
NORTHERN COLORADO
Bark Beetle
COOPERATIVE

Acronyms used in this document

RMRS – Rocky Mountain Research Station
USFS – United States Forest Service
USFWS (ESA) – United States Fish and Wildlife Service (Endangered Species Act)
DOT – Department of Transportation
FEF – Frazier Experimental Forest
GLEES - Glacier Lake Ecosystem Experiment Site

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INTRODUCTION

The forests of northern Colorado are dying by bark beetle epidemics at an historically unprecedented scale. Over 425,000 acres were infested by the end of 2005. Mortality in northern Colorado is unprecedented in recorded history. Urgent concerns about the threats posed by dead forests—wildfire risk to communities and watersheds, loss of key wildlife habitats, and impacts to local economies and infrastructure—prompted a meeting of many interests in October 2005 to decide what to do. The result was the Northern Colorado Bark Beetle Cooperative.

The purpose of the Cooperative is to develop a comprehensive program to address ongoing and projected forest mortality, and resulting impacts. Current cooperators include the Forest Service (Arapaho-Roosevelt, White River and Medicine Bow-Routt National Forests, and the Rocky Mountain Research Station); the Bureau of Land Management (Kremmling and Glenwood Springs Field Offices); the Colorado State Forest Service; Northwest Colorado Council of Governments (with a combined membership of forty county and municipal Governments); Eagle, Grand, Jackson, Routt, and Summit Counties; local communities; conservation districts; and private landowners. Ultimately, the Cooperative expects to incorporate 15 counties.

This strategy provides a framework for action that will be fine-tuned as the Northern Colorado Bark Beetle Cooperative meets with counties and communities over the next few months. It is meant to be strategic, rather than tactical, with broad priorities for treatment over the entire geographic area. Sub regional and local priorities for treatments and treatment areas will be established with local input from the counties, local fire districts, municipalities, business, industry, environmental interests, and the public. A general strategy is needed that identifies broad priorities upon which to focus our efforts in responding to this large scale natural disturbance. The strategy will be revisited after local involvement refines the priorities. Action plans will be developed and modified with local input.

VALUES AT RISK

An assessment conducted in late 2005 mapped current infestations and projected progression of the epidemics. It identified several values at risk:

- communities will face increased wildfire threat;
- ski areas that are losing aesthetic and practical values provided by tree cover, such as visual quality and snow retention;
- developed recreation areas where hazard trees threaten public safety;
- watersheds that can suffer damage to soils and increased sediment in streams from potentially severe wildfires;
- habitat that is damaged by loss of nest trees and large trees that support many species;
- transmission lines that can be lost or damaged in severe wildfires; and
- timber (580,000 acres—or about 80 percent of the suitable timber base—are moderately to highly susceptible to infestation).

STRATEGY FOR ACTION

Individual cooperators have taken many suppression and salvage actions in the last few years, but no one can do it alone. A Strategy for Action, comprising short- and long-term phases, has been built by the Cooperative to deal comprehensively with the epidemic. Priority treatment needs for both phases are communities/residential interface, ski areas, key recreation areas, utilities/transportation corridors, and watersheds. Existing local, county, state and federal land use/management plans will be used to guide implementation of these strategies.

The **short-term phase** focuses on actions that can be taken in 2006. This phase has two scenarios. The first scenario identifies actions to be taken with existing funds. They include preventive spraying and thinning in high-value, high-risk areas, and suppression and salvage in already infested areas. The second scenario outlines an accelerated schedule that increases treated acres by 25,307— as well as providing for reforestation of 70 acres in campgrounds, and environmental planning for six Forest Service projects.

Northern Colorado Bark Beetle Cooperative Strategy for Action

Short-Term Phase

Agency	Current Program Acres	Accelerated Program Additional Acres
USDA Forest Service		
Spraying	482	1,450
Suppression/Salvage	7,444	24,000
Hazardous Fuel Reduction	310	982
Reforestation (Campgrounds)		70
Accelerated Planning		6 decisions
Total USFS	8,236	
BLM		
Suppression/Salvage	360	500
Hazardous Fuel Reduction	174	600
Total BLM	534	
Colorado State Forest Service		
Spraying	120	Colorado State Forest Service is focusing efforts on areas that communities and local decision makers have cooperatively identified as priorities. If additional resources were available, CSFS would first expand operations to augment current community protection efforts, then would increase forest management activities to help protect watersheds and associated resources, and finally would expand efforts to protect, improve and enhance forest health across the landscape.
Suppression/Salvage	3,005	
Total CSFS	3,125	

The **long-term phase** focuses on actions that can improve the resilience of forests to future infestations. Not every acre can be treated. Actions will be strategically planned across jurisdictional boundaries to address the highest priorities in the Cooperative's 15-county area. Actions include prevention, direct control, and salvage/protection.

Northern Colorado Bark Beetle Cooperative Strategy for Action

Long-Term Phase

Agency	Outputs
USDA Forest Service	
Prevention	
Spraying	3,400 acres
Area-wide biological assessment (all units)	1 assessment
Thinning	5,000 acres 50,000 ccf
Suppression	
Suppression in ski areas	10 ski areas
Suppression in WUI	3,000 acres
Salvage/Protection	
Timber Harvest	3,200 acres 64,000 ccf
Stewardship Contract (all units)	1 contract
Fire behavior assessment/ model (all units)	1 assessment/model
Reforestation of developed sites	10 sites
Reforestation - timber base and other areas	1,000 acres
Defensible Space - WUI	20,000 acres
Defensible space – Powerline Corridors	1,000 acres
Hazard Tree Removal - Roads & Trails	100 miles
	Total
BLM	
Timber Harvest	1,000 acres 20,000 ccf
Defensible Space - WUI	500 acres
	Total
Colorado State Forest Service	
Timber Harvest	300 acres 6,000 ccf

A detailed table of the specific outputs for both the short term and long term strategies can be found in Appendix B at the end of this report.

Additional Strategic Actions

Additional strategic actions that can begin in the short-term and carry through into the long term include:

Coordination of Efforts

Twenty two priority treatment areas were identified by state & federal agency, county, and local governmental representatives with input from private landowners. Priority treatment areas include private, local government, state, and federal (USFS, BLM, NPS) lands. There is a map of these 22 priority areas in Appendix A of this report.

Fire Prevention

Continue efforts working with communities to develop and implement Community Wildfire Protection Plans (CWPP).

Salvage/Protection

Apply current, science-based fuels and fire modeling programs in support of identification of strategic placement of treatments across landscapes to increase the potential to control wildfires and to identify fire travel-ways.

Industry/Business

Undertake local biomass studies aimed at understanding fuel loadings and as a basis for utilization projects and the development/support of appropriate industries.

Collaborative Emergency Management Planning

Work with communities and counties and their emergency management services to develop contingency plans for mass evacuation and to increase fire suppression preparedness and capabilities.

Addressing Potential Air Quality Impacts

Model the impacts of treatments and large fires on air quality and how these impacts might be mitigated or accommodated.

Colorado Wood Utilization and Marketing Program.

This is a part of the Colorado State Forest Service, promotes healthy forests through healthy businesses and healthy communities. Utilization of the by-products of forest management is a key component in maintaining forest health. Through education, technical assistance, applied research and advocacy they are working to:

- Expand and/or establish industry capacity that can harvest, transport, and/or utilize forest management materials for biomass, solid wood and/or composites.
- Achieve broad-based application of biomass heating by providing technology overviews, feasibility studies and potential funding sources to decision makers who are exploring facility heating projects.
- Assist with gathering and compiling supply data for wood material produced statewide.
- Develop and maintain GIS-mapped databases for wood supply in Colorado and surrounding areas.
- Conduct grading, surfacing, and marketing work to assist businesses in improving the value of wood products they produce.
- Develop new end products and end-users of wood.

Summary

The bark beetle epidemic in northern Colorado is part of a natural cycle. It can't be stopped. However, aggressive strategic action, implemented swiftly, can minimize the threat that dead trees pose to local economies, infrastructure, natural resources, and---most important—public safety. The Northern Colorado Bark Beetle Cooperative has the will and skill to address the epidemic. Once the strategy is in place, the partners will work together to seek and leverage the funds to wage the campaign against the beetles.

Barriers to Implementation

Effectively implementing a comprehensive bark beetle strategy will pose a number of challenges. Challenges have been identified across a broad spectrum of settings. In order to manage and effectively meet those challenges they have been grouped into the following categories:

- Legislative / Political
- Administrative
- Industry / Business
- Communications / Education

Individual teams with representatives from various agencies and partners have been assigned to each category. These teams have the responsibility to assess, evaluate and seek collaborative solutions to identified barriers.

This process is expected to be dynamic, as existing challenges are worked on and solved it is anticipated that new challenges will arise. The dynamic nature of the process will necessitate the need for each team to routinely re-evaluate and adapt to situational changes that occur throughout the implementation of the Bark Beetle Strategy.

The tables on the following pages display the challenges identified to date.

Barrier	What is the Principle Challenge?	Who should take on the solution?	Outcome desired
Legislative / Political			
Matching planning *tools* with rate of infestation	Streamlining of planning processes still needed – NEPA/Decision making	Legislative team, Steering Committee	Identify mechanism(s) to initiate and respond to any legislation that may affect Cooperative operations.
	Roadless / Protected Areas require extra time during planning process and are highly controversial	Legislative team, Steering Committee	Agencies should selectively identify appropriate actions in roadless areas. When actions are needed, decision making process is expedited.
Effecting changes on the land at a scale commensurate with infestations	Requirements for treatments across administrative boundaries and on Private lands	Local Governments	Create incentives for treatments on Private lands

Barrier	What is the Principle Challenge	Who should take on the solution?	Outcome desired
Administrative			
Inadequate staffing to take on the program planning and implementation	Support Functions are understaffed, e.g. Engineering, Silviculturists, contract administration	Steering Committee, Line Officers at Regional and Forest levels – Administrative Team	Implement short and long term reorganization
	Hiring Processes and timelines are onerous		
	Budget levels are inadequate	Legislative, Administrative Teams	Increased and sustained funding (redirected or additional)
Effective Vegetation Mgt within Permitted Use areas, i.e., ski areas	Stewardship Contracts and Settlement Sale procedures are onerous when applied to bark beetle situations on ski areas.	Ski Industry, Timber Industry, and USFS	Contracting tools allow for rapid, equitable and effective treatments on ski areas
Limitations on treating small areas of blowdown	Lynx Amendment – Restrictions ($\leq$ 5 acres) on Insect and Disease project implementation in Lynx Denning Habitat	USFS and USFWS	Develop process to allow expanded bark beetle mitigation
Commitment to long term risk reduction	Maintain vegetation management activities over time to lower risk	USFS, BLM, Local Governments	Diverse mix of age and size classes of conifer stands across the landscape

Barrier	What is the Principle Challenge	Who should take on the solution?	Outcome desired
Industry/Business			
Wood Products Processing capacity	Need exceeds current capacities	USFS and State Rural Economic Development, CO State Forester	Ensure long term supply of product to justify capitalization costs
Biomass opportunities not in place	Cost effective fuel or defensible space treatments	Industry / Business Team, Colorado Wood, CROP Study, Local Governments	Improve utilization of biomass to add a higher value
Suitable processing locations	Cost effective fuel or defensible space treatments, saw log operations Fuel/Transportation Costs are high	USFS and State Rural Economic Development, CO State Forester, local governments, local industry associations	Create opportunities for needed industry to relocate or expand into the local area
Transportation Barriers (height, weight, truck arrangement regulations)	Cost efficient transport of product and equipment	DOT, State Legislature	Regulations are flexible enough to address needs

Barrier	What is the Principle Challenge	Who should take on the solution?	Outcome desired
Communications /Education			
Effective and Efficient Implementation across administrative boundaries and land ownership	Developing common understanding, goals and objectives	Bark Beetle Communication Team	Develop and implement comprehensive "Northern Colorado Bark Beetle Cooperative Communication Plan"
			Develop Briefing Booklet Periodic briefings, project newsletters, mailings, etc.
		Legislative Team	Periodic visits/contacts w/State and Federal congressional delegations
		Working Group and Project Leaders	Provide information on specific projects within the context of the strategy. Collaboratively with counties and communities, identify needed treatments and establish priorities for funding and treatment.

Related Efforts

Coordinated Resource Offering Protocol Study

One of six Coordinated Resource Offering Protocol (CROP) studies nationally is being conducted within a 100-mile radius of Kremmling, Colorado. This area contains the area most heavily hit and predicted to be impacted with increasing tree mortality in Northern Colorado. The timing and focus of the CROP study for this area, which will likely be completed in spring 2006, is a perfect compliment to the bark beetle assessment and development of strategies to deal with the huge increase in dead biomass.

Background

As part of the USFS National Strategy Plan for Woody Biomass Utilization implementation, Mater Engineering created the CROP model to help revive investor interest in forest landscapes where fuel-load reduction efforts were being undertaken to comply with the National Fire Plan. Efforts to invite investment into forestry-dependent communities for biomass reduction efforts is often less a function of total resource volume offering and more a function of providing a consistent supply among district resource offerings. Benchmark biomass inventory studies conducted by Mater Engineering during the last two years have documented a lack of inter-regional resource coordination and underscored the dramatic need to create a new coordinated resource offering protocol (CROP) for government agencies (BLM, USFS, State Forestry Divisions, State Department of Transportation, etc.). Since the initial CROP project was completed in 2004 in Arizona, modeling efforts have been refined and we have employed these CROP refinements on new CROP projects undertaken in the western U.S. during the last 12 months.

The four key elements of successful CROP implementation are:

1. Assessment: A biomass inventory assessment is conducted within a 100-mile radius (CROP investor landscape) from a defined geographic center point. Resource offering data for a 5-year period of time is obtained from all public forestland managers and, where available, private forestlands within this CROP landscape. From this data, the following is modeled:

1. What volume, species, and diameter sizes of resource are projected to be offered during those five years on an annual basis. Diameter sizes per species per year are provided.
2. How resources will be offered: timber sales; fuel load reduction contracts; precommercial thinning contracts; post and pole contracts; stewardship contracts, etc.

2. Mapping: Produce resource offering maps (ROMs) that allow interested parties (potential investors; technology providers, etc.) to quickly see projected resource flow within the defined investor landscape.

3. Marketing: The ***CROP*** model is intended to produce a long-term realistic marketing tool for the region, targeting several audiences: industry investors (primary and value-added producers), technology providers, financial institutions, USFS policy decision-makers, conservation groups, even the public at large.

4. Monitoring: Community-based organizations provide the logical collaborative structure and format to effectively monitor the performance of the CROP model from year to year and over time.

Anticipated deliverables for implementing CROP in the region are:

- To re-invite traditional investment back into the region; focused on both large and small log processing;
- To increase the value of the resources being offered (from "valueless" biomass to valuable resource); and
- To re-open financially-important production and marketing channels necessary to achieve successful landscape level fuel load reduction and forest restoration projects.

The CROP model projects resource removal from all public land owners within a defined CROP investor landscape. For most projects, this includes a) all ranger districts within National Forests, b) state government agencies – specifically the Departments of Forestry and Departments of Transportation, c) all districts within the Bureau of Land Management, and d) all cities and counties that manage forest lands.

Coordination with Research

Ongoing Efforts

The Rocky Mountain Research Station has a long history of collaborative research on bark beetle ecology, forest ecology and management, fire ecology, watershed hydrology, biogeochemistry, wildlife ecology, human use and social conflicts, and sustainable economies. Northern Colorado research studies occur in a diverse set of ecosystem types dominated by conifer species susceptible to bark beetles (lodgepole, ponderosa, limber and bristlecone pine, Douglas fir, Englemann spruce). Three experimental sites occur within the Initiative boundary: Manitou Experimental Forest (70 years of research), Fraser Experimental Forest (50 years) and Glacier Lakes Ecosystems Experiment Site (20 years).

Bark Beetle Research and Related Research in the Central and Northern Colorado Rockies

- Spatial and seasonal patterns of bark beetle activity;
- Characterization of stand conditions associated with bark beetle populations;
- Evaluation of bark beetle-induced mortality in stands previously thinned;
- Bark beetle flight and emergence at various elevations;
- Quantifying fuel loadings associated with bark beetle population development at various elevations;
- Riparian communities' response to beetle-related overstory mortality and fire;

- Changes in watershed hydrology, water balance, stream discharge, and sediment production and movement generated by bark beetle infestation at the Fraser Experimental Forest;
- Watershed biogeochemistry, water quality, within the Fraser Experimental Forest;
- Bark beetle influence on nutrient and carbon dynamics and export from managed and unmanaged watershed at the Fraser Experimental Forest;
- Influence of salvage logging, post-harvest site preparation and mechanical fuels reduction treatments on tree regeneration, forest and soil productivity and hydrologic and biogeochemical processes;
- Effectiveness of riparian buffer zones for water quality, habitat and stream channel protection following salvage logging;
- Alteration of stream channel stability and large wood dynamics by fire and bark beetle outbreaks at various sites in northern Colorado and Wyoming.
- Interaction of bark beetles with an exotic pathogen, pine hosts and post-disturbance forest recovery;
- White pine ecology and management in the Central Rockies;
- Forest stand dynamics, post-harvest site preparation and seedling regeneration ecology at Manitou Experimental Forest, GLEES, and other high elevation sites in Colorado and southern Wyoming
- Lynx demography, habitat-use patterns, food habits, dispersal and movements in western Montana.
- Goshawk population dynamics
- Ecological relationships between Black-backed Woodpeckers, mountain pine beetle infestations, and post-fire settings
- Community wildfire preparedness plans and the communities that prepare them, preferences and behavior of homeowners in the WUI, Homeowner response to fuel treatment incentives, methodology for obtaining broad scale input about the public's preferences and priorities regarding key national forest management questions

Current Bark Beetle Studies at the Fraser Experimental Forest

Rocky Mountain Research Station (RMRS) scientists first observed significant lodgepole pine mortality at the Fraser Experimental Forest (FEF) in 2002. RMRS scientists quickly recognized the unprecedented research opportunity to study an insect outbreak of this magnitude on a USFS watershed where 50 years of hydrologic data and extensive long-term climatic, biogeochemical, fluvial and vegetation data existed.

