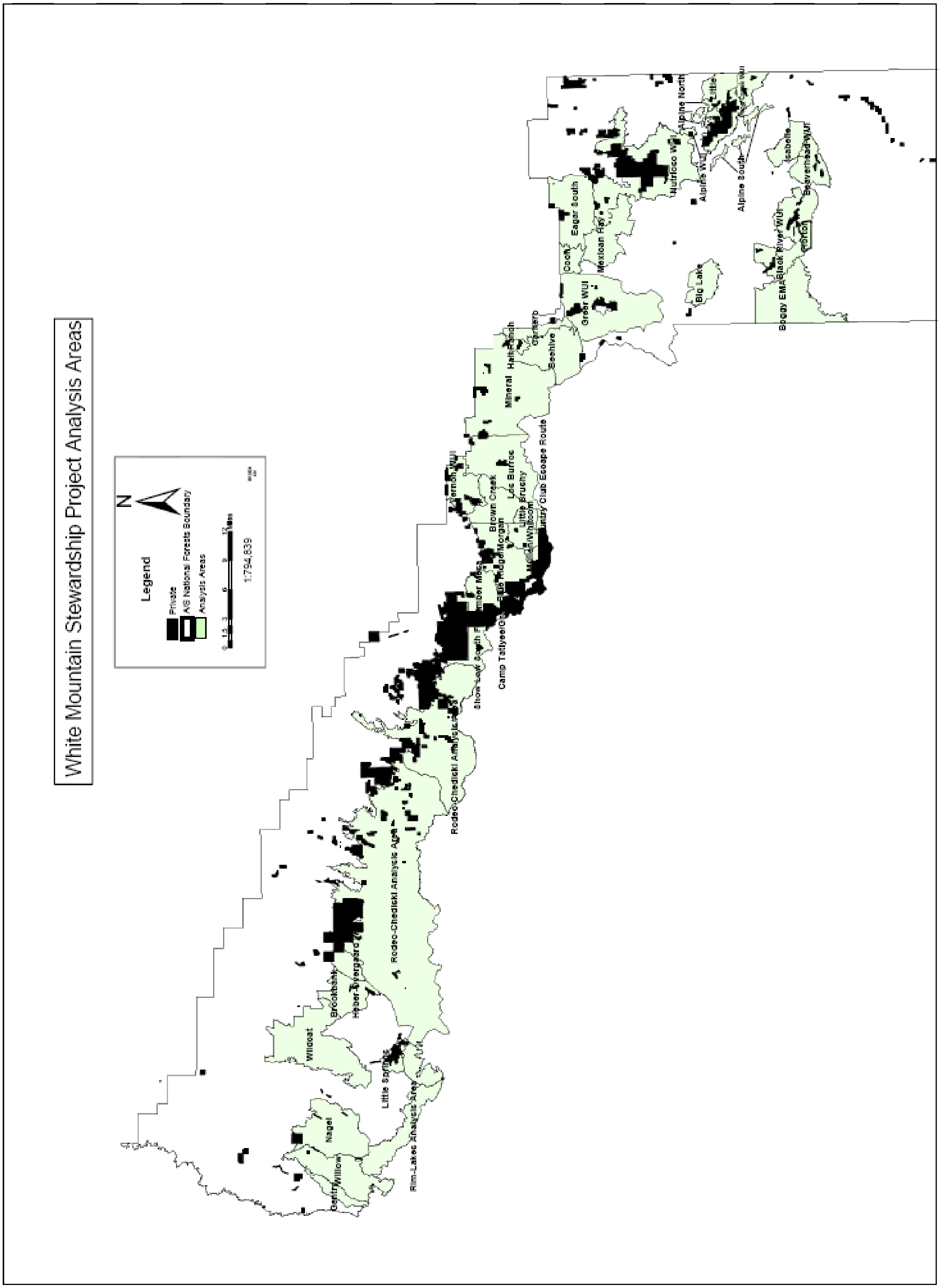
The ten-year stewardship contract experiment that the ASNF initiated five years ago has already demonstrated achievement of several objectives. What began as an attempt to change the potential fire behavior around communities evolved into the largest and longest national example of how various interests, businesses, communities, and the federal government can work together to improve local economies, enhance wildlife habitat, and restore forest health using a variety of treatments and adjusting as necessary. The White Mountain Stewardship Project showcased how a National Forest received input from stakeholders and incorporated immediate changes into future projects; this is exemplified in the willingness of the ASNF to try a wildlife habitat-based prescription to test its ability to meet both wildlife and vegetation-based objectives, while simultaneously changing potential fire behavior.

The White Mountain Stewardship Project has demonstrated that investment by government in managing public lands has contributed to help forest managers improve forest health and reduce the potential for active or passive crown fires that may impact communities embedded within or adjacent to these public lands. This investment has helped communities and stakeholders facilitate and identify opportunities for long-term economic sustainability in forest product industries. The Project has had the effect of helping to add value to small-diameter wood products, increase employment opportunities in rural communities, and boost local economies.

The first five years of the Project has been a time of learning, experimenting, and building trust among stakeholders and the public. In looking at the Project as a whole, one primary accomplishment was to demonstrate the use of adaptive management. Input from the Board was incorporated in future project planning and will likely continue as the contract enters its final five years. The White Mountain Stewardship Project has confirmed the hope held by many that working together, those with different perspectives can find common ground, accomplish multiple objectives, and ensure that their efforts benefit the communities, wildlife, and the forests on which both depend.

In the next five years, the Board will evaluate and refine its monitoring program and tailor data collection to meet specific information needs and to fill data gaps. The Board will also continue to build upon the ASNF's ability to use monitoring data to improve planning and treatment design and layout. Lastly, the Board will continue to share lessons learned with other collaborative projects to further the goal of ecological restoration of our forests across the nation.

Analysis areas to be completed under the White Mountain Stewardship Project



Appendix B.

Statistical methods for evaluating ecological monitoring data

Stand Structure and Understory Community Vegetation Monitoring Methodology

Forest stand structure and understory vegetation characteristics were monitored at permanent plots stratified by vegetation type. In areas selected to be treated, cutting units were randomly selected within a project area. Permanent plots were then established of approximately one plot per 20 acres, with a minimum of 3 plots in a cutting unit. Plots were randomly distributed throughout the cutting unit. Once a plot center was determined it was monumented to be re-located for post-treatment sampling. The Universal Transverse Mercator (UTM) coordinates were recorded for each plot center and a minimum of 2 reference trees were marked to help relocate the plot center during the post-treatment resampling period.

At each sampling plot, stand structure measurements were recorded following common stand exam procedures and entered into the FSVeg database and photos were taken at plot center in each of the four cardinal directions. Understory vegetation was assessed using a Daubenmire transect 50 ft long on the north azimuth. The Daubenmire protocol uses a 20 cm x 50 cm frame to estimate understory canopy cover by species and life form every 5 ft along the transect. Daubenmire transect data are scheduled to be collected prior to treatment and ten years post-treatment. A planar transect was completed on the east azimuth for 50 ft to measure fuel accumulations (Brown 1974). Overstory canopy cover was estimated using a 50-foot transect on the south azimuth. Ground surface cover was measured on a 50-foot transect on the west azimuth at 1-foot intervals using the point-intercept method. Large live trees were recorded with a 10 BAF prism, where diameter at breast height (dbh) was recorded for all live trees greater than 5 inches dbh (or diameter at root crown for non-conifer species) in a variable radius plot. All small live trees less than 5" dbh but at least 6" tall were counted and recorded within a 1/100th acre (11.8' radius) fixed plot. Snags and down logs were measured in a half-acre (83.3' radius) fixed plot in mixed conifer and a one-acre (117.8' radius) plot in ponderosa pine.

Fixed radius snag densities and transect data on surface cover categories (e.g., bare ground, grass, forbs, litter, wood, etc.) were analyzed using a non-parametric Wilcoxon sign-rank test. This test was used because the assumptions of this test do not rely on a normally distributed data set. Our data were not normally distributed and in this instance could not be transformed to meet the assumptions of common parametric tests. The Wilcoxon sign-rank test is a non-parametric analog to the paired t-test. A test that utilizes matched pairs was the appropriate analysis technique for this data, due to the lack of independence between pre- and post-treatment samples.

Fire Behavior Modeling Methodology

Ground based vegetation and stand structure data (as collected according to the above protocols) were used to inform the fire behavior models. These measures include basal area, canopy cover, crown bulk density, crown base height, surface fuel loading, and torching and crowning indices. These data were then processed through the Forest Vegetation Simulator (FVS) and the Fire and Fuels Extension (FFE) analysis tools to calculate pre- and post-treatment stand conditions. FVS and FFE were developed by the Forest Service and integrate large- and small-tree heights and diameters, mortality, crown changes, establishment of regenerating trees, shrub and tree vertical canopy distribution and development, and fire effects. By using commonly collected information on stand structure, FVS enables users to model changes in stand structural attributes following management activities such as thinning or prescribed fire.

The outputs of the FVS/FFE analyses were then used to calibrate Rapid Refresh LANDFIRE layers. These landscape files are then incorporated into the FlamMap (Finney 2006) fire models which combine with elevation, slope, aspect, and the fire behavior models. FlamMap is a fire behavior analysis and mapping program that computes potential fire behavior characteristics at a landscape scale for a specific weather and fuel moisture condition.

FlamMap incorporates Rothermel's fire behavior models which assume that fire is free-burning, fine fuels are the primary carrier of the fire front, and that they are continuous and uniform, and that fire behavior is predicted for the flaming front of the fire surface. The outputs from FlamMap in this exercise were used to calculate crown fire activity per pixel using average weather conditions as they were recorded during the 2002 Rodeo-Chediski fire on the Apache-Sitgreaves National Forest (23 mph 20' winds coming from 209 degrees SSW). While 23 mph wind speeds are common in northern Arizona, they are much lower than sustained winds and gust (winds 40-60 mph) shown to drive other large fires in the Southwest. Maps were generated to display fire type as projected during the pre- and post-treatment periods. The fire types identified include no fire (generally urban areas), surface fire (fire that stays on the ground not in the forest canopy), passive crown fire (fire does not carry continuously through the crown fuels, but burns crown fuels intermittently, such as when individual trees or groups of trees torch) and active crown fire (fire carries continuously through the canopy of the trees). The fire behavior analysis we completed is likely to be an underestimate of fire intensity compared to potential severe conditions. These models are useful in a comparative sense but should not be relied on to provide absolute numbers.

