United States Department of Agriculture

Spruce Beetle Epidemic and Aspen Decline Management Response

Final Environmental Impact Statement

Forest Service **Grand Mesa, Uncompahgre, and Gunnison National Forests** **February 2016**

SPRUCE BEETLE EPIDEMIC AND ASPEN DECLINE MANAGEMENT RESPONSE

Final Environmental Impact Statement

Delta County, Colorado

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Abstract: The Grand Mesa, Uncompahgre and Gunnison National Forests (GMUG) have prepared a Final Environmental Impact Statement (EIS) in compliance with the National Environmental Policy Act (NEPA) and other relevant Federal and State laws and regulations. Due to the ongoing spruce beetle epidemic and sudden aspen decline that is occurring across a broad landscape on the GMUG Forests, the GMUG proposes the Spruce Beetle Epidemic and Aspen Decline Management Response (SBEADMR) to adaptively implement vegetation management actions. The purpose and need is informed by the Western Bark Beetle Strategy (USDA 2011i) and guided by the GMUG National Forest Land and Resource Management Plan (Forest Plan), the National Cohesive Wildland Fire Management Strategy (USDA & USDI 2014), and other national-level policy and guidance. The focus of the proposed action is to actively manage spruce-fir and aspen vegetation to reduce hazards to the public and infrastructure, salvage dead and dying timber, reestablish forest cover and increase resiliency in green stands. Alternative 1 is the No Action Alternative. This alternative is used as a basis for comparing the effects of the Proposed Action and other alternatives. It assumes no implementation of any elements of the proposed action or other action alternatives. Alternative 2 is the Agency Preferred Action. This alternative uses an adaptive implementation approach to implement vegetation management activities across the landscape. Spruce stands with lower mortality would be partially harvested using uneven-aged management to increase spruce-fir resiliency. Both live green trees and pockets of dead and dying trees would be removed. In areas with higher overstory mortality, the amount of salvage harvest would increase. Aspen stands affected by sudden aspen decline would be prioritized for treatment with coppice cuts and/or prescribed fire, though selected aspen stands not currently affected would also be treated to increase resiliency. Alternative 3 focuses all proposed activities within the identified wildland urban interface (WUI) and roadside corridors. This Final EIS discloses the direct, indirect, and cumulative environmental impacts resulting from the action alternatives.

SUMMARY

The Grand Mesa, Uncompahgre, and Gunnison National Forests (GMUG) propose to implement multiple vegetation management actions within the Spruce Beetle Epidemic and Aspen Decline Management Response (SBEADMR) project. This proposal is guided by the Ecological Restoration and Resilience Policy (FSM 2020), the GMUG National Forest Land and Resource Management Plan (Forest Plan), the National Cohesive Wildland Fire Management Strategy (USDA & USDI 2014), and it is adapted from the Western Bark Beetle Strategy (USDA 2011i).

The SBEADMR project proposes to treat spruce and aspen forests impacted by the ongoing spruce beetle epidemic and by sudden aspen decline (SAD), as well as those areas that are considered high risk for spruce beetle or SAD across the GMUG National Forests. The GMUG contains approximately 223,000 cumulative acres of spruce beetle mortality and 229,000 acres of affected aspen accumulated over the past decade, which corresponds to approximately 30% of the spruce-fir and aspen vegetation on the Forests. While insects and disease naturally occur in these ecosystems, prolonged drought and unusually high temperatures exacerbated these disturbances. The rate of change in tree mortality is extensive, and both the bark beetle infestation and SAD outbreak are likely to continue for several more years. The implications of these continued conditions include increased high mortality in spruce-dominated stands, decline of aspen stands, risk to the public and infrastructure from hazard trees, and changes in plant community and vegetation structure over time. Given the substantial mortality of spruce-fir and aspen forests on the GMUG over the past decade, and current Forest Plan direction, the need for the project is to manage forest vegetation to bring current and foreseeable conditions closer to desired conditions on landscapes available for active management. Furthermore, in the context of a changing climate conducive to more frequent and extensive wildfires in forests at high elevation *irrespective of tree condition* (Westerling et al. 2006, Agee 2007; Funk 2012; Rangwala and Rondeau), desired conditions for fire and fuels management include more locations across the landscape from which firefighters can safely and effectively manage or suppress fires for values at risk and/or resource benefit.

The purpose of the project is to reduce the safety threats of falling, dead trees and of managing wildfires in affected stands; treat affected stands via recovery of salvageable timber and subsequent re-establishment of desired forest conditions; and improve the resiliency of stands at-risk of insect and disease. In spruce stands, improved resiliency would be achieved via increasing diversity of age class and tree species. In aspen stands, resiliency treatments would be implemented to promote regeneration prior to full-stand mortality.