RMRS researchers are addressing two management concerns regarding the effects of bark beetles on subalpine forest watersheds:

How does the present bark beetle outbreak influence watershed processes and forest conditions in managed and unmanaged basins?

What are the consequences of stand manipulations associated with the bark beetle outbreak?

The length of the FEF data record allows scientists to rapidly assess the impact of beetle infestation, permitting implementation of adaptive management practices and maximizing the effects of prescribed treatments on watershed health. Early collaboration with NFS managers in planning prescriptions has facilitated relevance in these studies and will provide a fast-response conduit for results to reach the field.

Current Cooperative Programs with Resource Management Agencies

- Upper Fraser River project, Sulphur RD of Arapaho/Roosevelt NF
- Front Range Fuels Treatment Partnership
- Trout West Stewardship Project – Pike San Isabel NF
- Central Rocky Mountains White Pine Health Working Group

Proposed Bark Beetle Research for the Northern Colorado Rocky Mountains

Research proposed by the Rocky Mountain Research Station (RMRS) builds on a long history of watershed hydrology and biogeochemistry, forest ecology and management, bark beetle ecology, and fire ecology research. Greater understanding of the nature of the outbreaks, management response, and their effects on watersheds will assist public and private land managers protect and sustain upland, riparian and aquatic ecosystem resources. RMRS science takes advantage of long-term data records gathered at multiple research facilities and field sites in the Northern Colorado Rockies and Southern Wyoming regions, permitting rapid assessment of forest disturbance and watershed change generated by bark beetle outbreaks. Cooperative research on National Forest lands allows quick delivery of RMRS findings and implementation of adaptive management strategies. RMRS science has and will contribute to land stewardship decisions that promote forest health objectives and increase public support for land management.

Bark Beetle Dynamics in Rocky Mountain Forests

The on-going insect outbreaks represent huge disturbances in our forest ecosystems. Current mortality is not only affecting large land areas but also numerous conifer species (Engelmann spruce, lodgepole, limber and bristlecone pines). Many aspects of bark beetle biology remain unexplored; studies to fill knowledge gaps will improve our understanding of outbreak spread, stand susceptibility and suppression activities. Entomological research will address knowledge gaps by 1) examining stand conditions associated with mountain pine beetle and spruce beetle in Colorado to develop stand rating systems, 2) assessing the effects of thinning on insect brood production; 3) quantifying habitat fragmentation caused by bark beetles; 3) modeling bark beetle movement across the landscape, 4) conducting spatially-referenced analysis of interactions between beetle mortality in lodgepole and spruce forests; and 5) quantifying coarse woody debris associated with beetle-caused mortality and impacts on fire behavior.

The spatial extent of forests that are in susceptible conditions and the intense insect population pressure is too great for an effective landscape-level response. To deal with future outbreaks, there is a need to develop a better understanding of the relationships between forest stocking levels and insect and disease susceptibility. For multi-aged stands it is unclear if susceptibility is regulated by the presence of big trees or by total biomass. Controls of susceptibility within multi-species forests are also unknown. Proposed silvicultural research will identify the likely changes in forest composition and structure caused by current outbreaks in multi-species or multi-structured forests. Specific studies include: 1) research to predict future tree species composition and growth rates; 2) studies to test stocking control activities to maintain desired forest composition for wildlife habitat, developed recreation, resistance to wildfire, future timber production, and water yield; 3) quantify seedling growth rates of naturally-established pine, spruce, fir, and aspen under a spectrum of stocking densities to improve models and provide crucial data on snowshoe hare / lynx habitat and recovery of crown fire risk.

Limber pine is a common forest species along the Colorado Front Range and in Southern Wyoming and is a preferred host for mountain pine beetle. Ongoing research has shown that white pine blister rust, caused by the exotic pathogen Cronartium ribicola, is also intensifying and causing limber pine mortality. The combination of overstory mortality by beetles with rust-caused mortality of limber pine seedlings threatens the sustainability of this forest type. RMRS and its partners are uniquely positioned to address the implications of the co-location of the rust and the mountain pine beetle on mortality patterns and forest recovery dynamics. Proposed research will (1) determine the relationship between the two stresses, (2) identify rust-resistant limber pine trees for protection from bark beetle attack, (3) provide guidelines to identify areas where white pine blister rust may significantly affect forest regeneration in openings created by beetle kill or subsequent fire.

Watershed Processes

Little is known about the impacts of catastrophic bark beetle induced mortality on hydrologic processes (e.g. water yield) in Northern Colorado watersheds. RMRS is uniquely positioned to conduct research that will increase understanding of bark beetle effects on watershed processes in these systems. We will develop and test physically based, process-oriented models to quantifying and predicting the effects of canopy mortality on snow accumulation and melt, water balance, runoff, water chemistry, erosion, and sedimentation at the Fraser Experimental Forest (FEF), and the upper Fraser River Valley. Our long-term hydrological and climatological data make it possible to quantify the direct impact of pine beetles on these critical watershed processes. Other northern Colorado sites (Williams Fork River, Rock Creek), and southern Wyoming sites (Glacier Lakes Ecosystem Experiments Site-GLEES, Coon Creek) will provide additional research opportunities and increase the range and impact of these studies.

Riparian Composition and Function

Insect-caused mortality of canopy trees and subsequent forest harvest treatments could dramatically alter valued characteristics of stream-riparian corridors that provide critical habitat for terrestrial and aquatic species. Increased fire risk in dead riparian forests also threaten aquatic resources and present management challenges. Proposed research will: 1) track successional changes in the extent, species composition, structure, and condition of riparian communities; 2) monitor changes in riparian microclimate and stream water temperature; 3) quantify shifts in quality and quantity of organic matter inputs to streams and subsequent effects on aquatic food webs and biota; 4) assess fuel load and fire risk in high-elevation riparian communities.

Stream Channel Processes

Increased understanding of the consequences of widespread tree mortality on instream sedimentation, channel instability, and large wood loading will provide forest managers with tools to evaluate short- and long-term impacts of bark beetle outbreak on channel processes and subsequent risks to infrastructure in developed areas. In particular, large wood is a driver of many elements of forested streams and riparian zones of importance to people and ecosystems, such as fish and wildlife habitat or sediment storage and routing. However, the dynamics of large wood in streams and riparian zones in Rocky Mountain forests are essentially unknown, and have only been the subject of limited study in upland sites. The on-going insect infestations will dramatically alter the abundance of wood in streams and potentially alter channel form and aquatic habitat, thus an understanding of large wood dynamics is critical to our ability to manage these sites. Moreover, increased fuel loads from dead and decaying trees could increase the intensity of fire behavior in future wildfires, thereby elevating the potential for hillslope erosion, flooding and sediment delivery to streams. Continued research at FEF and other areas of the region provide opportunities to evaluate geomorphic responses, sedimentation risks, and large wood dynamics in a variety of channel types, in different geologic terrain, and under different climatic regimes.

Wildlife, Bark Beetles and Fire

Habitat-use patterns of lynx are strongly affected by changes in forest cover, due to their almost complete reliance on snowshoe hares for food during the winter. To study how lynx respond to landscape-level reductions in forest cover (beetle kill, fire), a two-prong approach would first investigate how lynx use affected areas using GPS technology, and second, the response of snowshoe hare populations to landscape-level reductions in forest cover. Based on RMRS experience in collaring over lynx, we would trap lynx in home ranges that were impacted by landscape-level changes in forest cover. Concurrently, we will evaluate snowshoe hare densities in affected landscapes based on fecal pellet counts, trap grids and radio telemetry. Altered landscapes would be stratified by treatment (beetle kill, forest fire) and management action (salvaged, non-salvaged). Based on preliminary understandings from fecal counts, we would focus additional hare research on treatment and management strata that supported adequate densities to warrant further study of movement patterns, density, and mortality factors. Like lynx, we would also relate hare density, movements, and mortality patterns to landscape-level changes in forest cover using GIS.

The goshawk is a predator whose survival, reproduction and population viability is dependent on forest productivity as measured in the abundance and accessibility of as many as 20 different bird and mammal prey species that sum to some abundance threshold for goshawks to successfully breed. Goshawk prey on woodpeckers, thrushes, jays, grouse, tree squirrels, ground squirrels, rabbits, and hares. This diverse suite of prey will be most abundant where there is a diversity of habitats within a goshawk's home range. Habitat change resulting from insect-caused mortality of canopy trees in large landscapes, whether salvaged or not, will change the composition of the suite of prey as well as the structure of the vegetation suitable for goshawks. The extent of these changes and their effects on goshawks will depend on the extent (intensity, pattern) of insect-caused mortality within and among home ranges. Nevertheless, measuring the effects of insect-induced tree mortality on goshawks will require long-term monitoring because the compensatory changes in relative abundances of each prey species as the forest dies, snags fall, and regeneration begins will ameliorate possible effects on goshawk vital rates. Detecting such effects will also be confounded by short- and long-term weather effects on forest productivity. Finally, because goshawks live in the space below forest canopies, the greatest effect of landscape-level tree mortality on goshawks is likely to occur during the first 100 years of stand reinitiation when there is no subcanopy space. During this period, goshawks are more likely to be excluded from such landscapes.

The black-backed woodpecker (BBWP) is an uncommon Sensitive Species in Region 2 (Rocky Mountain Region). The BBWP is considered to be an obligate of post stand replacing fire in coniferous forests. Populations of BBWP invade areas burned immediately after the fire because of the flush of their primary food source [bark beetles, woodborers]. Usually, the duration of occupation of post fire areas is 2-3 years, but can last up to 6 years, after which the birds disperse back into the forest. Unpublished research in the Black Hills of South Dakota has shown that densities of BBWP in areas infested by mountain pine beetles (MPB) are as great as those in post stand replacing fires. MPB infestations may represent a longer term food base for sustaining BBWP than the ephemeral resources following fires. Current research in MPB infestations throughout the West are inconclusive in terms of the impact of salvage logging on BBWPs. Understanding how BBWPs utilize resources in MPB infestations and post-fire settings would allow managers to evaluate the impact of salvage logging on the sustainability of populations of this Sensitive species.

Ecosystem Services and Economics

Large scale tree mortality may lead to temporary (although lingering) decreases in scenic beauty, shifts in recreation use, reductions in property values, and increases in sediments and nutrients in source water streams; and because mortality temporarily increases fire danger, it also raises the risk of severe fire and related loss of property, scenic beauty, and water quality. Proposed socioeconomic research would pursue three objectives: to measure the effects of large scale mortality in alpine and subalpine species on important public concerns, to determine the public's preferences and priorities regarding agency responses to such mortality, and to evaluate capacity and demand for wood products. Studies in response to the first objective would measure the effects mortality or fire on 1) perceived scenic beauty (using well-developed methods from environmental psychology); 2) recreation use (given realistic scenarios including the availability of substitutes); 3) property values (using the hedonic method of economic valuation), and 4) costs of providing potable water. Studies meeting the second objective would 1) apply survey methodology to obtain broad scale input about the public's preferences and priorities regarding agency options such as salvage, fire suppression, and selective preventive measures; and 2) use economic valuation methods to measure the public's willingness to pay for preventive and mitigation efforts. For the third objective, research would examine wood products industry capacity, and adding higher value for biomass utilization.

Sound Management during Bark Beetle Outbreaks

Widespread forest mortality has created public anxiety over human safety and property loss, accentuated by recent catastrophic wildfires in the western US. Concern about excessive fuel loads on national forest lands led to enactment of the Healthy Forest Restoration Act of 2003, legislation that gives federal land managers the administrative tools to address hazardous fuel loads and other forest health issues rapidly. In spite of a broad mandate for this work, post-outbreak management of national forestlands is controversial. Federal resource managers currently lack information required to evaluate the influence of fuel reduction treatments on forest productivity, water quality, streamflow and other watershed resources. Research will 1) examine stand conditions associated with the outbreaks, evaluate the effectiveness of silvicultural management, investigate interactions with fire, and model population movement, 2) quantify the influence of salvage operations on nutrient, carbon, sediment and large wood retention within riparian buffers and validate the effectiveness of this watershed best management practice for protecting water quality and aquatic resources; 3) evaluate how mechanical fuel reduction treatments (chipping and mastication) and post-harvest site preparation impact seedling establishment and growth, plant nutrient and moisture relations, and biogeochemical and hydrologic processes; 4) assess the impacts of forest road construction and retirement on hillslope hydrology and nutrient and sediment fluxes. Greater understanding of these management practices will assist public and private land managers protect and sustain upland, riparian and aquatic ecosystem resources.

Colorado Community Assessment Project

Courtney Flint, an Assistant Professor at the University of Illinois has been contracted to assess local resident risk perceptions, attitudes regarding forest management options, and local participation in forest management actions in a number of the communities currently being impacted by the bark beetle epidemic. Surveys and interviews will be ongoing in these communities through the fall of 2006.

Continue Dialogue with Constituencies

The Colorado State Forest Service has taken the lead in coordinating meetings and ongoing dialogues with local bark beetle groups, local governments, homeowner associations and other target audiences. The objectives of these dialogues are to understand the bark beetle situation, provide them information on what types of treatments are possible and practical. The goal is to provide as much information as is necessary, determine a course of action, and build support for treatments. These will be coordinated with the local USFS Ranger Districts.

ASSESSMENT OF THE SITUATION

Biology of the Mountain Pine Beetle

Mountain pine beetle (MPB) (*Dendroctonus ponderosae* Hopkins) is a native insect that plays a major ecological role in maturing lodgepole pine (*Pinus contorta* Dougl. ex Loud) forests. MPB epidemics can cause dramatic tree mortality over extensive areas and the insect has been described as the most important biotic agent of change in western pine forests (Amman et al. 1989). MPB kills trees by feeding on the phloem tissue and by introducing a blue stain fungus, *Ceratocystis montia* (Rumb.) Hunt, which blocks the water conducting xylem tissue. MPB outbreaks reduce average stand diameter and age, and influence such things as canopy closure, stand structure, species composition, forage production, wildlife habitat, fuel loading, water yield and aesthetics. Downfall and woody debris following infestations can also hamper access by livestock, big game and humans (McGregor and Cole 1985).

Amman et al. (1977) developed a risk rating system for classifying lodgepole stand susceptibility for MPB epidemics based on average diameter at breast height (dbh), average age, and stand elevation and latitude. Lodgepole pine stands that are highly susceptible to MPB typically have the following characteristics: average dbh > 8 inches; average age > 80 years; and a suitable climate for beetle development determined by elevation and latitude (Amman et al. 1977). Warmer than average temperatures in recent years appear to have allowed beetles to be more successful at higher elevations than would be indicated by Amman, et als hazard rating system. Ground and aerial surveys in 2003-2004 have identified robust MPB populations above 10,500 feet. A 2004 study of MPB emergence at three elevations in nearby Grand County, Colorado indicates that beetle emergence trends did not differ significantly between elevations of 8,760, 9,200, and 9,900 feet (Tishmack et al. in preparation). The authors suggest that the upper elevational limit for the highly susceptible category should be raised to > 10,000 feet. Close proximity of MPB populations also increases the risk for tree mortality in susceptible stands (Shore and Safranyik 1992).

Schmid and Mata (1992) suggest that in ponderosa pine (*Pinus ponderosa* Dougl. ex Laws) forests, tree densities above 120 sq. ft. of basal area per acre are also more favorable to MPB than are less dense stands. The 120 sq. ft./acre basal area threshold may also be pertinent in lodgepole pine stands. A multi-year study in lodgepole pine found greater losses in stands thinned to 120 sq. ft. basal area and in unthinned control plots compared to stands thinned to 100 or less sq. ft. basal area per acre (McGregor et al. 1987).

Outbreaks of MPB tend to occur at intervals of fifteen to twenty years in older Rocky Mountain lodgepole pine forests and may last for six to ten years (Cole and Amman 1980). Schmid and Mata (1996) write “an epidemic may last several years in a particular stand whereas the epidemic as part of a drainage may last for ten or more years.”

Between outbreaks, low level populations referred to as endemic populations persist by selecting weakened or damaged trees, but no such selection is evident during periods when epidemic populations occur (Furniss and Carolin 1977). Endemic MPB populations are usually associated with single trees that are lightening-struck or diseased, cohabitating therein with other scolytids such as *Ips* (Schmid and Mata 1996). Finding infested trees when populations are endemic can be difficult. Lessard (1982) made the assumption in his study of MPB in the Black Hills ponderosa pines that fewer than one tree per acre is considered an endemic population. He described a building population as greater than one tree per acre and less than 10% of the stand infested over a three year period and an epidemic as greater than 10% of the stand infested over a three year period. Cole and Amman (1980) in a more detailed study of the course of a MPB outbreak in lodgepole pine described an endemic population as having less than half a tree per acre infested, a building outbreak as having between one half and five infested trees per acre and an outbreak as having more than five infested trees per acre. Once an epidemic is underway, most large trees in the outbreak area may be attacked (Cole and Amman 1980).