Avian Community Methodology

Songbird Density

A distance-based sampling approach was used to estimate avian density in ponderosa pine, pine-oak, and pinyon-juniper habitats. At each sampling point, surveyors recorded all bird species detected by sight or sound within a 100 m (328 ft) fixed-radius during a five minute period. Bird species that just flew over the point were excluded from the analysis. The observer estimated the distance to each bird detected to the nearest meter. Surveys were completed between 30 minutes after sunrise and 1000 hours. Each point-transect was visited only once per season. Distance-based models are robust to detecting the same individual(s) at more than one point or over the course of different sampling periods (Buckland et al. 2001). Because of these model characteristics, we were able to relax assumptions of complete spatial independence among sampling points (Buckland et al. 2001).

To obtain a suite of focal species, we used program DISTANCE (version 5.0; Thomas et al. 2005) to estimate density in each vegetation type. We used conventional distance sampling because no covariates (other variables) were measured at each sampling point. We estimated a global detection probability for each species which was not independent among treated and untreated estimates; therefore additional statistical tests were not conducted due to the violation of the assumptions of traditional statistics (Buckland et al. 2001). We used Akaike's Information Criterion (AIC) and the chi-square goodness of fit test to assess model fit and select the best model. Density estimates and associated standard error were obtained from the best model selected.

Songbird Diversity and Composition

To evaluate the effects of forest treatments on avian community diversity and composition, we used estimates of species richness based on the first-order jackknife and species evenness based on the inverse of the Simpson's index (1/D), which increases as the avian community assemblage becomes more even across the landscape (Magurran 2004). We calculated estimates for each vegetation type and pooled among years using EstimateS Software Program (V8.2; Colwell 2005). We estimated the mean and variance of species richness and evenness using 1,000 bootstrap randomizations (Sokal and Rohlf 1995).

Black Bear Analysis Methodology

Beginning in the summer of 2006, black bears were captured using leg hold or culvert traps and fitted with Global Positioning System (GPS) satellite tracking collars. GPS collars were programmed to acquire locations at intervals of every 4 h. Point locations were imported into a GIS and used to delineate 95% fixed kernel home ranges. A random-point generator in ArcGIS was then used to select point locations within the boundary of the home range to identify "available" habitat. Actual coordinates of bear locations received by the GPS collars were identified as "used" habitat locations. To account for variation in habitat use through time, black bear locations and associated resource selection analyses were stratified into the following three seasons based on food habits and selection patterns for the region (LeCount and Yarchin 1990): 1) spring, defined as den emergence, where black bears typically feed on carrion and herbaceous forage (April to 14 June); 2) summer, when black bears add consumption of ants to their array of foraging options (15 June- August); and 3) fall when black bears seek out soft mast (September to denning).

For each season, resource selection function (RSF) models were developed following Manly et al. (2002):

$$w(x) = exp(\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k)$$

where $w(x)$ is the resource selection function for a vector of predictor variables (e.g., dominant vegetation, slope, elevation, aspect, distance to water, distance to roads), xi and βi values are the corresponding selection coefficients.

During the 2007 growing season (May-August), vegetation sample plots were established within future fuel treatment areas and reference forest stands. All reference forest stands were representative of habitat associations used by black bears and used as a control in comparisons to treated areas. Habitat characteristics were measured at a subset of bear location plots and at a set of randomly-generated "available" plots (generated in a GIS) stratified within treatment and reference forest stands. At each plot, a 65 ft transect was established, running south-to-north with the 32.8 ft location being the plot center. Five 5 ft^2 herbaceous quadrats were established along each transect at 16 ft intervals. Within these quadrats, the presence of key black bear food items (LeCount and Yarchin 1990) was recorded. Presence of mast-producing species were measured in the shrub-layer (plants >1.6 ft in height) along a belt transect 215 ft2 in size. At each plot, mast production was estimated; berries and acorns were counted within quadrats or belt transects using hand-held tally counters and standardized to a per hectare (2.47 acre) basis. The presence of ants (in mounds and/or woody debris) was recorded using meander searches within 32.8 ft of either side of the established transect (20 m × 20 m; 4306 ft^2). After treatments are implemented, measurements will be repeated and the habitat characteristics will be compared between treatment and reference plots.

Appendix C.

Literature reviews for focal wildlife species included in wildlife habitat connectivity modeling

Red Squirrel

Red Squirrel Habitat Requirements

North American Red Squirrels (*Tamiasciurus hudsonicus*; hereafter red squirrel) inhabit boreal and mixed-conifer forests throughout North America (Patton and Vahle 1986; Frey 2008). They are broadly distributed from Alaska, across Canada to the Northeastern U.S, south into the Appalachians, and extend through the Rocky Mountains to the southwestern United States. (Vahle and Patton 1983; Patton and Vahle 1986; Rushton et al. 2006; Frey 2008). In the Southwest, red squirrels are associated with upper montane coniferous forests on high elevation mountaintops (Frey 2008). Commonly these forests include

http://www.wildlifenorthamerica.com/Mammal/ Red-Squirrel/ Tamiasciurus/hudsonicus.html

Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor),* corkbark fir (*Abies lasiocarpa var. arizonica*), ponderosa pine (*Pinus ponderosa*), southwestern white pine (*Pinus strobiformis*), Quaking aspen (*Populus tremuloides*), Engelmann spruce (*Picea engelmannii*), and blue spruce (*Picea pungens*; Vahle and Patton 1983; Patton and Vahle 1986; Rushton et al. 2006; Frey 2008; Edelman et al. 2009).

The red squirrel is a small (average weight ~225 grams) species that eats a wide range of foods including seeds, nuts, fruit, bark, insects, fungi and occasionally bird eggs and young birds and mice (Burt and Grossenheider 1976; Zugmeyer and Koprowski 2007). The diet requirements of the red squirrel overlap considerably with those of the Abert's squirrel, which leads to direct competition between these species in areas where they co-exist in the Pinaleño Mountains in southeastern Arizona. In these areas of their range overlap, the introduced Abert's squirrels may be competitively excluding red squirrels from primary, high quality habitats including nesting and foraging sites (Edelman et al. 2009). However, researchers have suggested that demographic and habitat requirements may differ among populations within the main distributional range and those of fringe populations (Rushton et al. 2006). Therefore, we have given priority to the research on red squirrels in the main range distribution, while recognizing that research conducted on the Mount Graham Red Squirrel (MGRS) was informative and may be included to provide perspective and fill in data gaps.

Red Squirrel Model Parameters

Red squirrels have been the subject of several home range and habitat use studies. Previous research has shown that squirrel density ranges from 1.3 to 1.5 squirrels per hectare (0.533-0.61 squirrels per acre) with a home range of ≤0.56 to 1.03 hectares (1.38-2.54 acres; Larsen and Boutin 1994; Goheen and Swihart 2005; Hedwall et al. 2006). However, MGRSs have been shown to have a much larger home range. Zugmeyer and Koprowski (2009) found that home range size of MGRS varied from 1.24 (± 0.17) ha to 3.66 (± 0.62) ha (3.06 ± 0.4 – 9.04 ± 1.5 acres) depending on the season. Dispersal distances have also been shown to differ between red squirrels across their range and MGRS in the Pinaleño Mountains based on a literature review by Rushton and coauthors (2006). Given the variation in home range size identified for red squirrels, we used a range of values to populate the PatchMorph model. We used the home range estimates to inform the minimum spur distance of 100 m (328 ft). Researchers have also found that red squirrels routinely move distance of 1 km (0.62 miles; Koprowski 2005; Bakker and Van Vuren 2004); therefore this distance was used as the maximum spur distance. Bakker and Van Vuren (2004) conducted an experimental study that tested the gap-crossing decisions made by red squirrels. Data from this previous study showed that red squirrels will cross gaps in habitat up to 500 m (547 yards; Bakker and Van Vuren 2004). Therefore, a gap distance of 0-500 m (0-547 yards) was used in the PatchMorph model for this species.

Given that red squirrels have been shown to be sensitive to habitat fragmentation and have specific habitat requirements, we reviewed the literature to inform the habitat suitability characteristic values used in the PatchMorph model assessing habitat connectivity. Previous research has suggested that conservation of squirrels can be achieved when a mosaic landscape is created (Korpowski 2005). A mosaic should include areas of dense forest conditions (high levels of canopy cover, basal area and interlocking branches) and the matrix could serve as lower quality habitat containing fuel reduction treatments, corridors for movement or fire breaks (Korpowski 2005). Group selection thinning treatments that retain structural diversity and large snags and mature trees are likely to have minimal impacts on squirrels while allowing for timber extraction (Vahle and Patton 1983; Koprowski 2005) and for reduced the threat of high-intensity wildfire. Nevertheless, thinning treatments that remove >50% of stems are generally associated with a decline in squirrel populations (Koprowski 2005). Seed and shelterwood cuts may retain some habitat characteristics, but usually the remaining stem density is too low to provide high quality squirrel habitat (Koprowski 2005). Vahle and Patton (1983) suggest that retained tree groupings of one-tenth acre with trees of 12 inches dbh or greater and a basal area of 150-200 square ft per acre is suitable for red squirrels. Fire is another component of fuel reduction treatments that may influence squirrel habitat and pose a threat when it is unplanned. Squirrels have been shown to be able to survive low-intensity fires when they stay on the ground and burn at lower temperatures; burrows and nests in tree canopies can serve as refugia (Koprowski et al. 2006). However, survival has been shown to decrease following crown fires due to immediate mortality during the fire as well as reduced habitat quality following the fire event (Koprowski et al. 2006; Zugmeyer and Koprowski 2009). These general forest characteristics have been used to assign habitat suitability values for the PatchMorph model after known forest management activities.