Smaller diameter and younger trees in and near outbreaks may be attacked and killed, but small trees alone are not capable of sustaining an outbreak (McGregor and Cole 1985). Stands having a high proportion of large diameter trees with thick phloem are most likely to be infested and will suffer proportionately greater losses (Amman et al. 1977). Stress factors, such as current drought conditions, may contribute to stand susceptibility, but the exact triggering mechanism of MPB outbreaks is not known. MPB epidemics do not require a landscape disturbance, such as fire or windthrow to be initiated or to spread. When factors favorable to MPB population increases coincide with host susceptibility, beetle outbreaks can result.

The course of MPB epidemics have been altered by extremely adverse weather conditions. The very cold winter of 1984 -1985 is reported to have contributed to the collapse of a MPB epidemic that began in 1980 in Grand County, Colorado (Lessard et al. 1987). An unpublished study (Wygant 1938) determined critical low temperature ranges for MPB larvae at different months of the year. The study did not consider the insulating effect of the bark or the duration of the cold temperatures but does shed some light on the seasonal cold hardiness of MPB. During the winter months of December, January and February, larvae taken from lodgepole pine began dying when temperatures went below -20º F, 50 % were dead at - 29º F and there was 100% mortality when the temperature dropped below - 36º F. Critical temperature varied incrementally in the fall and spring months.

Biology of the Spruce Beetle

The spruce beetle (SB) is a native insect capable of killing all species of native spruce by feeding on phloem tissue and introducing blue staining fungi, *Leptographium spp*. and *Ceratocystis spp*. In the central Rockies, SB has the greatest impact on Engelmann spruce stands. Furniss and Carolin (1977) wrote “like fire and wind, the SB is a natural though destructive means of liquidating overmature forests and making way for the new.” Baker and Veblen (1990) suggest that SB outbreaks may be as ecologically significant as fire in spruce-fir forests. In many of the central Rockies’ spruce-fir forests, successional stages are likely to be influenced more frequently by the infestations and epidemics of SB in Engelmann spruce and western balsam bark beetle, *Dryocoetes confusus* Swaine, in subalpine fir than they are by the rare high intensity fires that occur on the moist high elevation sites where the forest type occurs. Schmid and Hinds (1974) present a successional scenario of SB-caused shifts of old spruce dominated stands to younger fir dominated stands and a more gradual transition back to spruce dominated stands over hundreds of years.

Within that time span, smaller outbreaks of SB shift the spruce component to a more single storied stand while a combination of western balsam bark beetle and several pathogenic fungi reduce the abundance of mature subalpine fir. Eventually, the longer lived spruce dominates the forest and grows to maximum basal area for the site. In time, blowdown occurs and the windthrown trees provide breeding sites for a SB epidemic to develop. SBs emerging from windthrown trees infest standing, live trees when sufficient windthrown trees are unavailable. Widely scattered blowdown is especially conducive to increases in beetle populations (Wygant and Lejeune 1967) and is a prime source of outbreaks (Schmid and Frye 1977). Outbreaks may be more than 115 years apart and wide-scale epidemics may be separated by 250 years or more (Veblen et al. 1994). The return interval of multiple stand epidemics is dependent upon large acreages of spruce growing into an old dense condition and upon the occurrence of a triggering disturbance (Schmid and Frye 1977).

During a SB epidemic almost any spruce tree in the stand may be selected regardless of size and vigor (Wood 1982) and the number of live trees may be drastically reduced. During the 1940's White River National Forest epidemic, 99 percent of the overstory spruce trees were killed over thousands of acres (Schmid and Hinds 1974). Furniss and Carolin (1977) point out that there is preference shown for trees of larger diameter and Schmid and Frye (1977) observed larger trees (>20 inch diameter) growing where self pruning occurs due to competition are preferred by the beetles to open grown trees with live limbs in the basal portion. However, Schmid and Mata (1996) state that it should not be implied that SB always attack the largest trees first and then move to progressively smaller trees. Susceptibility of individual trees is influenced by more than just diameter, so 12-inch or 16-inch trees may be attacked first when mixed with larger trees. Even in the extensive White River National Forest epidemic, scattered, single medium diameter trees survived within the devastated stands. Massey and Wygant (1954) report that trees as small as 2 inches in diameter were attacked during a 1940's Colorado epidemic but Schmid and Mata (1996) and Veblen et al. (1991) indicate trees less than 4 inches in diameter are not usually attacked. Previously suppressed small diameter spruce and fir are released following the epidemic and appear to be more important in regenerating the forest than are new seedlings (Veblen et al. 1991).

Environmental changes following a SB epidemic include increased forage, increased stream flow, species dependent wildlife habitat changes and increased fuels, although not greatly increased fire hazard due to the generally moist site conditions (Schmid and Frye 1977). Unlike lodgepole pine beetle-killed forests, the epidemic area generally remains accessible as beetle-killed spruce trees remain standing for a long time. Mielke (1950) found 84% of killed spruce still standing after about 25 years.

Between outbreaks, low level populations referred to as endemic populations are found infesting the lower sides or shaded portions of windthrown trees or other prostrate dying green trees or in overmature or weakened standing trees larger than about eight inches (Schmid and Frye 1977, Wood 1982).

Although a one-year life cycle has been observed at warmer sites on the Routt National Forest, the more typical two-year life cycle described by Massey and Wygant (1954) occurs in the high elevation sites in most of Colorado. Emergence is temperature dependent and can occur as early as May, but more often occurs in June or July. Pheromone trap studies in the Medicine Bow National Forest showed peak beetle flights the fourth week of July in 2003 and the second week of July in 2004 (Bergher unpublished report). Most of the attacks in Northern Colorado occur in July and early August. Female beetles excavate galleries and lay eggs which hatch in late summer and the first winter is spent as larvae beneath the bark. Larvae typically mature in late spring or early summer. Pupation and transformation into adults occurs by August. A variable percentage of the adults, from 3%-88% (Knight 1961), that develop in standing trees will emerge from the tree in August and September and move down to the base of a host tree and reenter for hibernation. Snow cover insulates hibernation sites and protects young adults from woodpecker predation. Extreme cold temperature can be lethal to both larvae and adult SBs. Massey and Wygant (1954) found temperatures below -30ºF will kill all larvae and below -15ºF will kill all adults.

There are no precise guidelines for cutting old growth spruce to maintain low SB populations. Schmid and Hinds (1974) analyzed four infestations and suggest some stand characteristics favorable for outbreaks: 1) spruce-fir stands that are predominantly spruce in the canopy – the higher the percentage of spruce the greater the potential; 2) basal area (BA) per acre greater than 150 sq. ft. per acre, with the BA concentrated in the older larger-diameter spruce; 3) single- or two-storied stands; and 4) an average rate of diameter growth of .04 inch or less per 10 years. Schmid and Frye (1976) went on to describe high risk stands as those located on well-drained sites in creek bottoms, having an average diameter of live spruce more than 16 inches dbh, having a BA over 150 sq. ft. per acre and a proportion of more than 65% spruce in the canopy. They suggest that maintaining stand characteristics below the high risk level may be an effective management guideline. Holsten et al. (1999) state a principle strategy should consist of silvicultural treatments of moderate to high hazard stands that result in maintaining their health with moderate growth. Silvicultural strategies may be more effective if beetle populations are not immediately threatening resource values (Holsten et al. 1999). Where beetle populations are threatening resource values, suppression methods used can include infested and susceptible tree removal, treatment of logging residuals or windthrown trees by bark peeling, solarizing or burning, and the use of trap trees, aggregating and anti-aggregating pheromones, and preventive insecticides (Holsten et al. 1999).

Epidemics have also been reported to have originated from logging residuals from right-of-way cuttings (Wygant and Lejeune 1967) and logging operations (McCambridge and Knight 1972). Guidelines for handling logging residuals are presented by Schmid (1977). Stump height should be kept below 18 inches and cull logs and tops should be limbed, cut into short lengths and either peeled or left unshaded, unpiled and exposed to sunlight. Where a substantial SB population exists in the adjacent forest, it may be wiser to leave the logging residuals rather than remove or destroy them immediately after cutting. Suitable residuals will attract beetles and reduce mortality of standing trees. After infestation, the residuals must be removed or treated.

Beetle Activity

Rating Susceptibility of Stands to Bark Beetle

Hazard Classifications

This assessment is based on GIS mapping and on acreages of stand hazard ratings. It should not be considered a finished product. It should be updated each year as beetle activity increases and new information on beetles, stands, and associated activities becomes available.

Stand hazard rating is a measure of the degree of damage that can be expected in a stand if a beetle outbreak occurs. Stand hazard is influenced by site characteristics as well as stand characteristics. Hazard rating is done using specific plot data, which collects information on species composition, age, diameter, basal area, and other factors. The standard Forest Service "stand exam" program calculates and displays bark beetle hazard as a part of its normal output. That output was used in the preparation of the maps accompanying this assessment.

Much of the assessment area has not been surveyed. In order to provide a complete picture, interpretation was necessary. Interpreted data, as shown on the maps and tables, was done using the best available information. These are reasonable estimates, and we are confident of the over-all picture provided by the maps and tables. However, interpreted information should not be used for individual stand ranking. At a minimum, a trained professional should do a walk-through exam or, a set of standard plots should be taken before management actions are implemented.

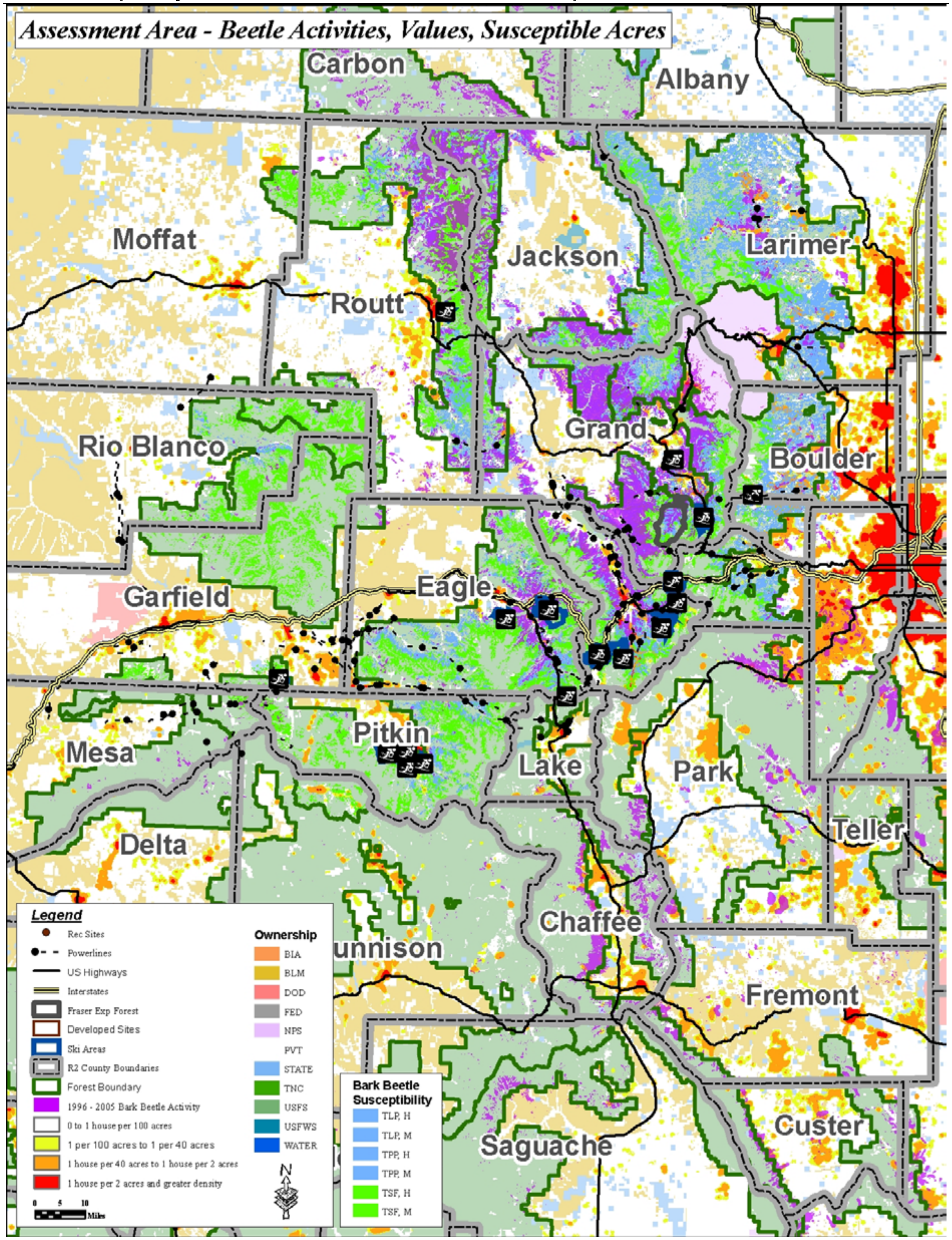
Stand hazard rating identifies stands where mortality can be expected if a bark beetle outbreak occurs. It is an important planning tool because it can identify stands that are most vulnerable to attack and most likely to sustain heavy mortality if attacked. This assessment is based on stand level information, but was mapped at a large scale to provide an over-all picture of the situation.

Individual tree hazard evaluation is difficult to estimate. In general, larger trees are more susceptible than smaller trees (6 to 8 inches DBH). Larger trees clear of live branches on the lower bole (typical in forest stand conditions) are more susceptible than open-grown trees with live branches in lower sections of the tree. This comparison is relative, and readily dissolves in the presence of high beetle populations when all but the smallest trees are likely candidates for attack.

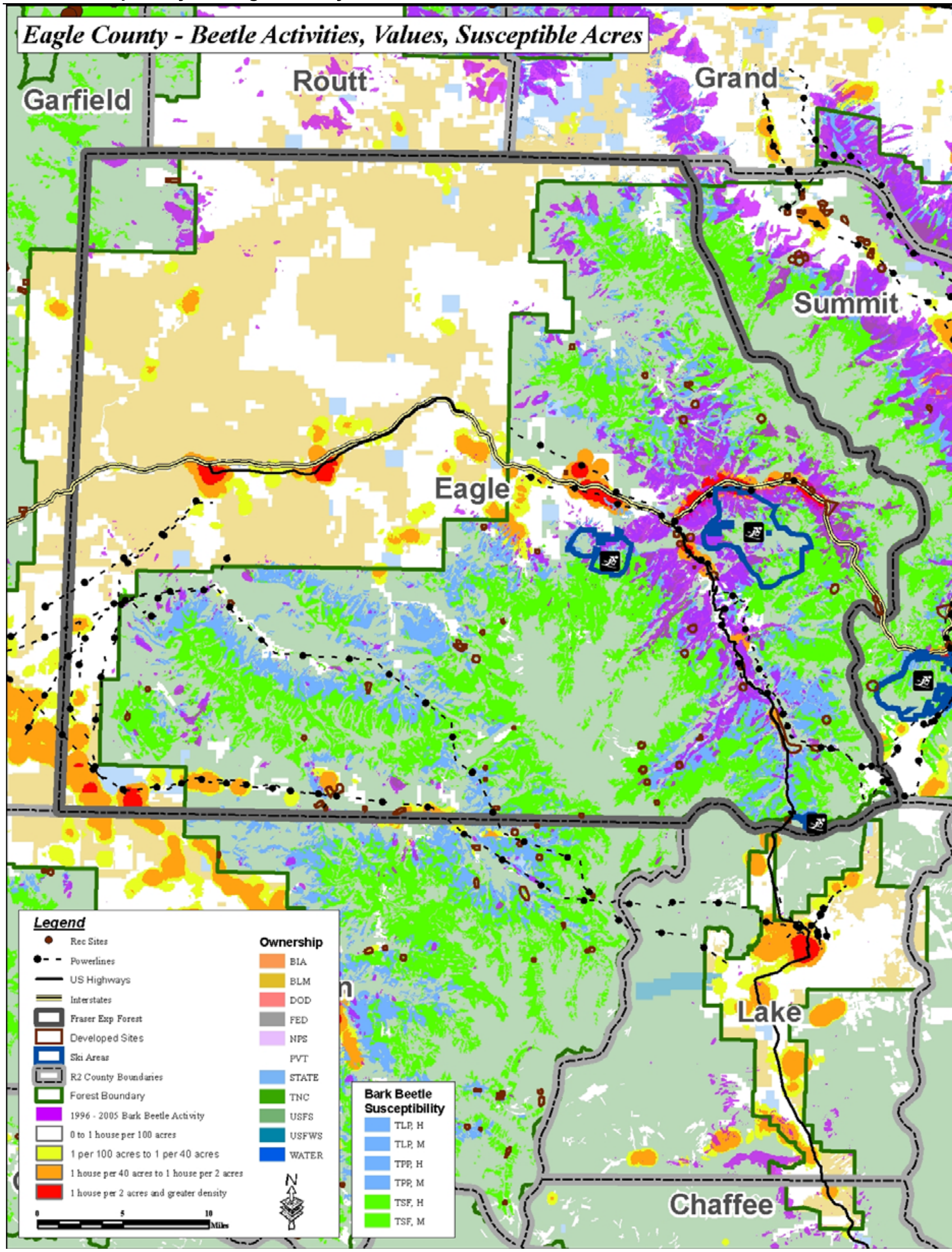
Risk is a measure of the likelihood of an outbreak occurring. The risk of an outbreak depends on both the stand hazard and on the size of the beetle population. A stand could be a high hazard stand, with little associated risk, because of low beetle pressure in or near the stand. Conversely, as beetle pressure increases, trees that may have escaped attack during the earlier stages of an outbreak may be attacked as the outbreak continues.