Abert's Squirrel

Abert's Squirrel Habitat Requirements

The Abert's Squirrel (*Sciurus aberti*), also known as the tassel-eared squirrel, inhabits ponderosa pine (*Pinus ponderosa*) and mixed-conifer forests in the Southwestern U.S. and Mexico. They are distributed across the Colorado Plateau and the southern

http://www.wildlifenorthamerica.com/Mammal/ Aberts-Squirrel/ Sciurus/aberti.html

Rockies of Colorado, Utah, Arizona and New Mexico (Keith 1965). Populations are also known to exist in the Sierra Madre Occidental of Chihuahua and Durango, Mexico (Keith 1965). Abert's squirrels were introduced by state and federal agencies (in the early 1940s, and again in the 70s) to several of the sky islands of southeastern Arizona and populations have become established in the Graham and Santa Catalina mountains (Keith 1965). The Abert's squirrel is a ponderosa pine obligate species, meaning that it is dependent on this species for its foraging and nesting requirements (Patton 1984; Dodd et al. 2003 and 2006; Prather et al. 2006). The only exception to this is where Abert's squirrels were introduced in the mixed-conifer forests of the sky islands in southeastern Arizona and their diet and habitat requirements overlap with red squirrels in this non-traditional environment (Hutton et al. 2003).

Abert's Squirrel Model Parameters

Abert's squirrels are highly dependent on forest structural characteristics. This species prefers habitat with areas of high basal area, canopy cover and interlocking branches. Research has shown that Abert's squirrels need habitat with a high density of mature trees (Dodd et al. 2006) and patches greater than 160 ha with more than 40% canopy cover (Prather et al. 2006). Dodd et al. (2003) also found that clumps of trees need to have a minimum of 3 trees with interlocking canopy. These areas that retain interlocking canopy in an aggregated clump, promote the production of fungi, a valuable seasonal food resource (States and Gaud 1997; Dodd et al. 2003). High quality habitat for Abert's squirrels can be summed up as a multi-aged stand with a well defined large tree component (20+ trees/ac; > 17 inches dbh), a basal area of > 35 m2/ha (153 ft2/ac) and canopy cover of 50% or more (Dodd et al. 2006). Low quality habitat can also be qualified as an even-aged stand with few large trees (< 8 trees/ac) with a basal areas of < 18m2/ha (78 ft2/ac) and canopy cover of less than 30% (Dodd et al. 2006). These forest structural characteristics are likely to be impacted by forest treatments, which may reduce the quantity of high quality habitat available to squirrels (Dodd et al. 2006).

While forest restoration treatments may seem to directly contradict the habitat need of Abert's squirrels, it is not necessarily so. Dodd and his co-authors (2003) have suggested that squirrels may take advantage of open areas that received thinning treatments that promote cone production when these areas are adjacent to higher-quality habitats. Squirrels may benefit from a mosaic of structural characteristics and patch sizes, such that intermediate proportions of high quality habitat (40 - 50%) are intermixed with other forest structural characteristics (Dodd et al. 2003 and 2006). Group or single-tree selection harvest will maintain or even improve uneven-aged forest structure that is preferred by squirrels (Patton 1984). However, it is when forest treatments severely reduce basal area and areas of interlocking canopy negatively impact squirrel habitat and have been shown to reduce recruitment (Dodd et al. 2003). Other treatments that maintain an even-aged forest structure such as shelterwood cuts should be minimized to limit impact of treatments on squirrel habitat (Patton 1984).

Given that Abert's squirrels are not territorial like some other species of tree squirrels (Farentinos 1979; Halloran and Bekoff

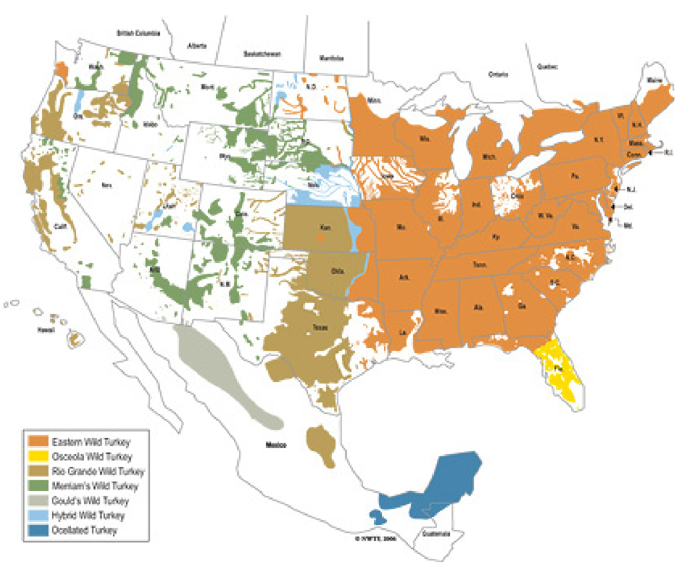
2000; Edelman and Koprowski 2006), habitat use and home range size are more difficult to ascertain. Previous research has found 0.42 ± 0.02 squirrels/ha (0.17 ± .008 squirrels/ac) in high quality habitat, with 2.5 times fewer squirrels in lower quality habitat (Patton 1984; Dodd et al. 2006). Juveniles have also been recorded frequently moving distances up to 1.5 km (Farentinos 1972). The home range of this species has been estimated at 7.8 to 14.2 ha (3.16-5.75 acres; Dodd et al. 2006), which is considerably larger than red squirrels. The Abert's squirrel home range size has also been shown to increase in harvested areas, indicating a reduction in habitat quality (Patton 1984). This information, provided by the literature, was used to inform the PatchMorph models. We used the home range size to inform the minimum spur distance of 200 m (0.12 mi) and the maximum of 2000 m (1.24 mi). We also used the frequent travel distance as an approximation of the maximum gap distance and used a range in the model of 0 to 1600 m (0-1 mile).

Merriam's Wild Turkey

Natural History Review of Merriam's Wild Turkey

The Merriam's wild turkey (*Meleagris gallopavo merriami*) is one of six subspecies of wild turkey that inhabit the United States. Merriam's turkey is widely distributed throughout the inter-mountain west, but their historical range only included parts of Arizona, New Mexico and Colorado (Mollohan et al. 1995). It is thought that this sub-species may be the descendants of birds brought to the Southwest by early Pueblo Indians (Hoffman et al. 1993). Since that time, turkey populations and range have expanded due to extensive transplanting by game agencies (Hoffman et al. 1993).

Merriam's Wild Turkey Habitat Requirements



http://www.nwtf.org/for_hunters/all_about_turkeys.html

Turkeys require specific habitat characteristics for nesting, roosting, foraging, and loafing. Turkey nests are commonly associated with large-diameter ponderosa pine trees in clumpy, uneven-aged stands which provide many nesting options (Wakeling 1991; Lehman et al 2008). Nests are often on slopes > 40% in areas of high canopy cover (Hoffman et al. 1993; Mollohan et al. 1995). Turkeys also utilize landscape topographic features, rock outcrops, herbaceous vegetation, or slash to conceal nests (Hoffman et al. 1993; Mollohan et al. 1995). Nest locations often have low horizontal visibility from shrubs, slash, or dead-and-down wood and prefer ground hiding cover between 1.5 and 6.5 ft high (Mollohan et al. 1995; Spears et al. 2007; Lehman et al. 2008).

Once poults are more than 10 days old, brooding hens can return to roosting in trees. Turkeys commonly roost on ridges or slopes and prefer tall, over-mature ponderosa pine trees with widely spaced branches (Wakeling 1991; Hoffman et al. 1993; Mollohan et al. 1995). Roost trees are often located near meadows and permanent water sources (Scott and Boeker 1975; Phillips 1980). Clumps of trees used by large flocks of turkeys for roosting occur in stands with a basal area of greater than 21 m^2/ha (92 ft^2/ac) with high canopy cover and more than 5 trees per site (Boeker and Scott 1969; Lutz and Crawford 1987; Hoffman et al 1993; Mollohan et al. 1995).

Foraging habitat for turkeys is a mix of forested habitat and open areas such as meadows. Access to escape cover while foraging is a component of habitat requirements for this species. Many of the same nest cover characteristics also provide cover at foraging sites (Mollohan et al. 1995). Foraging sites that are within one mile of roost sites receive the most use (Wakeling and Rogers 1994). Turkeys most often feed under forest canopy, cienegas, or small openings created by group-selection thinning treatments (Mollohan et al. 1995). Small openings are used more frequently than large openings for quick access to escape cover (Hoffman et al. 1993; Wakeling and Rogers 1994). Turkeys have been shown to utilize large openings or meadows, but rarely forage more than 147 ft from cover (Scott and Boeker 1975).

Loafing areas are another key component of turkey habitat. Loafing includes resting, preening, dusting, and thermal regulation in the summer months (Wakeling et al. 1997). Turkeys use areas with topographic relief for loafing, such as canyon rims, ridge tops or small drainages (Mollohan et al. 1995). Loafing habitat generally consists of dense overstory forests with an open understory for good visibility, with large-diameter fallen snags or slash and rock outcrops that can be used as perches (Hoffman et al. 1993). Forested areas most commonly used for loafing are small stands that are interspersed with small openings that have distinct edge contrast (Wakeling et al. 1997). Frequently used loafing sites are near (~100 ft) high-quality foraging sites with sufficient escape cover (Mollohan et al. 1995).

Merriam's Wild Turkey Model Parameters

Forest restoration treatments can directly affect turkey habitat (Wakeling 1991). Previous research has shown that turkeys are sensitive to habitat fragmentation; therefore forest management activities should retain movement corridors (Wakeling et al. 1997). Land managers should consider maintaining forest canopy and understory canopy cover especially near springs, seeps and narrow openings during the planning phases of forest treatments (Lockwood and Sutcliffe 1985). Forest treatments should also retain snags, large-diameter logs, and some slash material to provide horizontal screening for nesting and loafing cover (Lockwood and Sutcliffe 1985; Wakeling 1991; Hoffman et al. 1993; Wakeling et al. 1998). Roost sites are easily detected and should be retained during forest treatments, along with winter foraging sites within one mile of roost sites (Wakeling 1997). Roost sites should also be buffered by travel corridors at least 302 ft wide and no more than 453 ft long (Hoffman et al. 1993). Travel corridor estimates were used as the minimum gap and spur distances.

Restoration treatments also have the potential to improve turkey habitat by creating or retaining structural diversity, clumpiness, and sufficient cover (Wakeling 1991; Mollohan et al. 1995). Clumped stands that have an uneven-aged forest structure and a dense understory vegetation component are considered high-quality turkey habitat (Wakeling 1991). Areas that maintain a basal area greater than 70 ft^2/ac provide roosting habitat. Treatments that reduce basal area below this threshold have been shown to cause roost abandonment by turkeys (Scott and Boeker 1975; Wakeling et al. 1998). Forest treatments that maintain a basal area of > 109 ft^2/ac also provide high quality loafing habitat for turkeys. Turkey habitat can also be improved by limiting thinning treatments on slopes > 20% and even-aged stands to < 20 acres (Wakeling 1991; Mollohan et al. 1995). Turkeys commonly utilize edge habitat and will benefit from adjacent stands differing in basal area by approximately 30 ft^2/ac (Wakeling 1991).

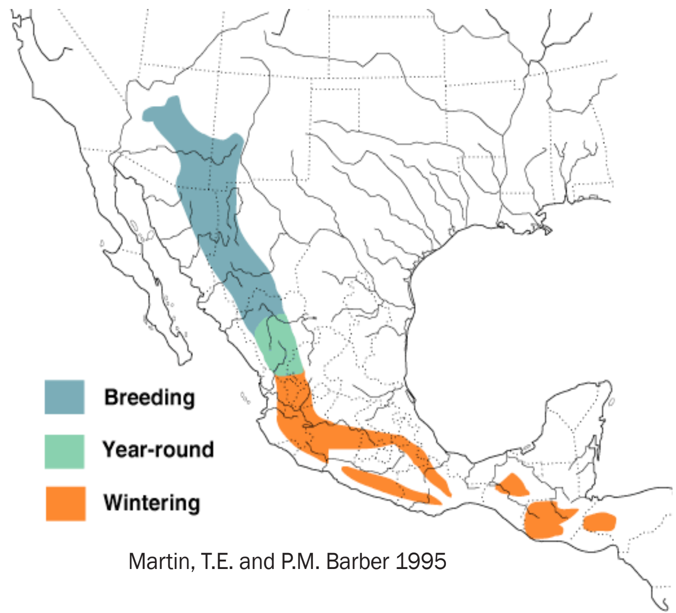
Given the diverse range of forest structural characteristics turkeys utilize, a slightly different approach to modeling functional connectivity is used. Because turkeys prefer to forage in open areas near escape cover, we have buffered the treatment edges by 50 m (164 ft) on each side. This creates a strip of edge habitat that may be used for foraging and loafing. The remainder of areas will be considered core thinned areas and core dense habitat. There is considerable variation in the estimation of home range size for turkeys. Previous research in Arizona has estimated an annual home range of 26 to 32 mi2 for a core area (Wakeling 1991). Other researchers have estimated seasonal home ranges of turkeys to be 1,572 to 6,363 ac (Lutz and Crawford 1989). Because of the considerable range of values, home range estimates were not used to inform gap and spur distances in the PatchMorph model. We estimated a maximum gap distance of 492 ft and a spur distance of 492 – 1,476 ft based on the corridor dimensions estimated by Hoffman et al. (1993).

Red-faced Warbler

Natural History Review of Red-faced Warbler

The red-faced warbler (*Cardellina rubrifrons)* is a striking warbler which inhabits coniferous forests ranging from north- and east-central Arizona and southwest New Mexico southwards to southern Mexico (Martin and Barber 1995; Corman 2005). It is the only representative of its genus.

The red-faced warbler is typically found in mixed-conifer, ponderosa pine, or ponderosa pine-Gambel oak forests associated with moist drainages or heavily-forested canyons (Martin and Barber 1995; Corman 2005). The most recent Arizona Breeding Bird Atlas indicates that the bird is rarely found using similar vegetation in flat, dry terrain (Corman 2005).



Martin, T.E. and P.M. Barber 1995

The red-faced warbler is one of the most striking warblers in southwestern montane forests. Their bright-red face with gray, black, and white markings is unique in the North American warbler family. Inquisitive by nature, these birds often fly and perch close to humans, offering excellent views of its namesake coloration.

Red-faced Warbler Habitat Requirements

In Arizona, red-faced warblers are most frequently observed in mixed-conifer vegetation with a preponderance of Douglas fir (*Pseudotsuga menziesii*), and interspersions of white fir (*Abies concolor*) and ponderosa pine (*Pinus ponderosa*). Deciduous trees or shrubs are often present, i.e. Rocky Mountain maple (*Acer glabrum*), Gambel oak (*Quercus gambelii*), or quaking aspen (*Populus tremuloides*) (Franzreb and Ohmart 1978; Franzreb and Franzreb 1983; Martin and Barber 1995). In Arizona, the species can also be found in forests below and above mixed-conifer habitats such as those dominated by ponderosa pine (often with some deciduous tree component) or in the lower reaches of spruce-fir forests (Corman 2005). Rosenstock (1998) suggested that warblers are more likely to be found in ponderosa pine stands with Gambel oak associations and not in homogenous stands of pure pine. In southeastern Arizona mountains, this species also inhabits moist, forested canyons containing Madrean-associated coniferous and deciduous species. In most cases, however, observations of birds away from cool, moist slopes, canyons, or drainages are atypical (Corman 2005).

The red-faced warbler is a ground-nesting bird that typically constructs nests on steep drainage slopes. Most nests are placed at the base of a grass clump which offers concealment from overhanging vegetation, but they can also be found among forest litter at the base of tree trunks, logs, rocks, shrubs or other vegetation. At times, the species will select for nest sites along rock faces that contain forbs for concealment (Martin and Barber 1995; Corman 2005). As a territorial species, males defend a breeding and foraging area ranging between 0.74 – 1.85 ac in areas of high quality habitat. In these areas, it has been suggested that territories occur at higher densities (Martin and Barber 1995). In areas of lower habitat quality, defended breeding and foraging areas are larger in size ranging between 1.24 – 2.47 ac and have lower bird densities (Martin and Barber 1995).

Predation accounts for the largest cause of mortality for this species. Predators include raccoon (*Procyon lotor*), jays, chipmunks, and squirrels, which can take eggs and young; and forest raptors such as Cooper's hawk (*Accipiter cooperii*) and sharp-shinned hawk (*Accipiter striatus)* which catch fledglings (and likely adults) in flight (Martin and Barber 1995; Lloyd et al. 2006). Predation rates have been shown to increase the closer the nest is to an edge (a transition area between two different habitats or structural differences within similar habitat; Lloyd et al. 2006). Nest predation is also significantly correlated with the forest structural context of the landscape within a 6.2-mi radius of the nest. In landscapes with low (<15%) forest cover, predation was high in both the forest edge and interior (Lloyd et al. 2006). In landscapes with a mid-range of forest cover (45-55%), predation was still high at forest edges, but low in the interior (Lloyd et al. 2006). In landscapes with high (>90%) forest cover, predation was low at both forest edge and interior (Lloyd et al. 2006).

Perhaps due to the need to protect a nest or nestlings on the ground, or possibly from niche-partitioning with other avian gleaners, the red-faced warbler feeds predominantly in the lower parts of trees < 30 ft from the ground, up to 60 ft. In one study, 97% of foraging observations occurred in branches <60 ft from ground-level (Franzreb and Franzreb 1983). Overall height of trees did not influence foraging behavior as much as the presence of foliage from ground-level to 60 ft height (Franzreb and Franzreb 1983). Franzreb (1978) suggests that it is not necessarily the tree species diversity that is of utmost importance to this species, particularly in a relatively homogeneous forest such as ponderosa pine; rather, it is the presence of foliage height diversity, particularly the presence of foliage from ground-level to 60 ft height.

Historical logging practices often negatively impacted red-faced warbler populations. In studies conducted by Szaro and Balda (1979 and 1982), in a gradient of treatments and an untreated control, they found that red-faced warblers were present only in the untreated plots. Franzreb (1977) and Franzreb and Ohlmart (1978) reported that numbers of red-faced warblers diminished drastically or vanished altogether as a result of overstory logging on breeding grounds.

Szaro and Balda (1982) concluded that red-faced warblers are found in old growth and only lightly disturbed areas, and are replaced in moderately to heavily cut areas by species such as western wood-pewee (*Contopus sordidulus*), yellow-rumped warbler (*Dendroica coronata*), and rock wren (*Salpinctes obsoletus*). Total BA can be removed from 15% up to 50% without significantly decreasing avian diversity; however, it has been recommended that large-scale thinning projects should be in strips or blocks, leaving some patches of dense forest (Szaro and Balda 1979 and 1982). In uniform thinning actions, Szaro and Balda (1979 and 1982) recommend only removing 30% of the total BA, because in their experiments, the red-faced warbler was the only species to completely disappear in all treatments above 29% foliage removal. Other recommendations from Szaro and Balda (1979) include leaving at least 32 trees per acre with a dbh equal or greater than 9 inches; leaving a minimum of 17 trees per acre in the 6 – 9 inch size class; and leave approximately 25 trees per acre in the 3 – 6 inch size class. In addition, Scott and Gottfried (1983) suggest that timber harvesting in southwestern mixed-conifer forests did not adversely affect bird density or species diversity, provided thinning removed less than 30-40% of the stand basal area (BA). Their study, on the Apache-Sitgreaves National Forest, showed no impact to red-faced warbler from this level of treatment.

Red-faced Warbler Model Parameters

Red-faced warblers have a suite of habitat requirements and optimal habitat conditions that may be impacted by management activities. Since this species is mostly associated with drainages and canyons as well as a mix of coniferous and deciduous trees, it is likely that their primary habitat may be in areas generally restricted from treatment such as steep slopes, riparian areas, and drainages. However, the width of this restricted canyon or riparian "strip" of habitat may not be sufficient for most foraging needs of this species.

Given the specific needs of forest structural characteristics utilized by the red-faced warbler, we have taken a slightly different approach to modeling functional connectivity for this species. Two objectives of this species-specific analysis are to determine: 1) the impact of treatments in drainages and canyon or slope bottoms; and 2) the adequacy of current buffer areas on top of canyons and beyond riparian areas for providing foraging habitat for this species.