Surveys are needed to detect endemic populations, and infestations that could lead to outbreaks. They are needed to find areas of breeding habitat. Surveys measure beetle populations and trends. They estimate the number of infested trees and determine concentrations.

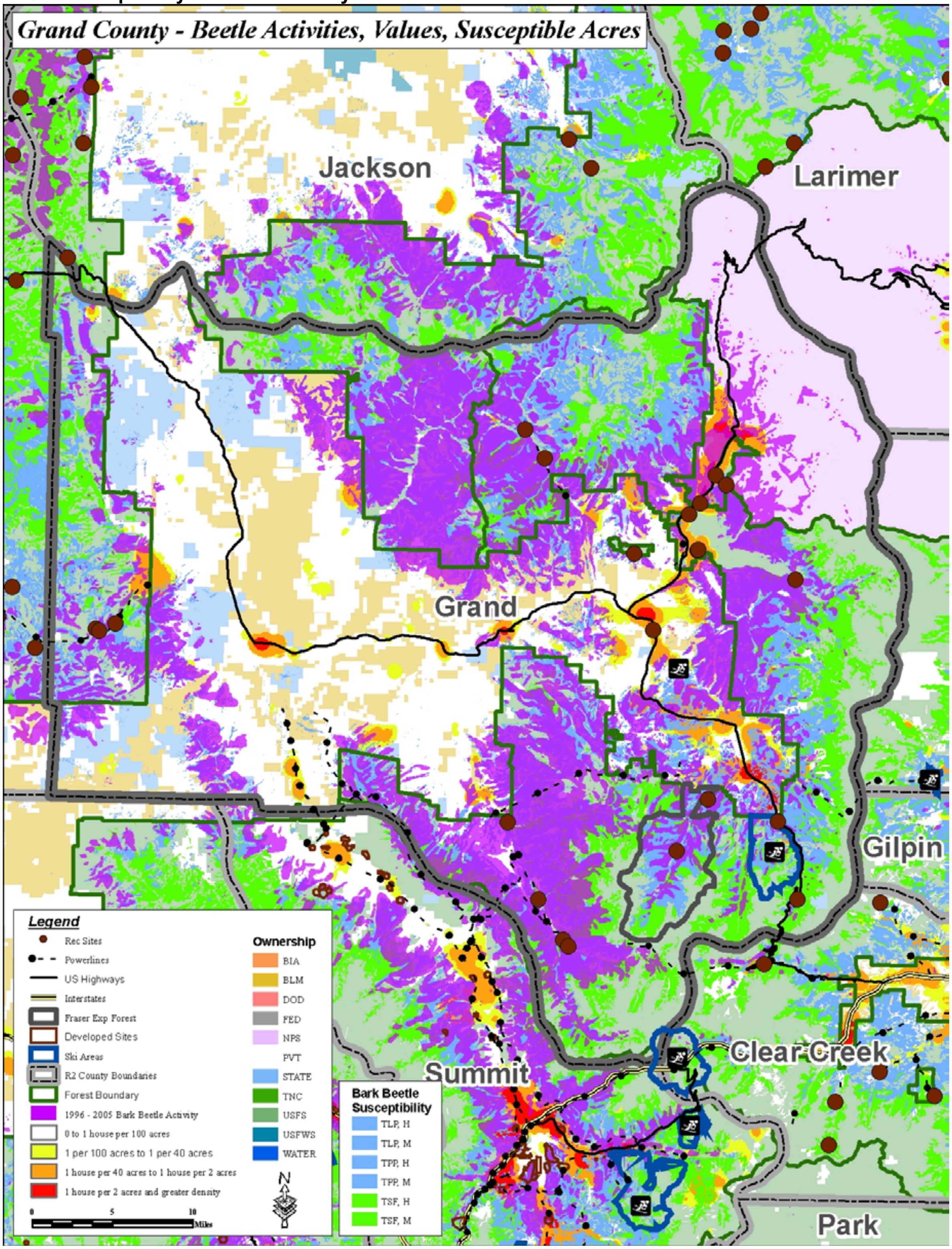
Stand Susceptibility for the Northern Colorado Bark Beetle Cooperative Assessment Area



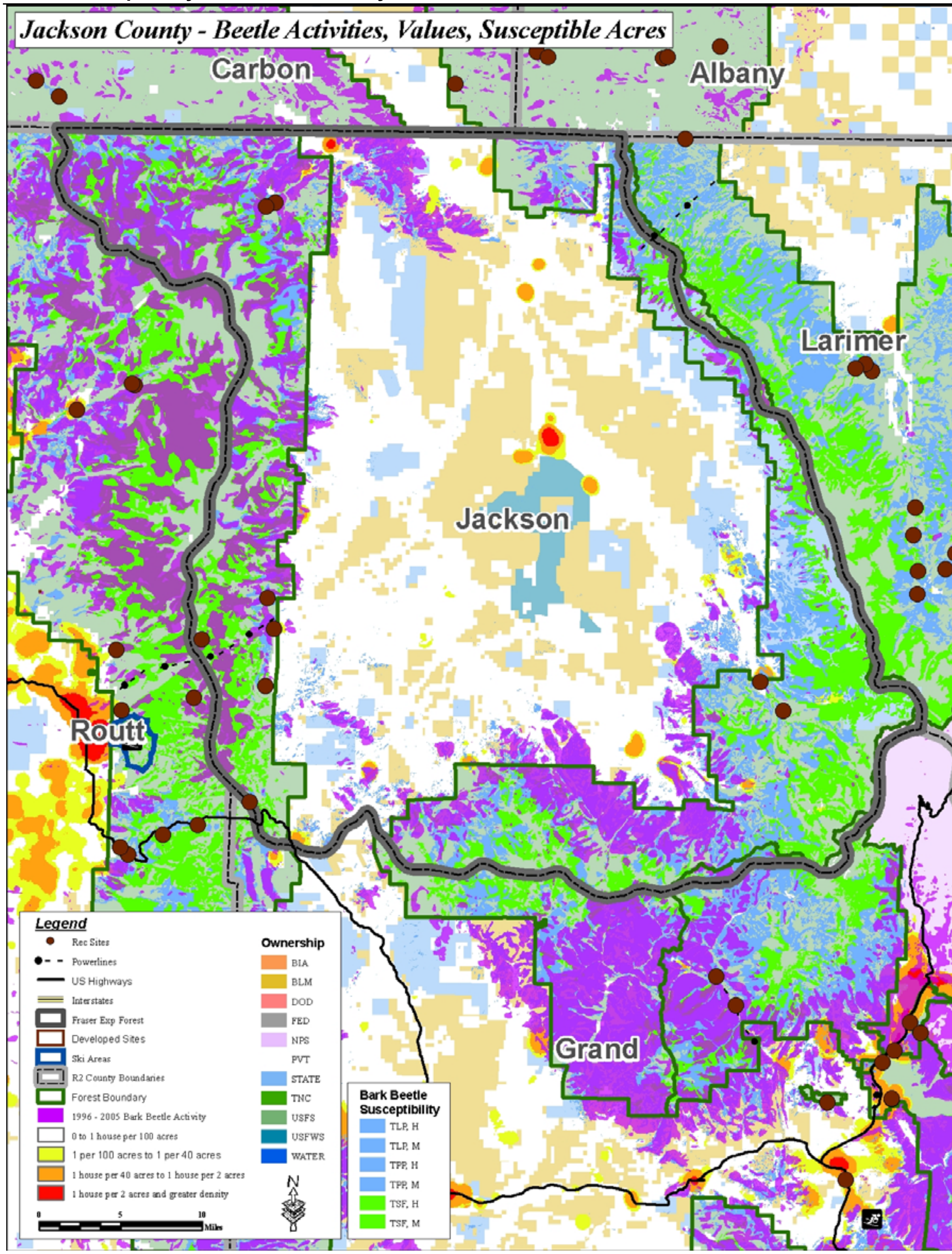
Stand Susceptibility for Eagle County



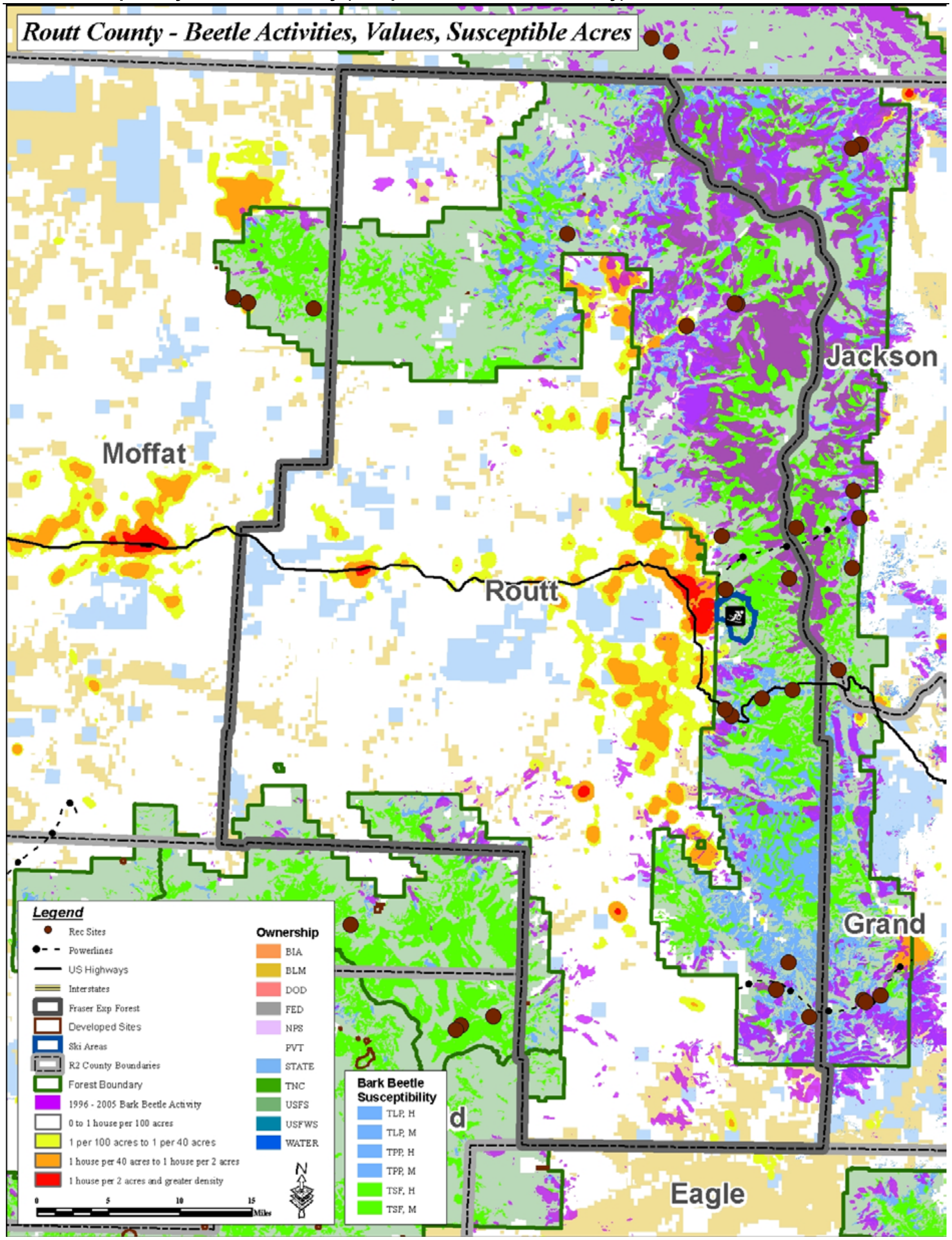
Stand Susceptibility for Grand County



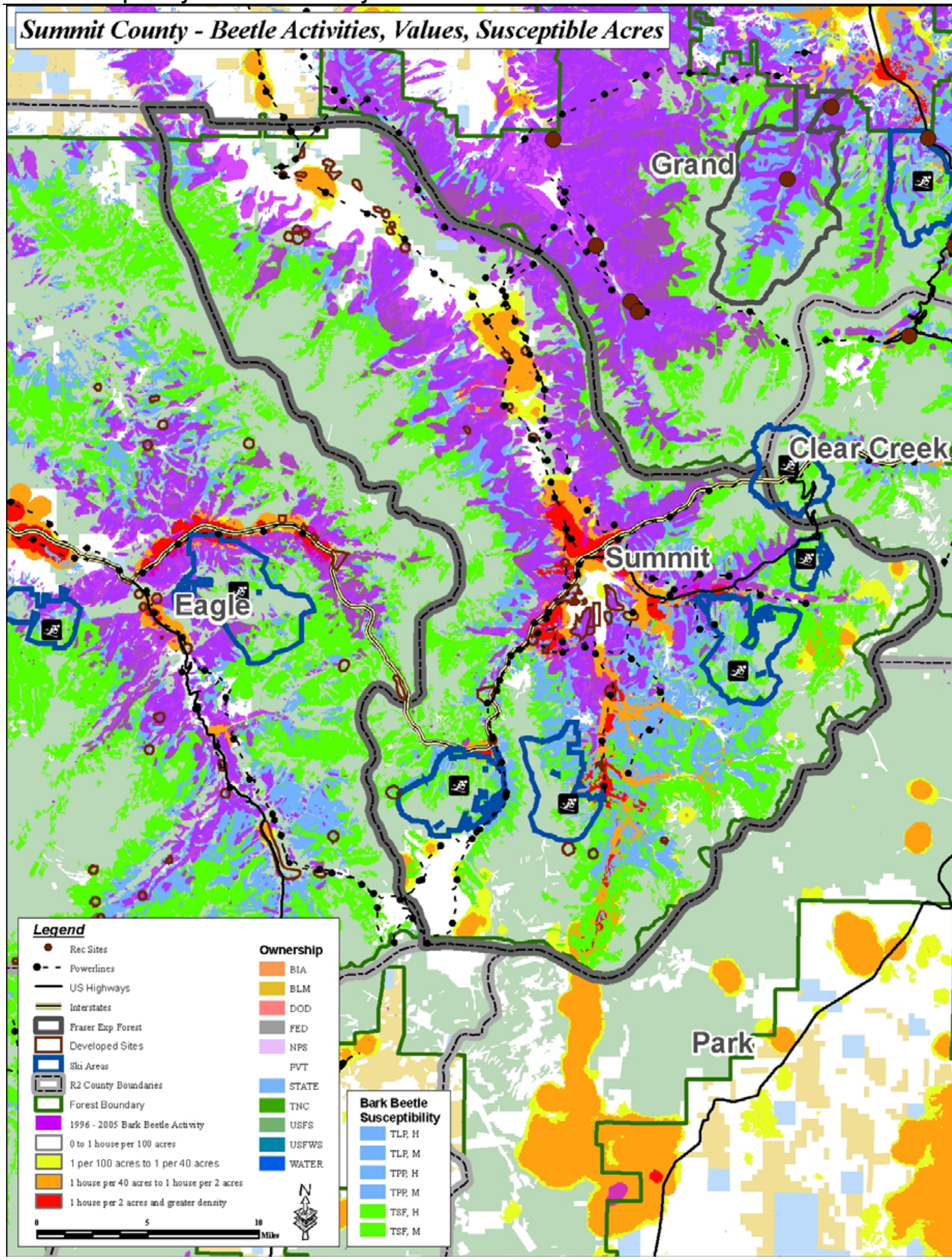
Stand Susceptibility for Jackson County



Stand Susceptibility for Routt County (and portions of Moffat County)



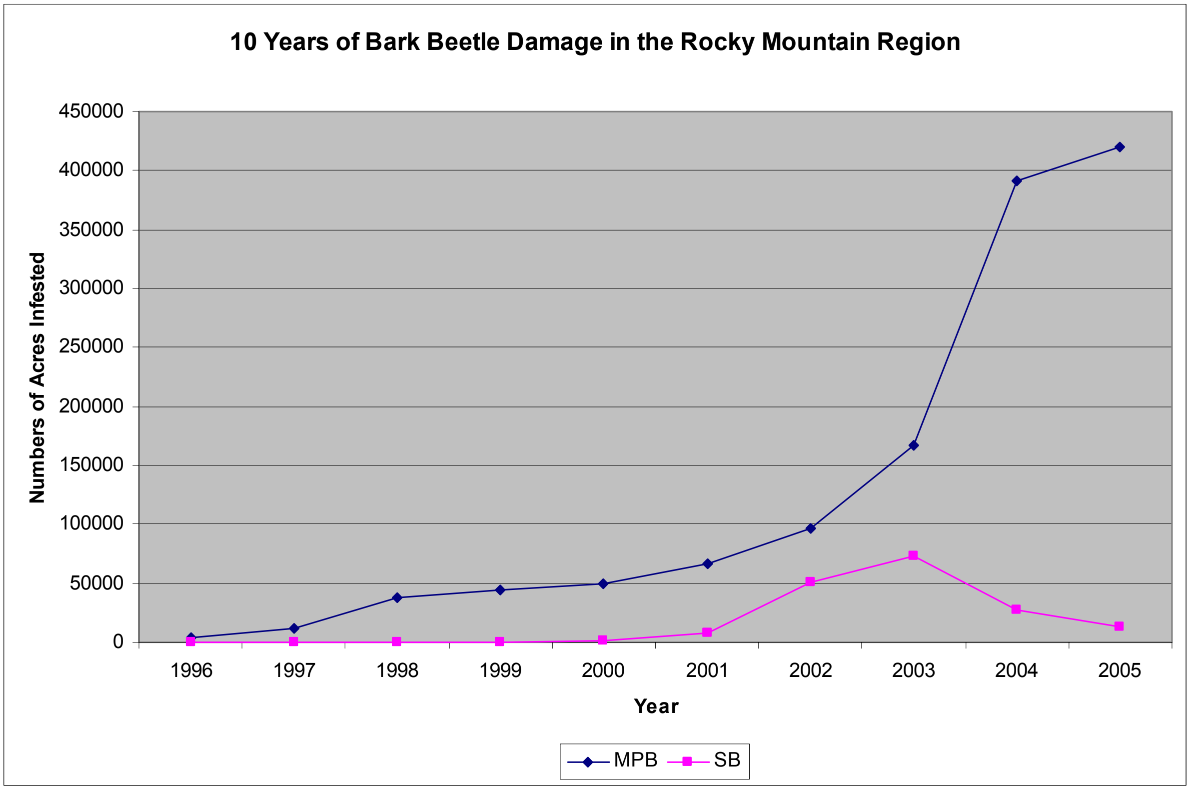
Stand Susceptibility for Summit County



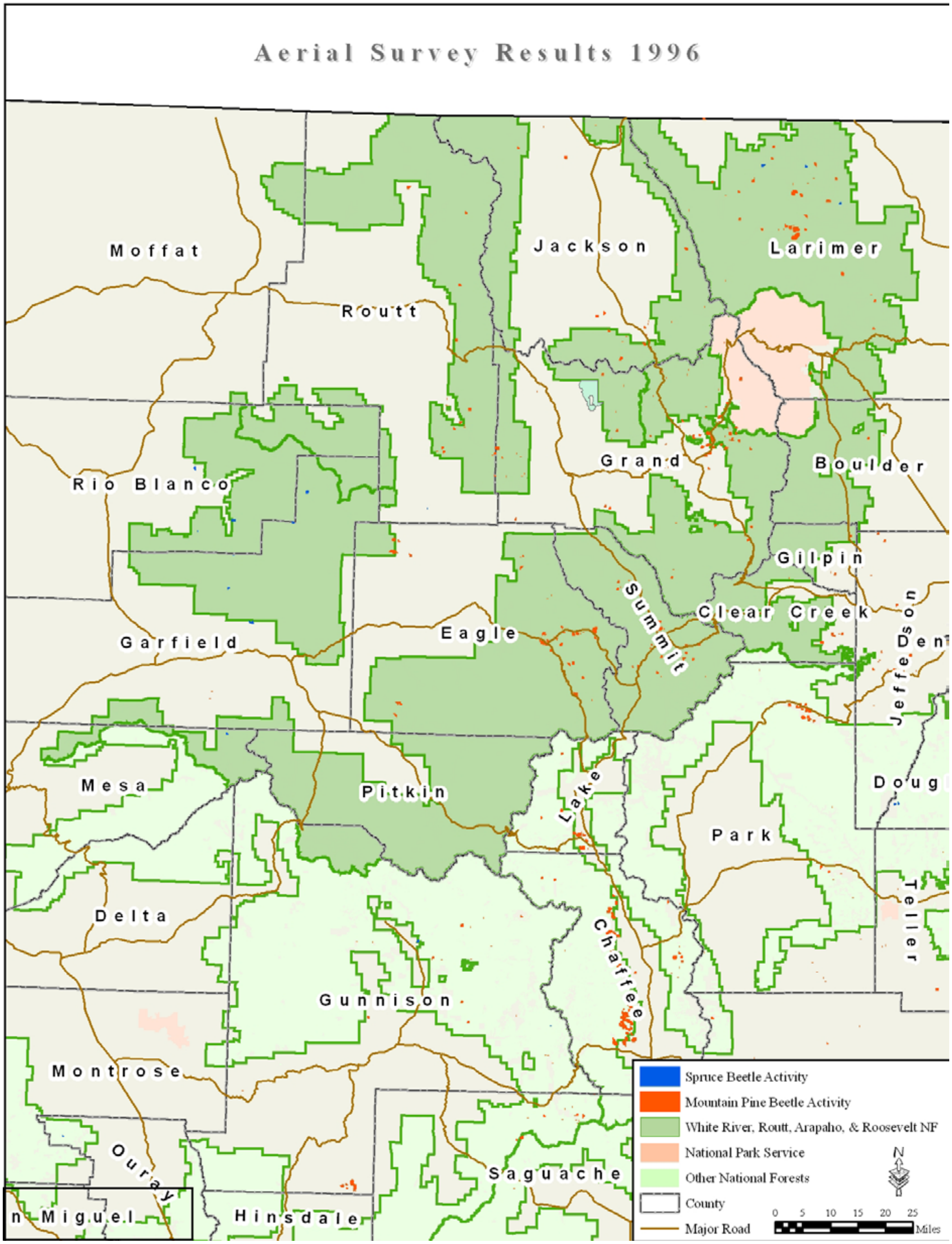
Recent Bark Beetle Activity

Aerial Survey Results from 1996 through 2005

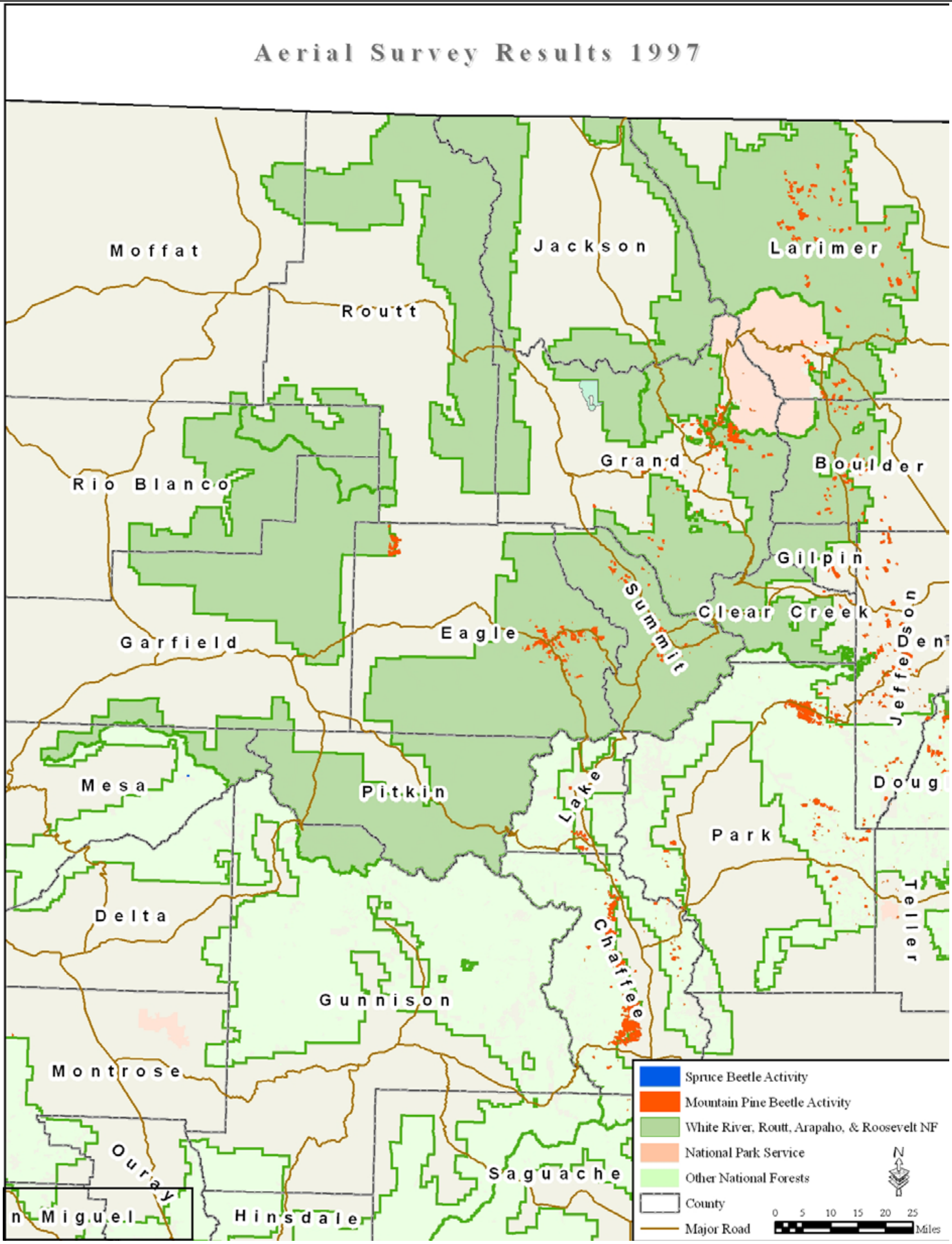
Bark Beetle activity for both the Mountain Pine Beetle and the Spruce Beetle has risen dramatically in the last decade or so. This trend is expected to continue. The graph below shows the 10 year trend for bark beetle mortality within the region.