In addition, given the nature of the White Mountain Stewardship Project treatments to focus on small-diameter trees <16" diameter, a third potential objective for this analysis is to determine if enough foliage remains in the ground-level to 60 ft height class within these buffer strips. We will evaluate information collected from permanent vegetation plots to determine if these data show significant differences in mid-story vegetation from thinning treatments.

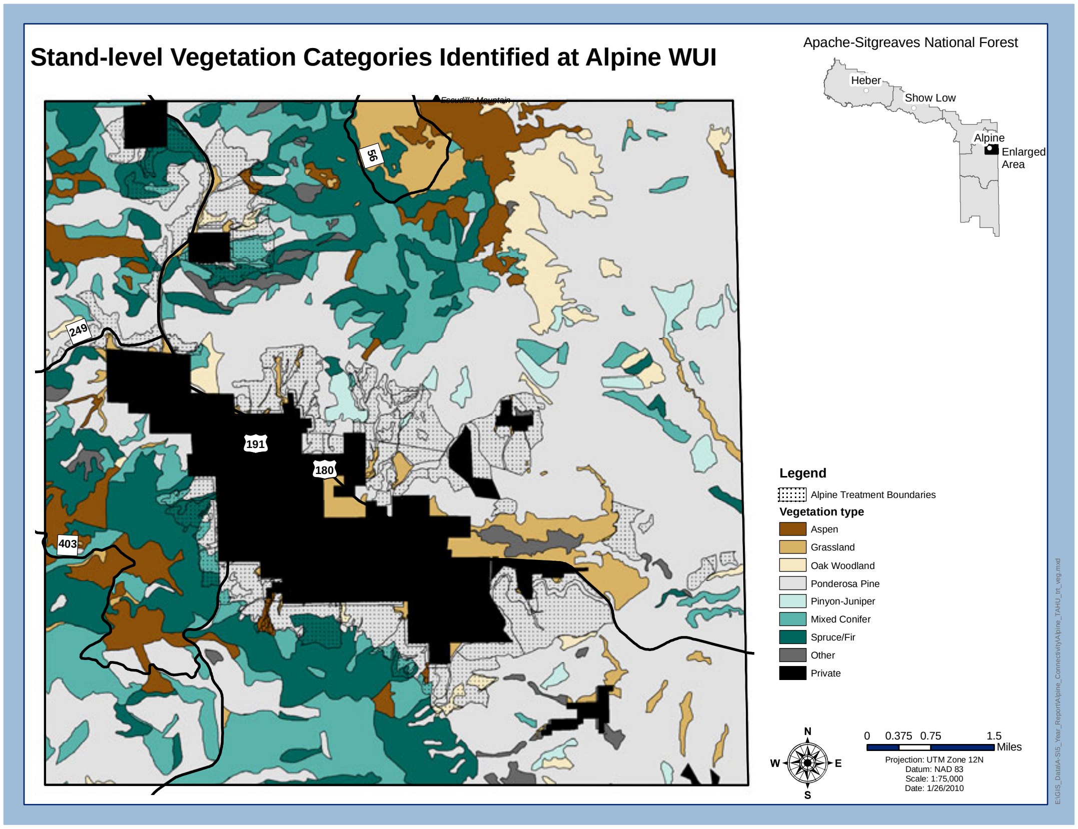
The model for the red-faced warbler will incorporate a minimum to optimal buffer area around primary habitat. In addition, if feasible using existing data, estimates of basal area reduction within these buffer areas will be evaluated for their impact on the foraging needs for this species to assign habitat suitability values in the model. For the purposes of the PatchMorph model, we assume a 2.47 ac territory size for the species, which translates into a defended territory of approximately 197 ft in any direction from the nest. Therefore, threshold to optimal habitat for red-faced warblers will include areas that are within 394 ft total width of vegetated drainages, riparian areas, and canyons that have been either left untreated, or received treatments that only removed 30% or less of existing BA and foliage density.

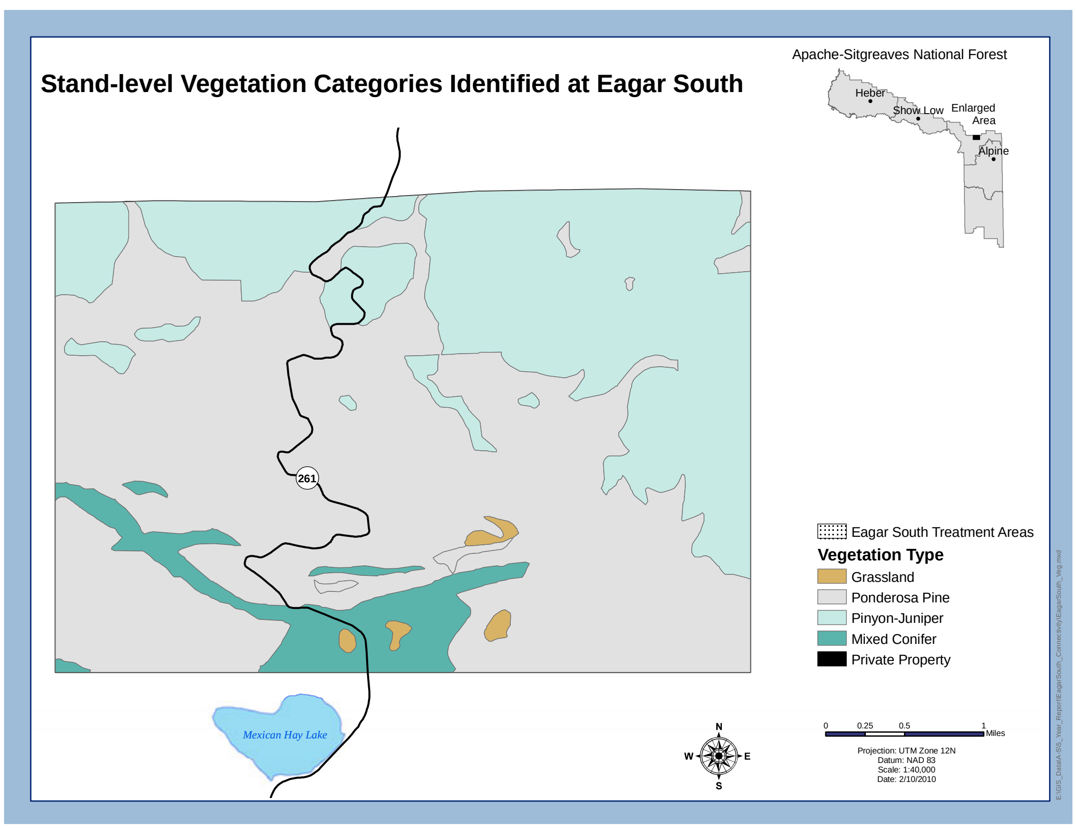
Gap and spur distances utilized in PatchMorph were also derived from an estimated territory size of up to 2.47 ac for this species. Given the mobility of avian species to move between patches of optimal habitat, we assume that the ability to fly between or cross patches of unsuitable habitat is generally further than a defended territory. For the purposes of this model, we doubled the defended territory diameter of 394 ft to arrive at a gap distance of 787 ft as a conservative estimate. For determining spur distances, we use a range of 787 – 1,640 ft. For the purposes of determining optimal vegetative structure and density, we are assuming that a reduction in 30% in BA from pre-treatment conditions (Szaro and Balda 1979) is considered the highest end of tolerance for this species.

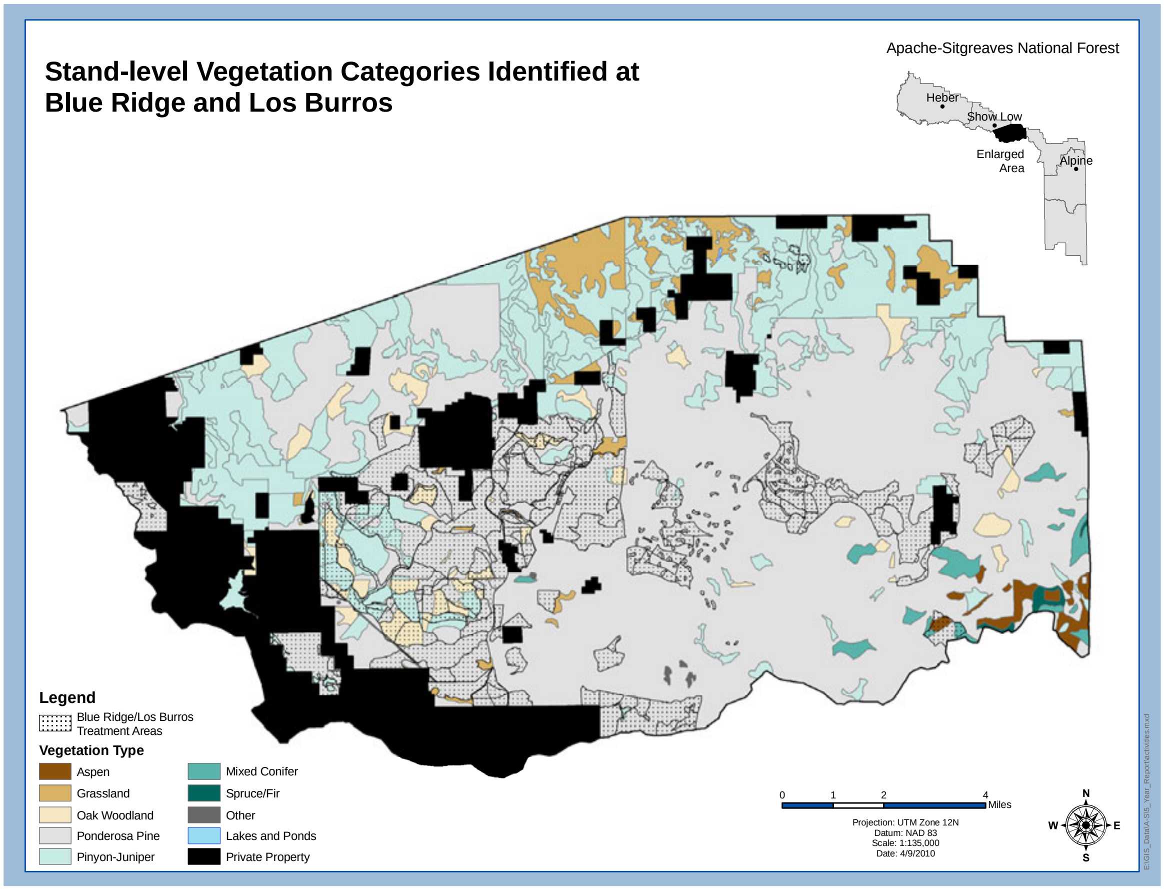
Forest restoration treatments can directly affect red-faced warbler habitat (Szaro and Balda 1979). As discussed above, treatments that remove foliage from ground level to 60 ft in height and 30% BA may render previous warbler habitat unsuitable (Szaro and Balda 1979; Franzreb and Franzreb 1983). However, restoration treatments also have the potential to improve red-faced warbler habitat if a buffer area up to 150' from the outer edge of drainages is created and that buffer area incorporates: 1) light treatments that may open up the overstory to improve herbaceous and understory growth; 2) retaining of snags and large downed logs; and 3) lop and scatter of some slash to provide additional ground cover.