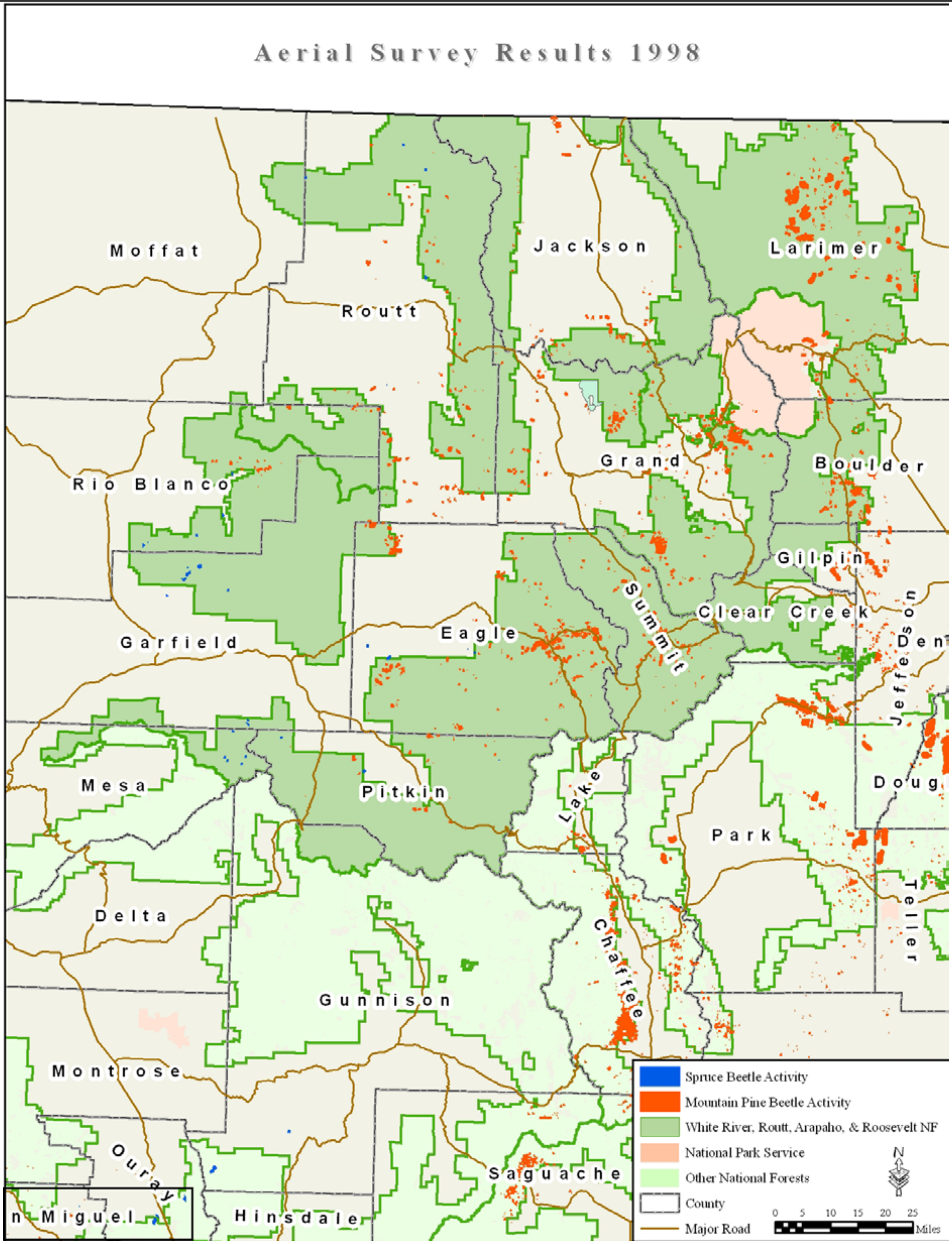
Aerial Survey Results - 1996



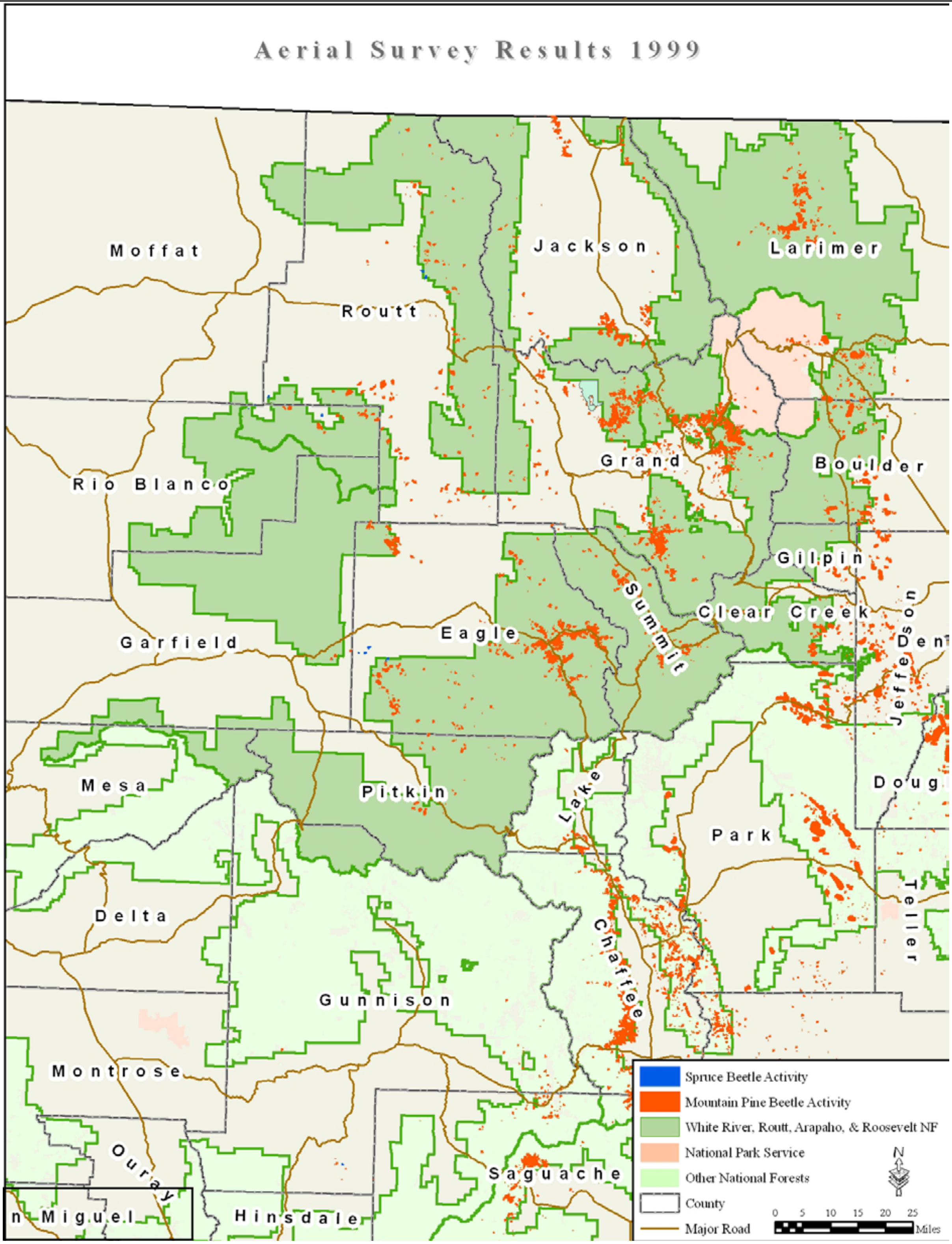
Aerial Survey Results - 1997



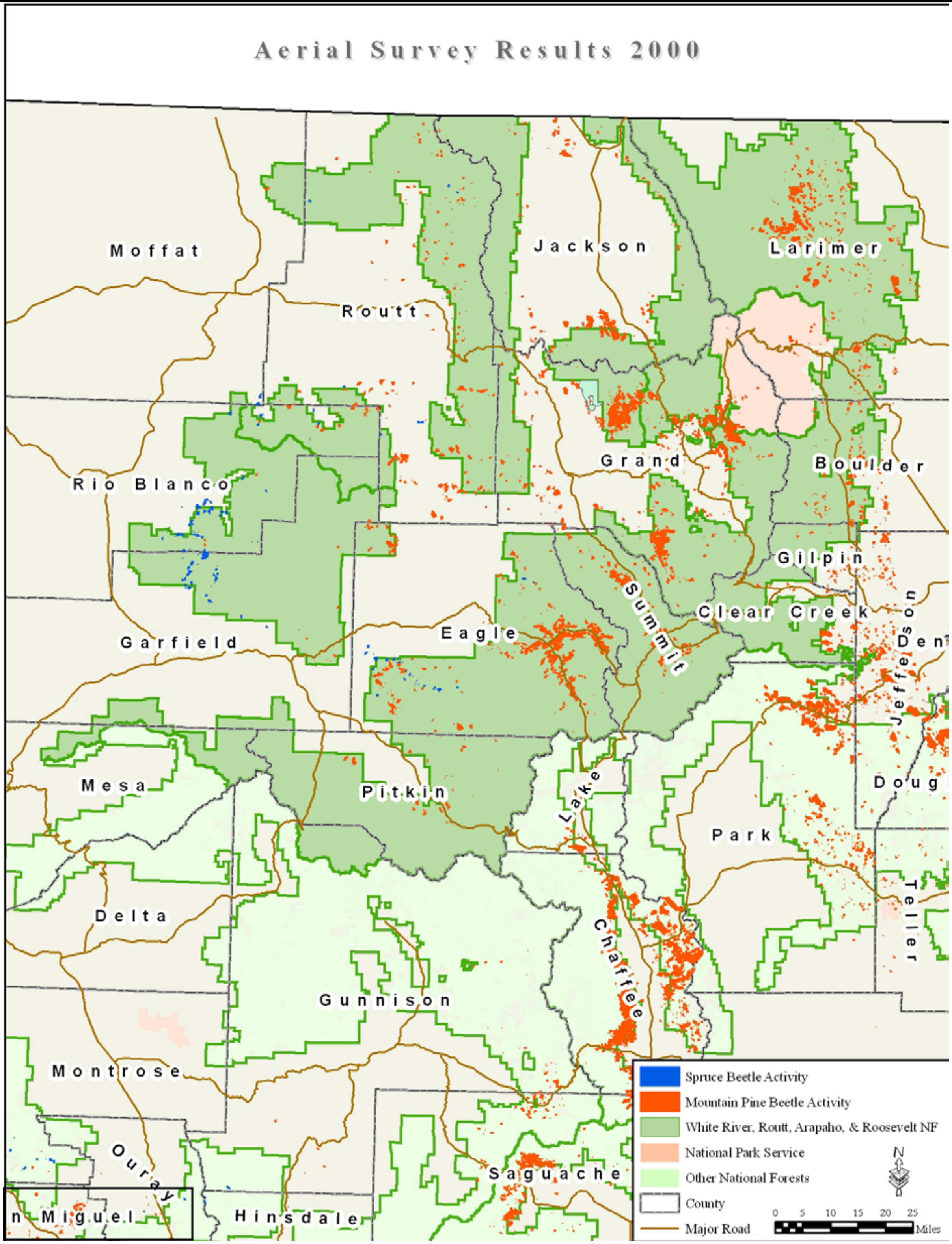
Aerial Survey Results - 1998



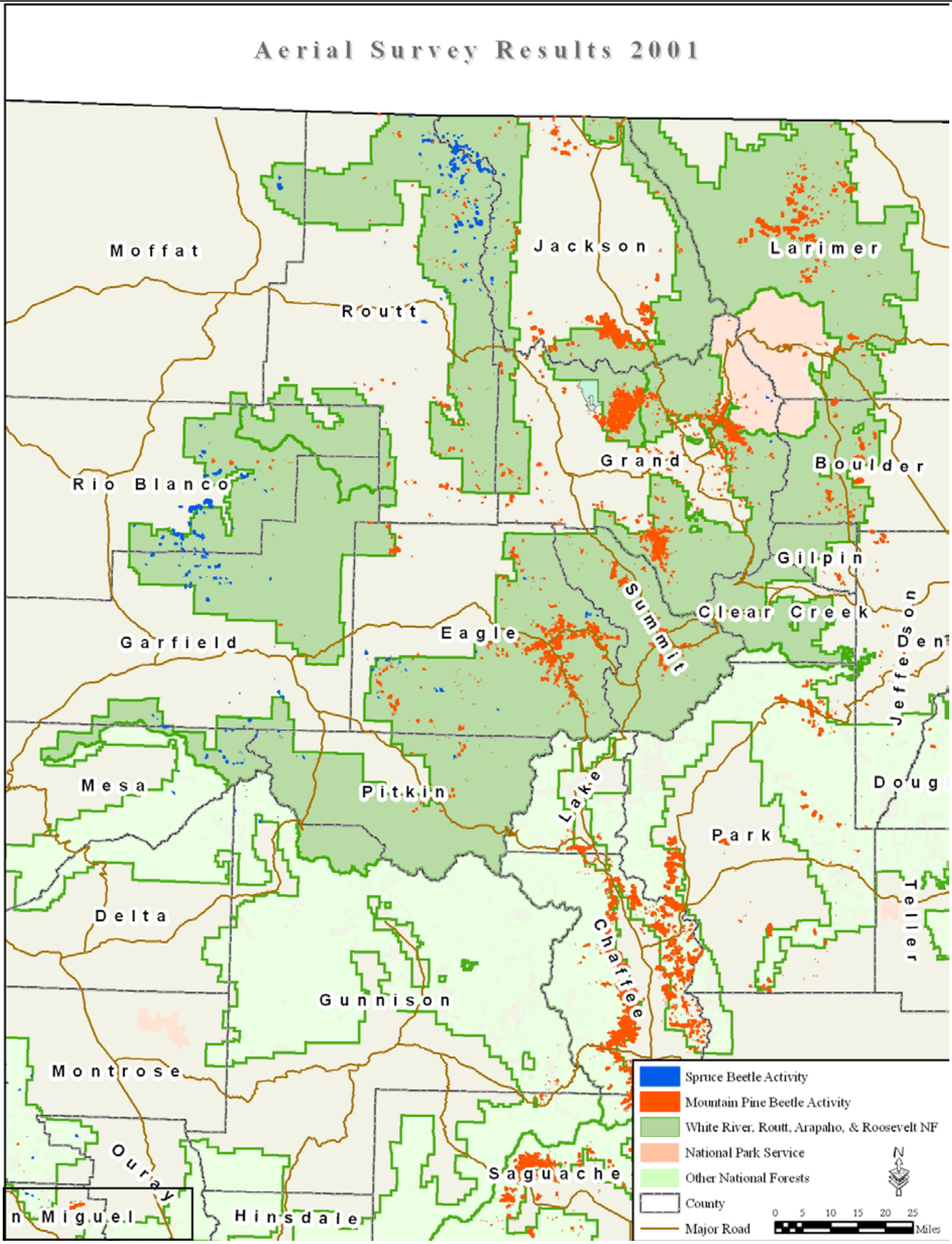
Aerial Survey Results - 1999



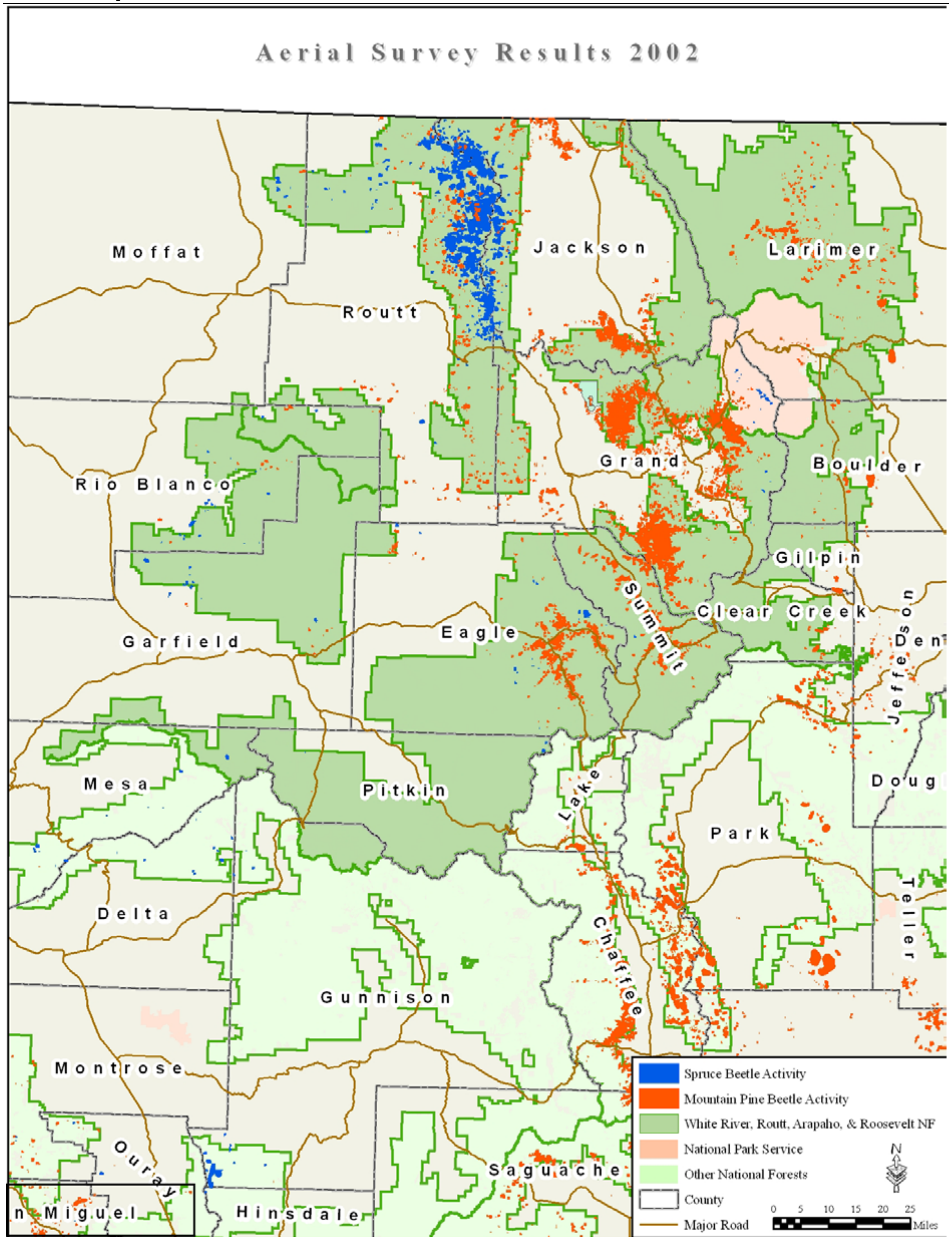
Aerial Survey Results - 2000



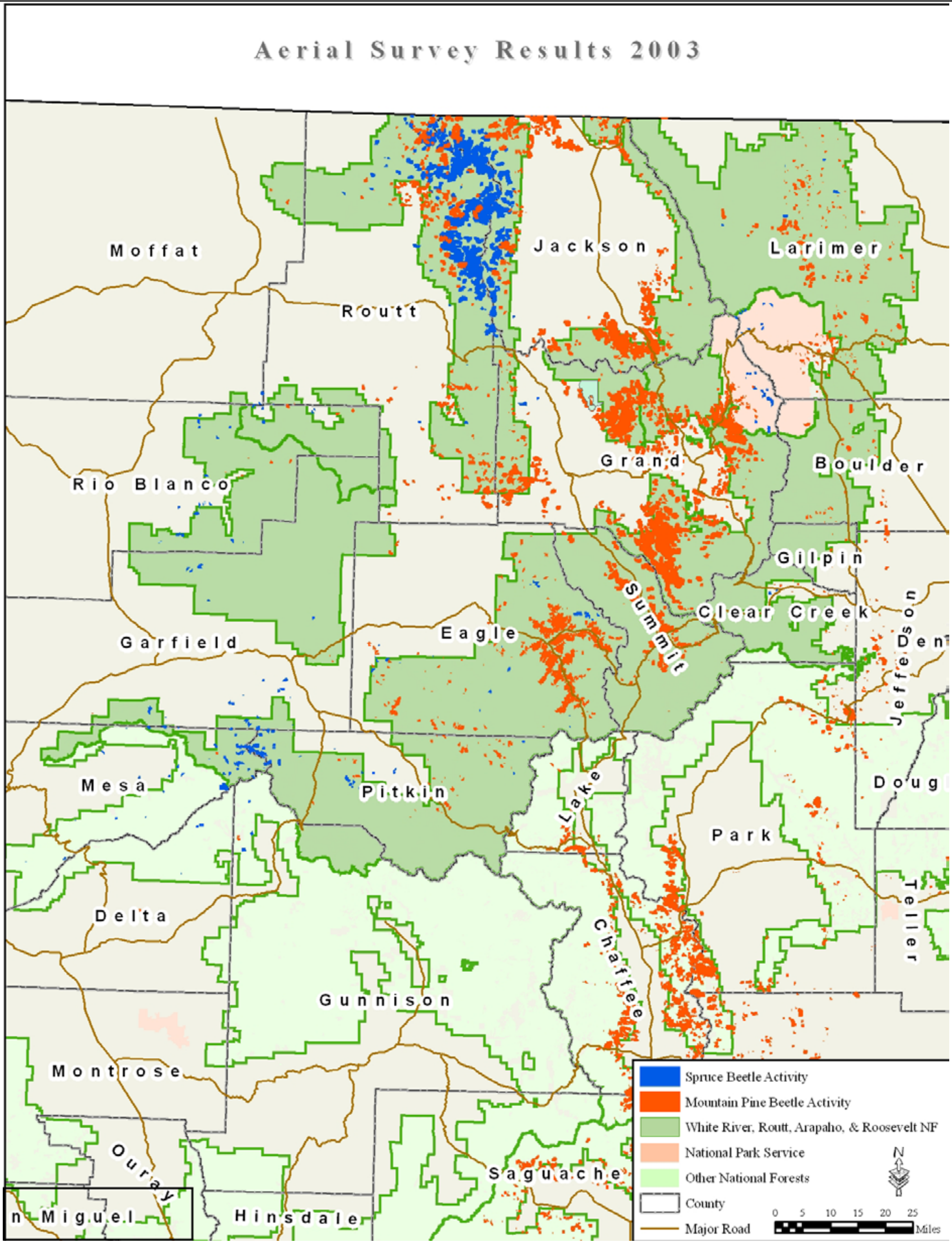
Aerial Survey Results - 2001



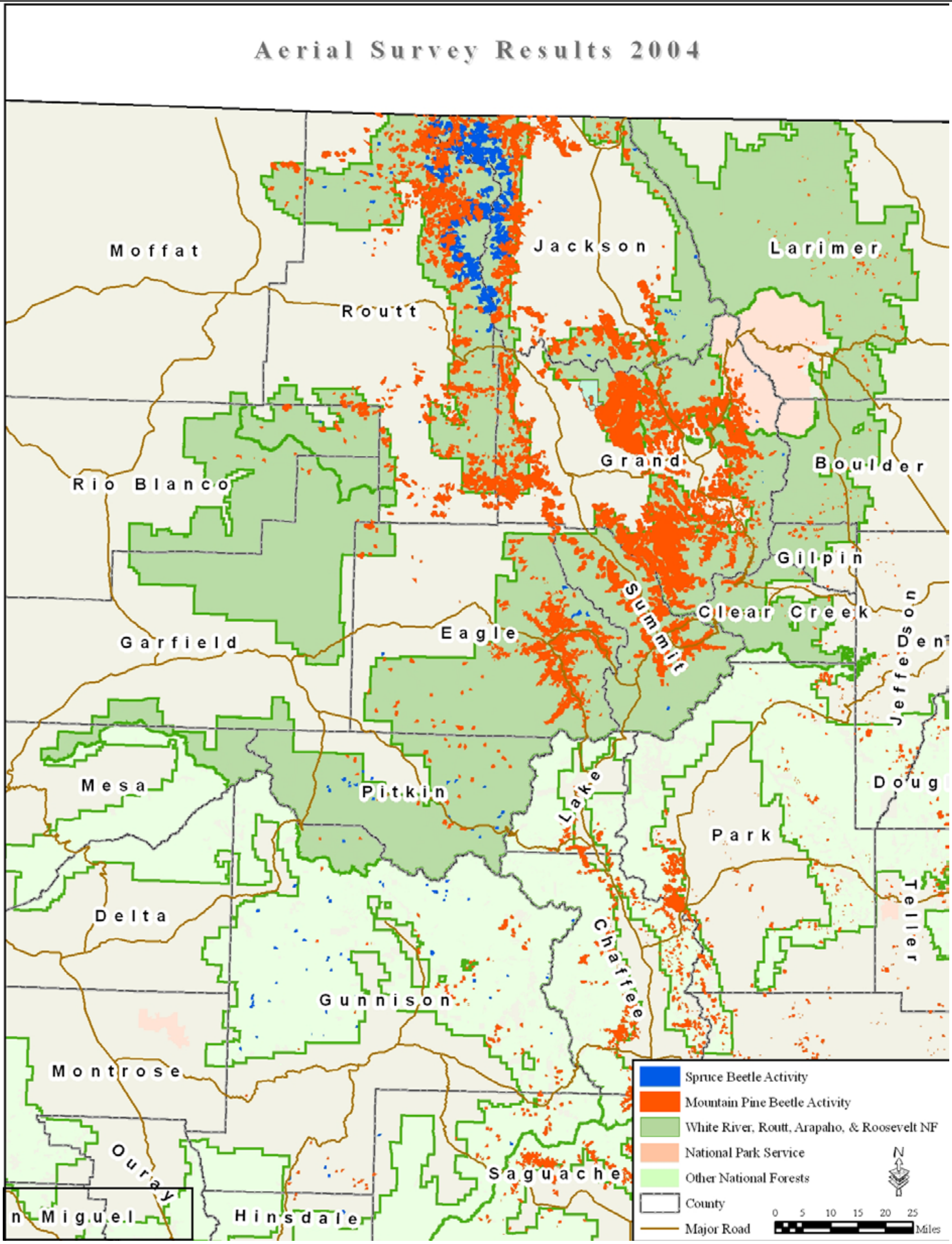
Aerial Survey Results - 2002



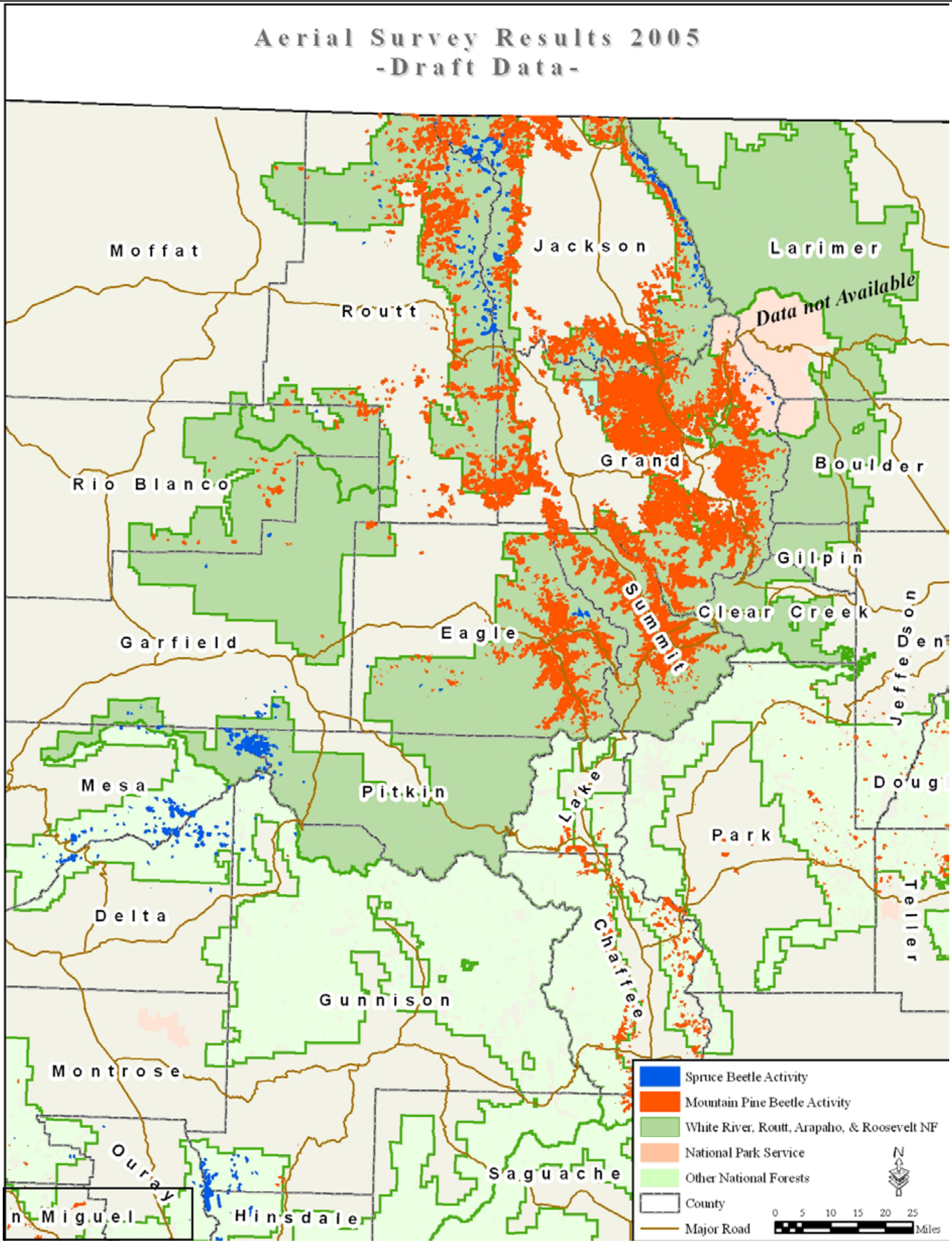
Aerial Survey Results - 2003



Aerial Survey Results - 2004



Aerial Survey Results - 2005



Assumptions for Current and Future Bark Beetle Activity

This section includes the assumptions made about Mountain Pine Beetle and Spruce Beetle that were used for this assessment.

Assumptions Regarding Mountain Pine Beetle

1. The primary factor leading to beetle epidemics is a stand of trees in a susceptible condition. Susceptible stand conditions are different for different tree species.

2. Specific stand attributes can be used to classify stand susceptibility or "hazard", which estimates how much of a stand will be killed in a beetle epidemic (Stand hazard classes are at the end of this document).

3. Widespread, intense epidemics are more likely to occur where there are greater concentrations of susceptible stands.

4. Landscape scale epidemics result from many smaller, stand-level epidemics that coalesce.

5. Epidemic beetle populations may develop anywhere there is suitable habitat. Beetle activity in an area does not necessarily begin in the high hazard stands.

6. Epidemics spread as beetles disperse across the landscape.

7. Natural enemies such as parasites, predators or diseases will be unable to suppress increasing beetle populations, except in occasional isolated outbreaks.

8. It is possible but highly unlikely that cold temperatures will halt beetle epidemics.

9. Epidemic beetle populations collapse due to the depletion of suitable host material, adverse weather, natural enemies, and other unknown factors.

10. In order to keep suppression actions effective, it will be necessary to monitor infestations and establish thresholds at which suppression is no longer effective and will be stopped.

11. Mountain pine beetle outbreaks are occurring in the assessment area; epidemics will grow and coalesce over the next 5 years.

12. The average stand diameter (live trees) will be lowered significantly by an outbreak within a stand.

13. Mortality will occur on a large scale but will not encompass all lodgepole stands. Stands located one mile or more from other lodgepole pine stands may develop epidemics but these epidemics will not coalesce.

14. The largest diameter trees in a lodgepole stand will be attacked first (these are often called “focus” trees), and in succeeding years, increasingly smaller diameter trees will be attacked.

15. Smaller diameter trees adjacent to these largest diameter “focus” trees will be killed in groups; this will occur more frequently and extensively in stands with a high percentage of lodgepole pine.

16. Numerous small epidemics will or are starting to intensify, spread, and coalesce, affecting 90% of the lodgepole pine in high hazard stands in the analysis area, 75% of the moderate hazard stands and 33% of the low hazard stands in the next five years.

17. Where outbreaks occur, mortality of pines with greater than six inch DBH will be as follows:

    - High hazard stands - 90% mortality
    - Moderate hazard stands - 50% mortality
    - Low hazard stands - less than 25% mortality

Assumptions Regarding Spruce Beetle

1. A major landscape-scale spruce beetle epidemic will occur within the analysis area.

2. Spruce beetle populations will emerge from blowdown and will attack and kill standing green spruce nearby.

3. A landscape-scale epidemic will occur over the next 15 years as several small epidemics intensify, spread, and coalesce, affecting a majority of the spruce/fir cover type in the analysis area as follows:

    - All of the spruce over nine inches DBH (Diameter at Breast Height) will be killed.
    - Half of the trees 5” to 8.9” DBH will be killed.
    - High hazard stands will lose 70% of their basal area.
    - Moderate hazard stands will lose 25% of the stand basal area on average. Stand composition, or the kinds of trees present in a stand, varies widely in the moderate hazard class.
    - Low hazard stands will lose 10% of the stand basal area. Low hazard stands will still lose most of their mature spruce basal area, but other factors such as non-host trees and smaller diameter spruce generally associated with these stands will lessen effects associated with the loss of the mature spruce component.

4. Beetle populations are expected to disperse into urban areas and kill spruce on private lands.

Resources at risk due to mortality

The following resource areas are felt to be at risk due to the expected and experienced levels of bark beetle induced tree mortality within the assessment area.

General Setting

	Total Acres	Forested Acres	Coniferous Acres
National Forest System Lands	5,840,000	3,848,000	3,012,000
Public Lands (BLM)	946,000	405,000	301,000
Colorado State Forest	71,000	55,000	49,000
Other State Lands and Private Lands (Within Eagle, Grand, Jackson, Routt and Summit Counties)			216,100

Recreation

Ski Areas

The following ski areas are at risk for losing substantial amounts of mature lodgepole pine and spruce trees:

> Arapahoe Basin, Aspen Highlands, Aspen Mountain, Beaver Creek, Breckenridge, Buttermilk, Copper Mountain, Eldora, Howelson Hill, Keystone, Loveland, Ski Cooper, Snowmass, SolVista, Steamboat, Vail and Winter Park/Mary Jane.

Bark Beetles are currently active at epidemic levels on or adjacent to Beaver Creek, Breckenridge, Copper Mountain, Keystone, SolVista, Steamboat, Vail and Winter Park/Mary Jane.

Loss of tree cover in these cover types at the intensities in the assumptions for MPB and SB would have the following impacts on ski areas:

- Loss of wind blocks for lifts, facilities, snow retention and the ski experience;
- Loss of shade for snow retention;
- Loss of trail definition for skier separation, skier safety, sense of low skier densities and a reduction in visual quality;
- Increase in the amount of hazard trees;
- Increased fuel hazard and resultant fire risk;
- Difficulty in revegetation efforts due to the loss of natural barriers;

- Increased risk of widespread blow-down of remaining trees; and
- Potential impact on water resources through increased snow-making needs.

It is uncertain whether this will reduce the number of skiers visiting these ski areas, but certainly these effects will substantially increase operating costs for these areas.

Current Status of Infestations on Ski Areas

Ski Area	Level of Mountain Pine Beetle	Level of Spruce Beetle
Arapahoe Basin	N/A	Not Yet
Aspen Highlands	Low	Not Yet
Aspen Mountain	Not Yet	Not Yet
Beaver Creek	Moderate	Not Yet
Breckenridge	Moderate	Not Yet
Buttermilk	Incipient	Not Yet
Copper Mountain	Moderate	Incipient
Eldora	Not Yet	Not Yet
Howelson Hill	Not Yet	Not Yet
Keystone	High	Not Yet
Loveland	Incipient	Not Yet
Ski Cooper	Incipient	Not Yet
Snowmass	Moderate	Not Yet
SolVista	Moderate	Not Yet
Steamboat	Moderate	Moderate
Sunlight	Not Yet	Moderate
Vail	High	Incipient
Winter Park/Mary Jane	Moderate	Incipient

Developed Recreation Areas (Campgrounds, Picnic Grounds)

Tree mortality in campgrounds and other developed recreation sites would bring a short-term loss of visual and physical separation between campsites, which could lead to a loss in sense of seclusion for campers. There would be a loss of shade, wind protection, a reduction of buffering of visual and sound disturbances, and a loss of visual screening of facilities. There would also be an increase in the number of hazard trees to be removed from campgrounds. These changes would lead to a loss of quality of experience and most likely a reduction in use at the campgrounds.

There are approximately 110 Campgrounds, 25 Picnic Grounds and dozens of Administrative Sites (Guard Stations, Work Centers, etc.) at risk.

Habitat

Goshawk

Mountain pine beetles tend to attack and kill the largest lodgepole pines in a stand, thus decreasing the numbers and availability of suitable nest trees. Moreover, losses in the largest live trees in an area also reduces essential habitat (carrying capacity) for some primary prey species, such as red squirrels and many songbirds. Overall, a decline in the extent and suitability of mature lodgepole pine forests (and to a lesser degree the spruce/fir forests) on the landscape translates directly into diminished carrying capacity and reproductive success for goshawks. We would expect a decline in the population of Northern Goshawks due to the extent and intensity of the bark beetle epidemics.

Others

The changes in forest structure and composition from the bark beetle induced mortality will have noticeable effects to habitat conditions for Canada Lynx.

Mortality of canopy species will also impact stream- riparian corridors through alteration of riparian plant communities (spatial complexity), riparian microclimate and stream temperature, and increased loading of large wood to streams and floodplains. Many terrestrial species utilize riparian habitat for food, cover, and nesting; riparian and aquatic species that may be impacted include plant species of concern, boreal toads, and fish.

Watershed Condition

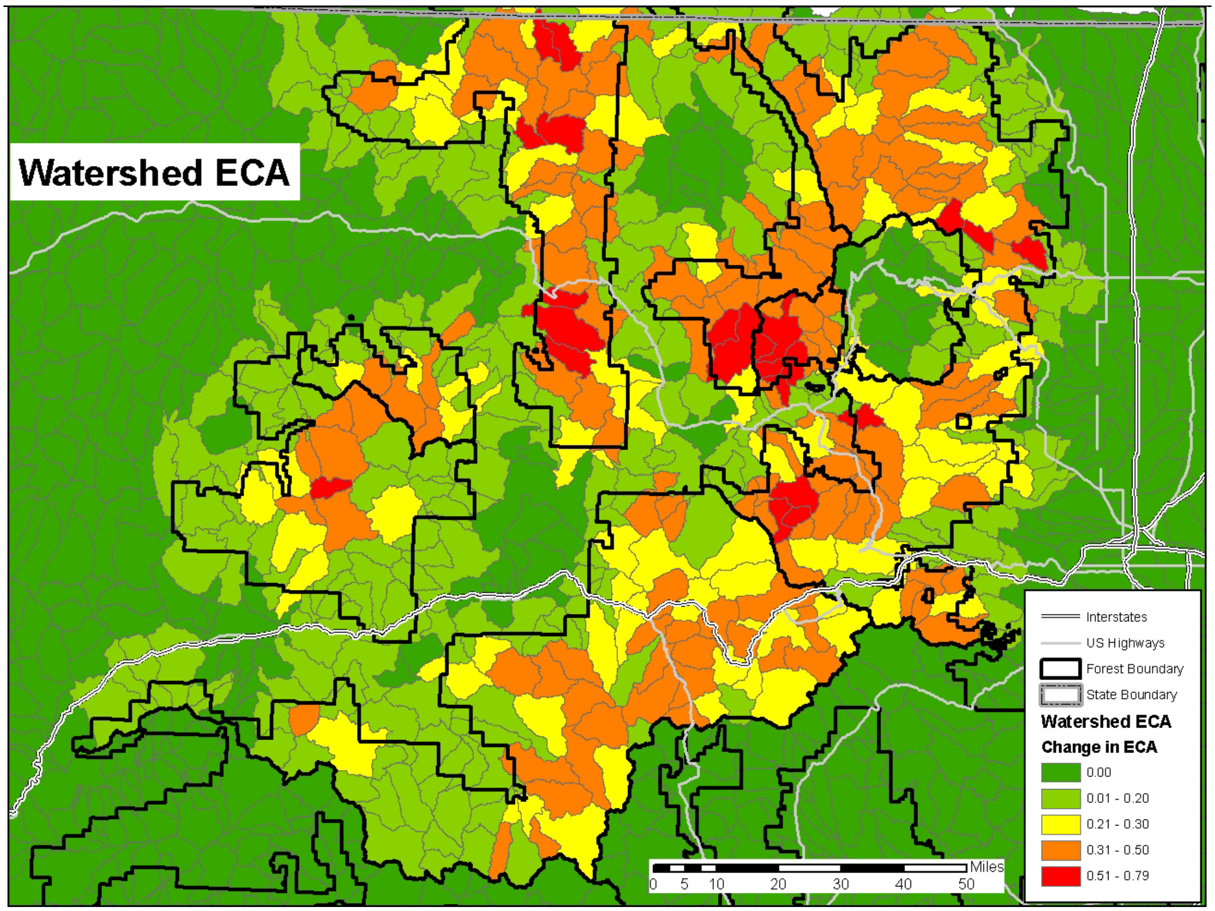
Stream Channel Stability

Mortality of trees likely will increase water yield in watersheds. This generally becomes detectable when the loss of tree cover (as measured by ECA or Equivalent Clearcut Acre) by whatever means exceeds 25% - 30%. This increase in water yield can create peak water flow that causes stream channel instability.