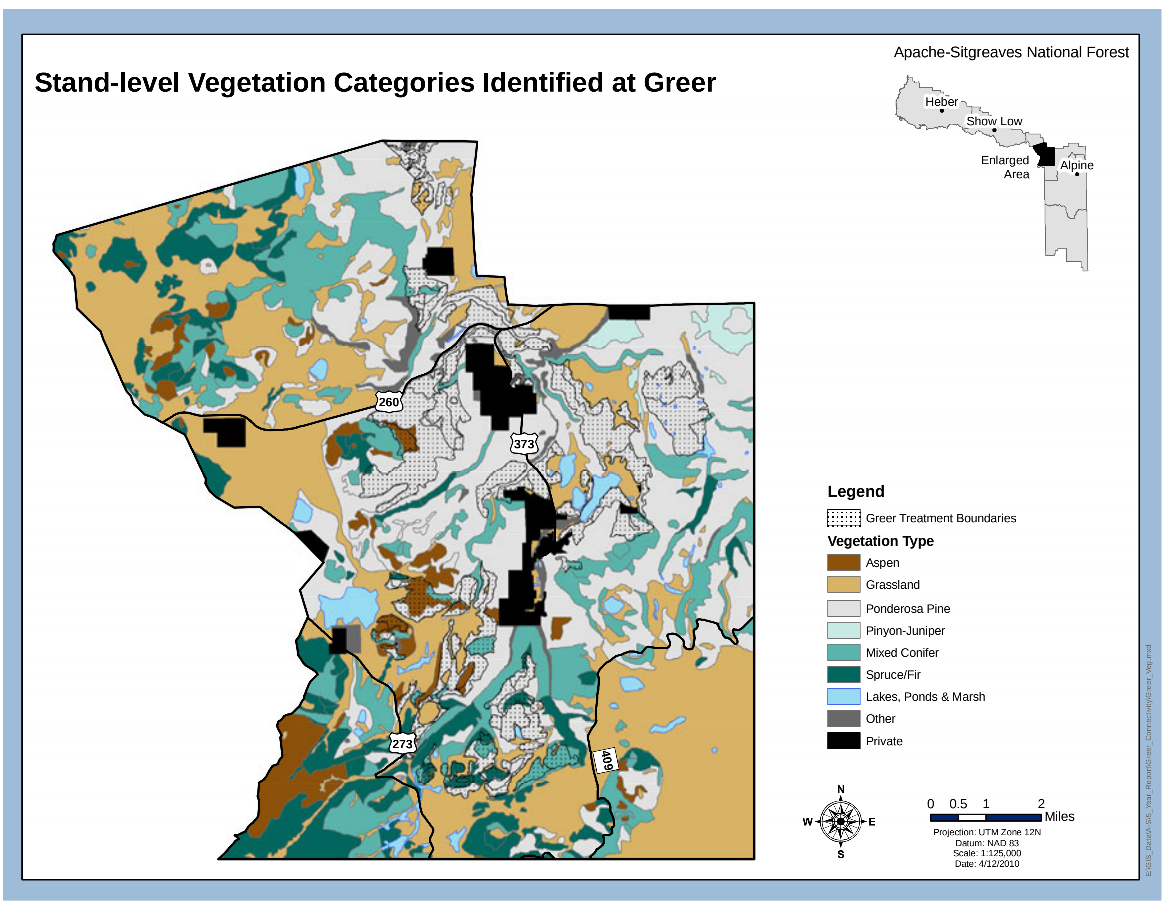
Appendix D.

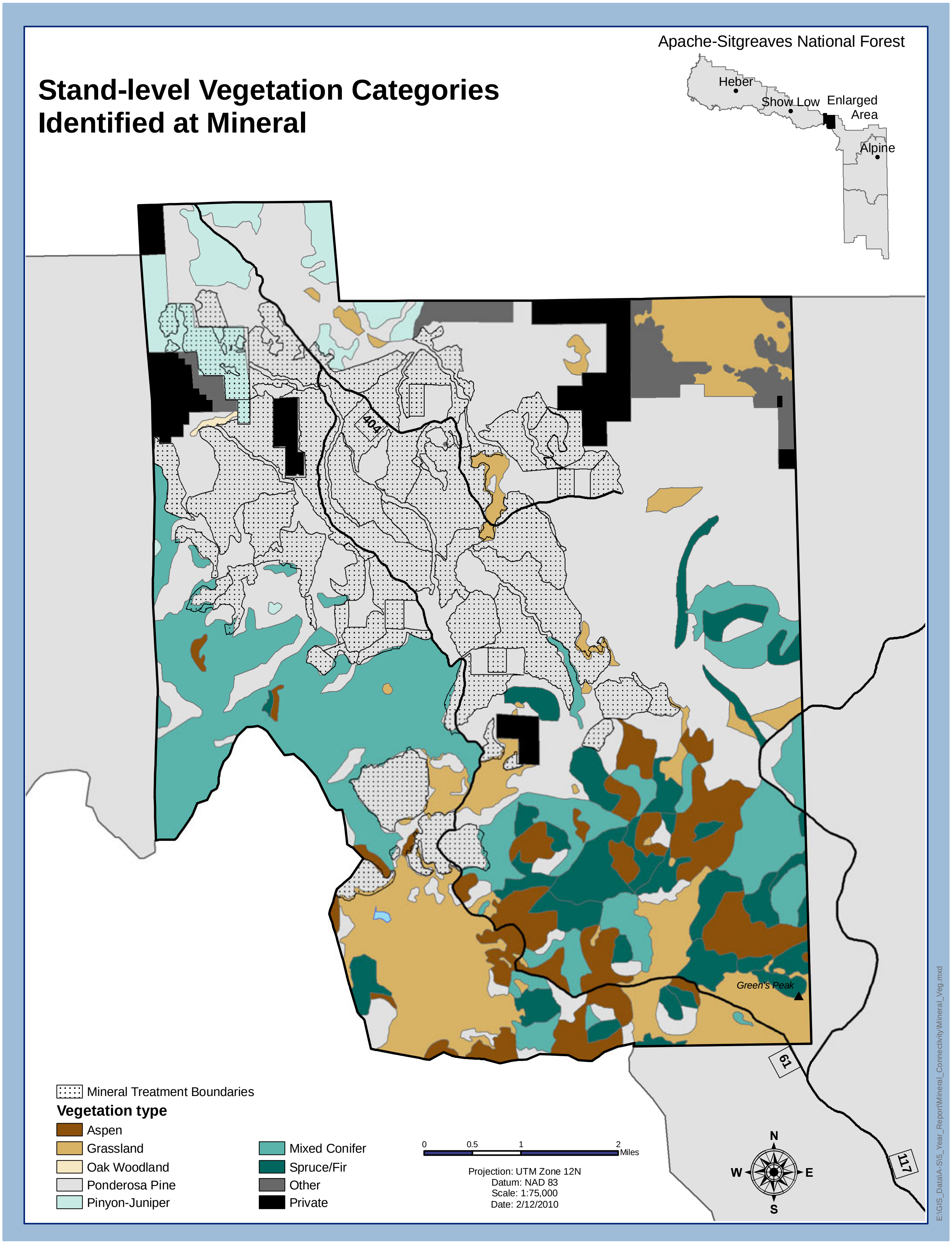
Dominant vegetation types for project areas associated with wildlife habitat connectivity modeling






Stand-level Vegetation Categories Identified at Blue Ridge and Los Burros
Apache-Sitgreaves National Forest
Heber
Show Low
Enlarged Area
Alpine
Legend
Blue Ridge/Los Burros Treatment Areas
Vegetation Type
Aspen
Grassland
Oak Woodland
Ponderosa Pine
Pinyon-Juniper
Mixed Conifer
Spruce/Fir
Other
Lakes and Ponds
Private Property
0 1 2 4 Miles
Projection: UTM Zone 12N
Datum: NAD 83
Scale: 1:135,000
Date: 4/9/2010
N
W
E
S


Stand-level Vegetation Categories Identified at Greer
Apache-Sitgreaves National Forest
Heber
Show Low
Enlarged Area
Alpine
260
373
273
409
Legend
Greer Treatment Boundaries
Vegetation Type
Aspen
Grassland
Ponderosa Pine
Pinyon-Juniper
Mixed Conifer
Spruce/Fir
Lakes, Ponds & Marsh
Other
Private
0 0.5 1 2 Miles
Projection: UTM Zone 12N
Datum: NAD 83
Scale: 1:125,000
Date: 4/12/2010
N
W
E
S



Apache-Sitgreaves National Forest
Stand-level Vegetation Categories
Identified at Mineral
Heber
Show Low
Enlarged
Area
Alpine
404
Green's Peak
61
117
Mineral Treatment Boundaries
Vegetation type
Aspen
Grassland
Oak Woodland
Ponderosa Pine
Pinyon-Juniper
Mixed Conifer
Spruce/Fir
Other
Private
0
0.5
1
2
Miles
Projection: UTM Zone 12N
Datum: NAD 83
Scale: 1:75,000
Date: 2/12/2010
N
W
E
S
E:\GIS_Data\A-S\5_Year_Report\Mineral_Connectivity\Mineral_Veg.mxd

Appendix E.