Channel instability can cause the following effects:

- Increased water yields above and beyond the range of flows that streams have adjusted to accommodate can cause channel instability due to channel erosion.
- Increased channel erosion increases sedimentation which can affect aquatic habitat
- Channel instability can affect the ability of the watershed to transport the natural bedload and suspended sediment load.
- Roads exacerbate the problem by converting subsurface flow to surface flow, which can further augment peak flows and cause additional channel instability.
- Roads are also a source of increased sediment through connected disturbed areas.
- Culvert failures at road-stream crossings

Watershed - Potential Loss of Mature Tree Cover



As can be seen on the figure above there are twenty-two 6th level watersheds (containing 319,000 acres) where the loss of mature tree cover is represented by an ECA exceeding 50%, 110 watersheds (containing 2,219,000 acres) where the ECA is greater than 30% but less than 50%, and 77 watersheds (containing 1,807,000 acres) where the change is greater than 20% but less than 30%. This data represent only the change expected due to recent or imminent tree mortality caused by bark beetles and does not incorporate the existing condition for ECA. Stream channel instability is likely to start occurring at ECA thresholds of 25% - 30%.

Municipal Watersheds

Many of the watersheds listed above are used as municipal water supplies. Large scale mortality may lead to additional sedimentation in reservoirs, leading to additional operations and maintenance costs. Large high intensity fires in municipal watersheds create the potential to overwhelm the capabilities of municipal water storage and treatment systems.

Existing Infrastructure

Increased water flows could exceed capacity for culverts, leading to potential for "blowing out" of road/stream crossings.

Wildfire Risk/Potential for Loss

Introduction

High intensity crown fires occur infrequently in lodgepole pine stands when an ignition, conducive weather conditions and the fuel profile are aligned. Large scale insect epidemics and large fires have no doubt shaped these ecosystems for thousands of years. In these kinds of forest ecosystems, weather conditions have a far greater influence on the probability of a crown fire than do fuel loadings; however, with the predicted increase in mortality across this large landscape, dramatic changes in fuel hazards and fire behavior would be expected. Once those changes occur, weather patterns may influence the likelihood of large landscape scale fires occurring.

Harvesting trees and removing heavy fuel loadings in areas adjacent to residential interface, high value recreation areas, and around infrastructure such as power transmission lines, transportation corridors, and key communication sites, is intended to reduce the risk of loss of human life and property by increasing the opportunity for control of natural and human-caused wildfires within the residential intermix.

Residential Interface

Communities

Within the assessment area there are 67,000+ acres of moderate and high susceptibility pine and spruce within 1 mile of high density developments (defined as 1 house or more for every 2 acres of land). This acreage figure is only for federal lands (and the Colorado State Forest) adjacent to these developed areas. The acreage of these high density developed areas has not been calculated. Many of these mountain communities are in a forested environment.

The fuel hazard and resultant risk of loss due to wildfire in these high density areas is increased. There is increased potential for loss of life and property. Many of these communities at risk are resort communities with median house values in excess of $500,000 each.

Subdivisions

Within the assessment area there are 299,000+ acres of moderate and high susceptibility pine and spruce within 1/2 mile of moderate or low density developments (defined as 1 house or more for every 100 acres of land but less than 1 house for every 2 acres of land). This acreage figure is only for federal lands (and the Colorado State Forest) adjacent to these developed areas. The acreage of these moderate and low density developed areas has not been calculated. Many of these developments are in a forested environment.

The fuel hazard and resultant risk of loss due to wildfire in these moderate and low density areas is increased. There is increased potential for loss of life and property.

Developed Sites

The increase in fuel hazard in and adjacent to these areas, and the subsequent increase in fire risk creates the potential loss of capital improvements (tables, outhouses, etc.) as well as the potential for loss of life and property of the recreational users.

Transmission Lines

The increase in fuel hazard in and adjacent to these areas and the subsequent increase in fire risk creates the potential loss or interruption of power transmission capabilities. Interruption of power transmission on the major lines can have sweeping effects on a regional scale.

There are 55,000+ acres of moderate and high susceptibility stands in close proximity (1/4 mile) to the major power transmission lines.

Increased Fuel Hazard across Landscape

The potential for 50 to 100 percent mature tree mortality occurring on more than 2,500,000 acres increases the likelihood of more large high intensity fires.

Suitable Timber Base

There are more than 680,000 acres of moderate and high susceptibility stands in the suitable timber base (National Forest System suited lands, BLM commercial forestlands and Colorado State Forest suited lands). This is slightly more than 80% of the suitable timber base in the area. The loss of the live growing stock of such a high percentage of the suitable base may impact the ability to meet long term sustained yield objectives. The loss of tree cover and the additional risk of losses due to wildfires creates concern about regenerating stands.

Ecosystem Function

The on-going insect outbreaks are a huge disruption to these subalpine ecosystems that is unprecedented in recent history (250+ years). This disturbance not only is affecting large land areas but numerous conifer species as well (Engelmann Spruce, lodgepole, limber and bristlecone pines). We can expect a number of significant effects that are likely to have management repercussions for a long time into the future. These include:

- Profound shifts in the age class structure and species composition of affected forests;
- Huge shifts in live versus dead biomass, either remaining on-site, or potentially to be removed;
- Significant alteration of water yield and quality, wildlife and fish habitat, and potential alteration of fire risk, behavior, and severity of effects;
- Potential mortality of those few limber and bristlecone pine trees with heritable resistance to the exotic disease white pine blister rust; and
- Potential for invasion of exotic species, soil erosion, and alteration of water quality in watersheds supplying a significant portion of Colorado's population.

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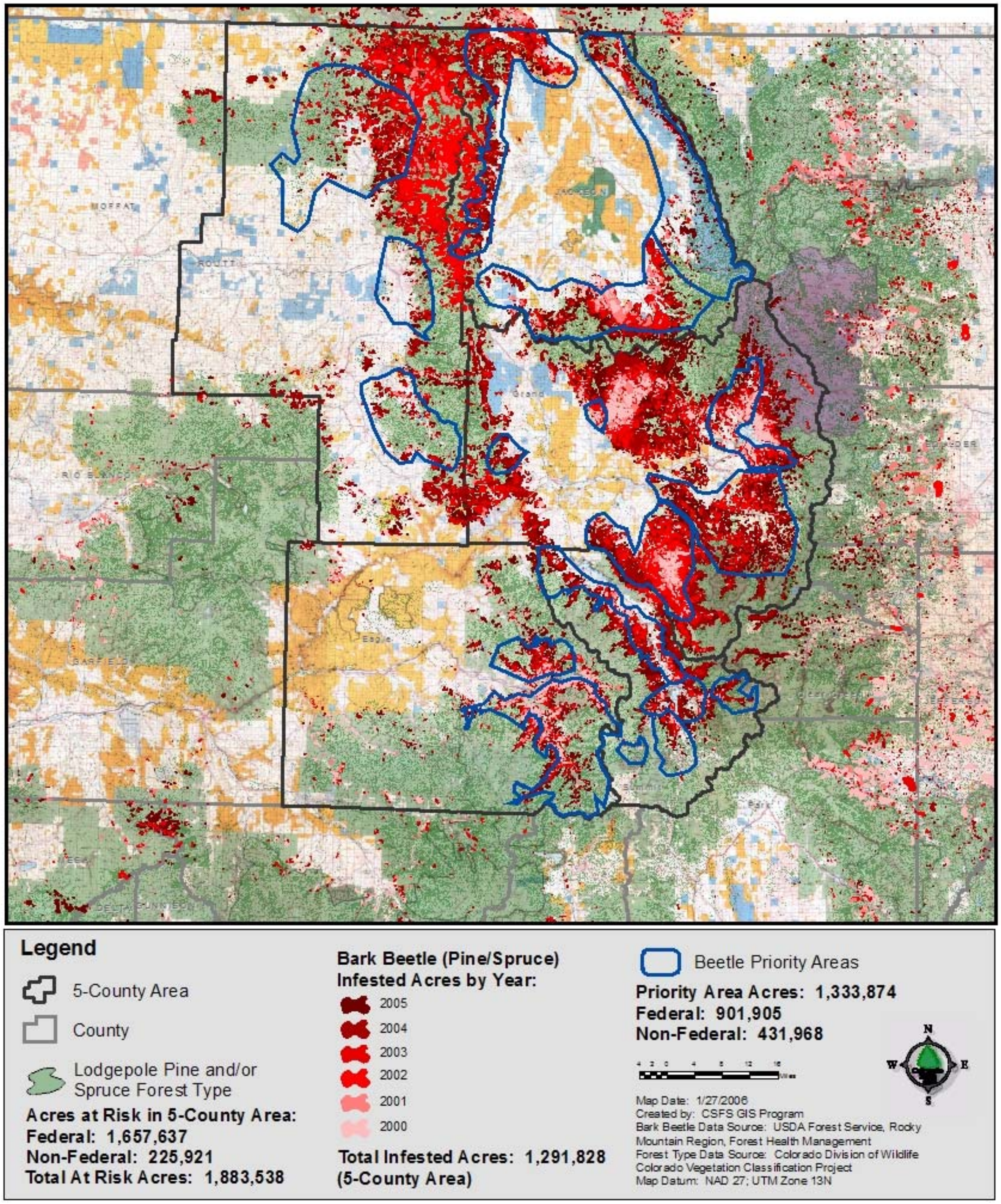
Appendix A

A map of the 22 draft priority areas for treatment (identified by the Colorado State Forest Service and key stakeholders).

Draft Priority Areas for Bark Beetle Mitigation in North-Central (5-County Area) Colorado

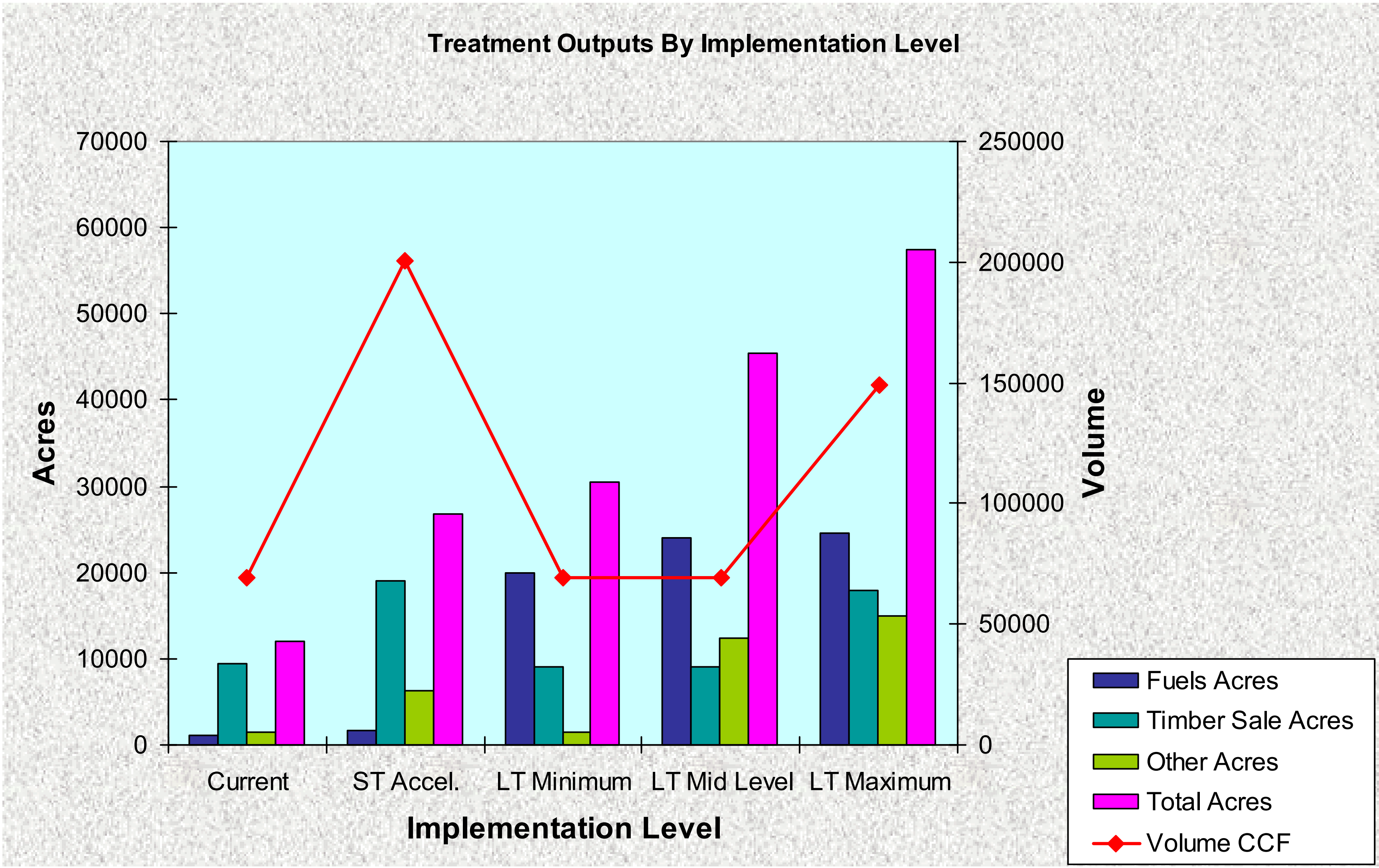


Appendix B

A detailed list of the projects and outputs for the short and long term strategies

Short-term Strategy - Expected Outputs for Accelerating Existing Projects in FY06 and FY07		
	Current Program of Work	**Accelerated Program of Work (Additional)**
Actions	**Outputs**	**Outputs**
Arapaho-Roosevelt NF		
Preventive spraying - high value areas	332 acres	700 acres
Suppression/salvage treatments	4,394 acres/26,000 ccf	
Accelerate planning/decisions-Complete FY07		2 decisions
Hazardous fuels reduction	350 acres	332 acres
Medicine Bow-Routt NF		
Preventive spraying - high value areas	100 acres	350 acres
Suppression/salvage treatments, prep and offer	3,000 acres/31,000 ccf	6,300 acres/66,000 ccf
Suppression/salvage treatments, advanced prep		3,000 acres/32,000 ccf
Suppression treatment - no timber volume	1,000 acres	5,050 acres
Accelerate planning/decision		4 decisions
Hazardous fuels reduction	486 acres	646 acres
White River NF		
Preventive spraying - high value areas	50 acres	400 acres
Suppression/salvage treatments, including planning and decisions as needed	2,050 acres/12,000 ccf	9,650 acres/33,500 ccf
Hazardous fuels reduction	310 acres	650 acres
Reforestation - campgrounds		70 acres
Bureau of Land Management		
Suppression/salvage treatments, including planning and decisions as needed	360 acres/2,000 ccf	500 acres/5,000 ccf
Hazardous fuels reduction	174 acres	600 acres
Colorado State Forest Service		
Suppression/salvage treatments	3,005 acres	
Preventive spraying - high value areas	120 acres	

Long-term Strategy – Expected Annual Outputs					
	Arapaho-Roosevelt	Medicine Bow-Routt	White River	BLM	Colorado State
Actions	**Outputs**	**Outputs**	**Outputs**	**Outputs**	**Outputs**
Prevention					
Preventive spraying in sites currently with beetle pressure (annual for 5 yrs)	500 acres	500 acres	400 acres		
Preventive spraying in sites not yet threatened by beetle (annual for 10 yrs)	250 acres	750 acres	1,000 acres		
Area wide biological assessment (one time cost)	1 assess. - all units				
Silvicultural treatments in areas not yet infested (annual for 10 yrs)	10,000 ccf	20,000 ccf	20,000 ccf		
Suppression					
Suppression action in ski areas (10 ski areas/yr for 10 yrs)	2 ski areas	1 ski area	7 ski areas		
Suppression action in WUI areas (annual for 3-5 yrs)	1,000 acres	1,000 acres	1,000 acres	200 acres	
Salvage/Protection					
Harvest of timber-primarily suitable timber base (annual for 5 yrs)	4,000 ccf	30,000 ccf	30,000 ccf	4,000 ccf	6,000 ccf
Develop large scale long-term stewardship contract (one time cost)	1 contract - all units				
Landscape fire behavior assessment and treatment optimization model (one time cost)	1 assessment - all units				
Reforestation of developed sites (one time cost per site)	4 sites	2 sites	4 sites		
Reforestation of suitable base and other areas (annual for 10 yrs)	300 acres	300 acres	400 acres		
Defensible space-WUI-Residential (annually for 5 yrs)	10,000 acres	5,000 acres	5,000 acres		
Defensible space-power line corridors (annual for 5 yrs)	100 acres	200 acres	700 acres		
Hazard tree removal - roads and trails (annual for 10 yrs)	30 miles	30 miles	40 miles		
Research Topics	Bark Beetle Dynamics in Rocky Mountain Forests, Watershed Processes, Riparian Composition and Function, Stream Channel Processes , Sound Management during Bark Beetle Outbreaks,				



- Dramatic increase in timber output in short term is a result of liquidating all "shelf" volume
- Long term timber output does not reflect volume that may be realized from fuel reduction work
- Emphasis at lower funding levels for the long term is based on treating high priority areas first (e.g. residential interface and ski areas) and deferring silvicultural treatments in suitable timber base to higher funding levels

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