All species detected in ponderosa pine, pine-oak, and pinyon-juniper vegetation types during pre- and post-treatment breeding bird surveys completed between 2007 and 2009

Pine-Oak Species	Pre-	Post-	Pine-Oak Species	Pre-	Post-
Acorn Woodpecker *(Melanerpes formicivorus)*	X	X	Northern Flicker *(Colaptes auratus)*	X	X
American Crow *(Corvus brachyrhynchos)*		X	Olive Warbler *(Peucedramus taeniatus)*	X	
American Robin *(Turdus migratorius)*	X	X	Olive-sided Flycatcher *(Contopus cooperi)*	X	X
Ash-throated Flycatcher *(Myiarchus cinerascens)*	X	X	Pine Siskin *(Spinus pinus)*	X	X
Brown-headed Cowbird *(Molothrus ater)*	X		Plumbeous Vireo *(Vireo plumbeus)*	X	X
Black-headed Grosbeak *(Pheucticus melanocephalus)*	X	X	Purple Martin *(Progne subis)*	X	X
Brown Creeper *(Certhia americana)*	X		Pygmy Nuthatch *(Sitta pygmaea)*	X	X
Broad-tailed Hummingbird *(Selasphorus platycercus)*	X	X	Red-breasted Nuthatch *(Sitta canadensis)*	X	
Chipping Sparrow *(Spizella passerina)*	X		Red Crossbill *(Loxia curvirostra)*		X
Cordilleran Flycatcher *(Empidonax occidentalis)*	X	X	Red-faced Warbler *(Cardellina rubrifrons)*	X	X
Cooper's Hawk *(Accipiter cooperii)*	X		Red-tailed Hawk *(Buteo jamaicensis)*	X	
Common Nighthawk *(Chordeiles minor)*	X	X	Sharp-shinned Hawk *(Accipiter striatus)*	X	X
Common Raven *(Corvus corax)*	X	X	Steller's Jay *(Cyanocitta stelleri)*	X	X
Dark-eyed Junco *(Junco hyemalis)*	X	X	Townsend's Solitaire *(Myadestes townsendi)*	X	X
Downy Woodpecker *(Picoides pubescens)*		X	Three-toed Woodpecker *(Picoides dorsalis)*	X	
Gray Flycatcher *(Empidonax wrightii)*	X		Violet-green Swallow *(Tachycineta thalassina)*	X	X
Gray Vireo *(Vireo vicinior)*	X	X	Virginia's Warbler *(Vermivora virginiae)*	X	
Grace's Warbler *(Dendroica graciae)*	X	X	Warbling Vireo *(Vireo gilvus)*	X	X
Hairy Woodpecker *(Picoides villosus)*	X	X	Western Bluebird *(Sialia mexicana)*	X	X
Hepatic Tanager *(Piranga flava)*		X	Western Tanager *(Piranga ludoviciana)*	X	X
Hermit Thrush *(Catharus guttatus)*	X	X	Western Wood-Pewee *(Contopus sordidulus)*	X	X
Hutton's Vireo *(Vireo huttoni)*	X		White-breasted Nuthatch *(Sitta carolinensis)*	X	X
Mountain Bluebird *(Sialia currucoides)*	X	X	Williamson's Sapsucker *(Sphyrapicus thyroideus)*	X	
Mountain Chickadee *(Poecile gambeli)*	X	X	Yellow-rumped Warbler *(Dendroica coronata)*	X	X
Mourning Dove *(Zenaida macroura)*	X	X			

Ponderosa Pine Species	Pre-	Post-	Ponderosa Pine Species	Pre-	Post-
Acorn Woodpecker *(Melanerpes formicivorus)*	X	X	Northern Mockingbird *(Mimus polyglottos)*		X
American Coot *(Fulica americana)*		X	Northern Pygmy-Owl *(Glaucidium gnoma)*	X	
American Kestrel *(Falco sparverius)*	X		Olive Warbler *(Peucedramus taeniatus)*	X	
American Robin *(Turdus migratorius)*	X	X	Olive-sided Flycatcher *(Contopus cooperi)*	X	X
Brown-headed Cowbird *(Molothrus ater)*		X	Pine Siskin *(Spinus pinus)*	X	X
Black-headed Grosbeak *(Pheucticus melanocephalus)*	X	X	Plumbeous Vireo *(Vireo plumbeus)*	X	X
Brown Creeper *(Certhia americana)*	X		Purple Martin *(Progne subis)*	X	X
Broad-tailed Hummingbird *(Selasphorus platycercus)*	X	X	Pygmy Nuthatch *(Sitta pygmaea)*	X	X
Band-tailed Pigeon *(Patagioenas fasciata)*	X		Red-breasted Nuthatch *(Sitta canadensis)*	X	
Chipping Sparrow *(Spizella passerina)*	X	X	Red Crossbill *(Loxia curvirostra)*	X	X
Clark's Nutcracker *(Nucifraga columbiana)*	X	X	Red-faced Warbler *(Cardellina rubrifrons)*	X	
Cordilleran Flycatcher *(Empidonax occidentalis)*	X	X	Steller's Jay *(Cyanocitta stelleri)*	X	X
Cooper's Hawk *(Accipiter cooperii)*	X	X	Townsend's Solitaire *(Myadestes townsendi)*	X	
Common Raven *(Corvus corax)*	X	X	Tree Swallow *(Tachycineta bicolor)*		X
Dark-eyed Junco *(Junco hyemalis)*	X	X	Turkey Vulture *(Cathartes aura)*	X	
Downy Woodpecker *(Picoides pubescens)*	X	X	Violet-green Swallow *(Tachycineta thalassina)*	X	X
Grace's Warbler *(Dendroica graciae)*	X	X	Virginia's Warbler *(Vermivora virginiae)*	X	
Hairy Woodpecker *(Picoides villosus)*	X	X	White-breasted Nuthatch *(Sitta carolinensis)*	X	X
Hermit Thrush *(Catharus guttatus)*	X	X	Western Bluebird *(Sialia mexicana)*	X	X
Lewis's Woodpecker *(Melanerpes lewis)*		X	Western Meadowlark *(Sturnella neglecta)*		X
Mountain Bluebird *(Sialia currucoides)*	X		Western Tanager *(Piranga ludoviciana)*	X	X
Mountain Chickadee *(Poecile gambeli)*	X	X	Western Wood-Pewee *(Contopus sordidulus)*	X	X
Mourning Dove *(Zenaida macroura)*	X	X	Williamson's Sapsucker *(Sphyrapicus thyroideus)*	X	
Northern Flicker *(Colaptes auratus)*	X	X	Yellow-rumped Warbler *(Dendroica coronata)*	X	X
Northern Goshawk *(Accipiter gentilis)*	X				
American Crow (Corvus brachyrhynchos)	X				
American Kestrel (Falco sparverius)	X				

Pinyon-Juniper Species	Pre-	Post-	Pinyon-Juniper Species	Pre-	Post-
American Robin *(Turdus migratorius)*	X		Juniper Titmouse *(Baeolophus ridgwayi)*	X	
Ash-throated Flycatcher *(Myiarchus cinerascens)*	X	X	Lark Sparrow *(Chondestes grammacus)*	X	
Bendire's Thrasher *(Toxostoma bendirei)*	X		Lesser Goldfinch *(Spinus psaltria)*	X	
Bewick's Wren *(Thryomanes bewickii)*	X	X	Mountain Bluebird *(Sialia currucoides)*	X	
Black-headed Grosbeak *(Pheucticus melanocephalus)*	X	X	Mountain Chickadee *(Poecile gambeli)*	X	X
Black-throated Gray Warbler *(Dendroica nigrescens)*	X	X	Mourning Dove *(Zenaida macroura)*	X	X
Blue-gray Gnatcatcher *(Polioptila caerulea)*	X		Northern Flicker *(Colaptes auratus)*	X	X
Brewer's Blackbird *(Euphagus cyanocephalus)*	X		Northern Mockingbird *(Mimus polyglottos)*	X	
Broad-tailed Hummingbird *(Selasphorus platycercus)*	X		Pinyon Jay *(Gymnorhinus cyanocephalus)*	X	
Brown-headed Cowbird *(Molothrus ater)*	X		Pine Siskin *(Spinus pinus)*	X	X
Bushtit *(Psaltriparus minimus)*	X	X	Plumbeous Vireo *(Vireo plumbeus)*	X	
Cassin's Finch *(Carpodacus cassinii)*	X		Pygmy Nuthatch *(Sitta pygmaea)*	X	
Cassin's Kingbird *(Tyrannus vociferans)*	X		Red Crossbill *(Loxia curvirostra)*	X	X
Chipping Sparrow *(Spizella passerina)*	X	X	Red-tailed Hawk *(Buteo jamaicensis)*	X	
Clark's Nutcracker *(Nucifraga columbiana)*	X		Say's Phoebe *(Sayornis saya)*	X	
Cordilleran Flycatcher *(Empidonax occidentalis)*	X		Spotted Towhee *(Pipilo maculatus)*	X	X
Common Raven *(Corvus corax)*	X	X	Steller's Jay *(Cyanocitta stelleri)*	X	
Dark-eyed Junco *(Junco hyemalis)*	X	X	Townsend's Solitaire *(Myadestes townsendi)*	X	
Downy Woodpecker *(Picoides pubescens)*	X	X	Turkey Vulture *(Cathartes aura)*	X	
Gray Flycatcher *(Empidonax wrightii)*	X	X	Vesper Sparrow *(Pooecetes gramineus)*	X	
Gray Vireo *(Vireo vicinior)*	X	X	Violet-green Swallow *(Tachycineta thalassina)*	X	
Grace's Warbler *(Dendroica graciae)*	X	X	Virginia's Warbler *(Vermivora virginiae)*		X
Hairy Woodpecker *(Picoides villosus)*	X		Western Bluebird *(Sialia mexicana)*	X	X
Hepatic Tanager *(Piranga flava)*	X		Western Scrub-Jay *(Aphelocoma californica)*	X	
Hermit Thrush *(Catharus guttatus)*	X		Western Tanager *(Piranga ludoviciana)*	X	X
House Finch *(Carpodacus mexicanus)*		X	Western Wood-Pewee *(Contopus sordidulus)*	X	
House Wren *(Troglodytes aedon)*	X		White-breasted Nuthatch *(Sitta carolinensis)*		
Horned Lark *(Eremophila alpestris)*	X		Yellow-rumped Warbler *(Dendroica coronata)*	X	

Appendix F.

Region-wide tax revenue estimations

The following spreadsheet, provided by Engle (2010), estimates tax revenue generated by the White Mountain Stewardship Project from County property tax (Project-associated businesses and residents employed); school district revenue from employed residents with children; sales tax from capital equipment and consumables; and similar taxes generated by indirect employment using multipliers. Expenditures and employment numbers are based upon data from annual economic surveys undertaken for the White Mountain Stewardship Project monitoring effort. Data on taxes, per capita average expenditures, students-per-household, and other statistics are derived from Navajo County information databases. Similar data were not available from Apache County; therefore, Engle assumed similarities between the two counties and extrapolated Navajo County statistics for Apache County figures derived from the economic survey.

Engle, M. 2010. Estimates of Regional Tax Revenue from the White Mountain Stewardship Project, 2006-2015

Revenue, Years 2006-2009

Ten-Year Total and Individual Year	10-Year Total	2006	2007	2008	2009
Job estimates from annual economic surveys		125	245	228	246
ECONOMIC CONTRIBUTIONS					
Gross contributions:					
Added Tax Base (revenue from sale of wood products)		$3,750,000	$6,250,000	$5,522,000	$7,200,000
Payroll (est. $24K/employee/year using annual job calculation)		$3,000,000	$5,880,000	$5,472,000	$5,904,000
School - Increased Enrollment (17% of employees with students)		21	42	39	42
Estimated Local Purchases (capital; >1 year lifespan use)		$5,000,000	$10,000,000	$10,024,000	$10,000,000
Net calculations:					
County Property Tax Revenue (2% of tax base)		$75,000	$125,000	$110,440	$144,000
School District Revenue (State/Fed appropriation per student)		$76,680	$150,293	$139,864	$150,906
Sales Tax from local capital purchases (2.0%)		$37,480	$74,960	$75,140	$74,960
Navajo County Sales Tax from capital purchases (0.5%)		$9,370	$18,740	$18,785	$18,740
TOTAL NET ECONOMIC CONTRIBUTIONS	$4,416,750	$198,530	$368,993	$344,229	$388,606
REVENUE FROM WMSP-ASSOCIATED EMPLOYEES					
Gross contributions:					
Employee's Taxable Consumption (20% of payroll for consumable goods i.e. food)		$573,900	$1,124,844	$1,046,794	$1,129,435
Employee's Property Tax Payments (all jurisdictions; 2% of payroll)		$59,100	$115,836	$107,798	$116,309
Net calculations:					
Local Sales Tax Capture Rate (37.48%)* [amt. kept in community from above]					
Local Sales Tax (2.0%) from employees		$4,302	$8,432	$7,847	$8,466
County Sales Tax (0.5%) from employees		$1,075	$2,108	$1,962	$2,117
Local Property Tax collected from employees		$36,199	$70,950	$66,027	$71,239
TOTAL NET EMPLOYEE REVENUE	$879,420	$41,576	$81,489	$75,835	$81,822

MULTIPLIER-EFFECT EMPLOYMENT					
Direct Effect Multipliers - Employment / Earnings** (1.95 and 1.69 respectively)					
Employment: Direct and Multiplier Effect Total Jobs					
(Direct Jobs x 1.95 Employment Multiplier)		244	478	445	480
Earnings of Direct and Employment Multiplier Jobs (payroll x 1.69)		$5,070,000	$9,937,200	$9,247,680	$9,977,760
Multiplier Jobs Taxable Consumption (20% of payroll for consumable goods)		$969,891	$1,900,986	$1,769,081	$1,908,745
Multiplier Jobs Property Tax Payments (2% of payroll)		$99,879	$195,763	$182,179	$196,562
Local Sales Tax (2.0%) from Multiplier Jobs		$7,270	$14,250	$13,261	$14,308
County Sales Tax (0.5%) from Multiplier Jobs		$1,818	$3,562	$3,315	$3,577
Local Property Tax collected from Multiplier Jobs		$61,176	$119,905	$111,585	$120,394
REVENUE FROM MULTIPLIER JOBS	**$1,486,219**	**$70,264**	**$137,717**	**$128,161**	**$138,279**
TOTAL EXPECTED REVENUE	**$6,782,389.06**	**$310,369.96**	**$588,199.12**	**$548,225.29**	**$608,707.28**

Projected Revenue Years 2010-2015	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Job estimates from annual economic surveys and projected trends	300	300	300	300	300	300
ECONOMIC CONTRIBUTIONS						
Gross contributions:						
Added Tax Base (revenue from sale of wood products)	$10,000,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000
Payroll (est. $24K/employee/year using annual job calculation)	$7,200,000	$7,200,000	$7,200,000	$7,200,000	$ 7,200,000	$ 7,200,000
School - Increased Enrollment (17% of employees with students)	51	51	51	51	51	51
Estimated Local Purchases (capital; >1 year lifespan use)	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
Net calculations:						
County Property Tax Revenue (2% of tax base)	$200,000	$250,000	$250,000	$250,000	$ 250,000	$ 250,000
School District Tax Revenue (State/Fed appropriation per student)	$184,032	$184,032	$184,032	$184,032	$ 184,032	$ 184,032
Sales Tax from local capital purchases (2.0%)	$74,960	$74,960	$74,960	$74,960	$ 74,960	$ 74,960
Navajo County Sales Tax from capital purchases (0.5%)	$18,740	$18,740	$18,740	$18,740	$ 18,740	$ 18,740
TOTAL NET ECONOMIC CONTRIBUTIONS	**$477,732**	**$527,732**	**$527,732**	**$527,732**	**$ 527,732**	**$ 527,732**

REVENUE FROM WMSP-ASSOCIATED EMPLOYEES						
Gross contributions:						
Employee's Taxable Consumption (20% for consumable goods)	$1,377,360	$1,377,360	$1,377,360	$1,377,360	$1,377,360	$1,377,360
Employee's Property Tax Payments (all jurisdictions, 2% payroll)	$141,840	$141,840	$141,840	$141,840	$141,840	$141,840
Net calculations:						
Local Sales Tax (2.0%) from employees	$10,325	$10,325	$10,325	$10,325	$10,325	$10,325
County Sales Tax (0.5%) from employees	$2,581	$2,581	$2,581	$2,581	$2,581	$2,581
Local Property Tax collected from employees	$86,877	$86,877	$86,877	$86,877	$86,877	$86,877
TOTAL NET EMPLOYEE REVENUE	$99,783	$99,783	$99,783	$99,783	$99,783	$99,783

MULTIPLIER EFFECT EMPLOYMENT						
Employment: Direct and Multiplier Effect Total Jobs	**585**	**585**	**585**	**585**	**585**	**585**
Earnings of Direct and Employment Multiplier Jobs (payroll x 1.69)	$12,168,000	$12,168,000	$12,168,000	$12,168,000	$12,168,000	$12,168,000
Multiplier Jobs Taxable Consumption (20% for consumable goods)	$2,327,738	$2,327,738	$2,327,738	$2,327,738	$2,327,738	$2,327,738
Multiplier Jobs Property Tax Payments (2% of payroll)	$239,710	$239,710	$239,710	$239,710	$239,710	$239,710
Local Sales Tax (2.0%) from Multiplier Jobs	$17,449	$17,449	$17,449	$17,449	$17,449	$17,449
County Sales Tax (0.5%) from Multiplier Jobs	$4,362	$4,362	$4,362	$4,362	$4,362	$4,362
Local Property Tax collected from Multiplier Jobs	$146,822	$146,822	$146,822	$146,822	$146,822	$146,822
REVENUE FROM MULTIPLIER JOBS	**$168,633**	**$168,633**	**$168,633**	**$168,633**	**$168,633**	**$168,633**
TOTAL EXPECTED REVENUE	**$746,148**	**$796,148**	**$796,148**	**$796,148**	**$796,148**	**$796,148**

*   Estimate by Navajo County, 2008
** Obtained from U.S. Bureau of Economic Analysis, Regional Input-Output Modeling System (RIMS II) Arizona input-output accounts for Logging, Sawmill, and Wood Manufacturing Industries, 2006

Appendix G.

Methodology for the social assessment for Navajo and Apache counties

The Monitoring Board used a post-doctoral social assessment conducted by Timothy W. Collins, Ph.D., in 2005 in Navajo County for developing baseline (pre-Project) surveys on social perspectives of general forest management practices in the White Mountains region. That survey was expanded to include Apache County as commissioned by the Board in 2006. The Apache County survey was identical, but included different methodologies to collect the information.

For Navajo County, the assessment used door-to-door direct contacts with households as the primary tool to obtain surveys, reaching 1,050 households distributed from Linden and Show Low to Pinetop-Lakeside. Of the surveys distributed, 563 were completed and returned, translating into a 53% response rate. Due to time and staff limitations, the Apache County sample was obtained using a mail approach. Postmasters in Springerville, Eagar, Alpine, Nutrioso, and Greer were contacted and asked to receive 200 surveys and to distribute those surveys in a 2:1 ratio (133:67) of full-time and part-time residents' post office boxes. A modification of this method was made in Greer, where 182 surveys were placed in only full-time residents' post-office boxes. Accounting for another 13 surveys returned as undeliverable, a total of 969 surveys were distributed to Apache County residents, of which 209 were completed and returned, for a response rate of 21.6%. In total, 2,019 surveys were distributed to White Mountains residents in Navajo and Apache counties, 772 of which were returned, for an overall response rate of 38.2%.

Question topics included residential status, values of place, perceptions of fire hazard, knowledge of fire ecology, perspectives on forest management approaches, perspectives on forest management and fire insurance institutions, preferences for home site characteristics, property fire hazard adjustments, and socio-economic characteristics of the household.

A complete survey form is available in the original social assessment report, located on the Board's webpage at http://www.fs.fed.us/r3/asnf/stewardship/multi-party-monitoring.shtml.

Appendix H.

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