A maximum of 120,000 acres of National Forest System (NFS) lands –60,000 of commercial treatment and 60,000 of noncommercial treatment—within the GMUG are proposed under both action alternatives in this DEIS for treatments over an approximately 8-12 year implementation timeframe.

Comments on the proposed action, potential concerns, and opportunities for managing the SBEADMR project were solicited through varied public involvement and collaboration efforts. Those solicited for input included Forest Service resource specialists, tribal representatives, members of the public, other public agencies, adjacent property owners, and organizations. Methods used to request comments included: Publishing a Notice of Intent (NOI) in the Federal Register to prepare this Environmental Impact Statement (EIS); mailing a scoping letter that solicited comments to approximately 1,300 interested parties; conducting public meetings prior to and throughout the two-year planning process; publishing a Notice of Availability (NOA) in the Federal Register of the Draft EIS; mailing and e-mailing notice letters of the Draft EIS comment period to approximately 2,100 interested parties; and meetings with interested parties and individuals.

Comments received during scoping were used to help define issues, develop alternatives and mitigation measures, and analyze effects. Through review and analysis of the scoping comments, the Interdisciplinary Team (IDT) identified four substantial issues: (1) impacts from roads, (2) efficacy of resiliency treatments, (3) socioeconomic impacts to local communities, and (4) restricting treatments to address only public safety.

To address the issues, the IDT developed action alternatives, design features common to all action alternatives, and/or completed more analysis of the particular effect. The alternatives analyzed in detail in the Final EIS are briefly described as follows:

Alternative 1: No Action – The National Environmental Policy Act (NEPA) requires the study of the No Action Alternative and to use it as a basis for comparing the effects of the Proposed Action and other alternatives. This alternative assumes no implementation of the proposed action or any of the alternatives within the project area. Vegetation management would not take place unless authorized by other decisions. Vegetation structure would change over time through natural growth and mortality and events such as wildfires, storms, and insect or disease outbreaks. Under the No Action alternative, current management plans would continue to guide management of the project area. Routine activities not tied to this analysis such as scheduled road maintenance, treatment of noxious weeds, and fire suppression would also continue.

Actions Common to All Action Alternatives

Each action alternative proposed adaptive management implementation of a suite of treatments to address the effects of the spruce beetle epidemic and sudden aspen decline and promote resiliency to future insect outbreaks and disease.

Treatment methods used would consist of: 1) commercial mechanical treatment, which is ground-based mechanized timber cutting that produces a commercial product; SBEAMDR limits such to lands suitable for timber harvest; 2) non-commercial mechanical treatment, which is ground-based mechanized timber cutting that does not produce a commercial product, and includes use of mechanized equipment for tree cutting, mastication, and hand treatments using chainsaws; and 3) prescribed burning, which includes broadcast burning and pile burning. Both action alternatives would use existing roads where possible and include some amount of road construction; all new roads would be decommissioned following project implementation.

The maximum total acres proposed for treatment is the same for both action alternatives, with 120,000 acres proposed for treatment across the life of this project. Approximately 4,000-6,000 acres of commercial harvest would be treated annually, and approximately 3,000-6,000 acres of non-commercial mechanical or prescribed burning treatments would be treated annually over the life of the project. While the maximum proposed treatment is the same, the *areas* where these treatments would be implemented differ by alternative.

Continued public participation during project implementation is a critical aspect of both action alternatives, and it is integrated into the adaptive implementation strategy.

Alternative 2: Agency Preferred Action – Alternative 2 analyzes 207,615 acres of potential disturbance acres. 190,014 of these acres are identified and analyzed as Priority Treatment Areas (PTAs), 17,388 acres as potential hazard tree treatments outside of PTAs, and 213 acres as potential new road disturbance outside of PTAs. Both PTAs and potential hazard tree treatments are located in spruce, aspen, and aspen-mix cover types. Of the PTA acres, approximately 59% (112,768 acres) are identified as commercially suitable timber acres, and 41% (77,246 acres) are identified for noncommercial treatment.

Alternative 3: Wildland Urban Interface (WUI) Focus – Alternative 3 shifts the geographic extent of treatments exclusively to 1) the wildland urban interface (WUI) and 2) outside the WUI, proximal to roads and additional human infrastructure. This alternative was developed to address public comments that proposed that treatments focus on public safety objectives.

The total area analyzed in Alternative 3 encompasses 127,023 acres. 102,159 of these acres are identified and analyzed as Priority Treatment Areas (PTAs), 24,695 acres as potential hazard tree treatments outside of PTAs, and 169 acres as potential new road disturbance outside of PTAs. Of the PTA acres, approximately 45% (45,967) are identified as commercially suitable timber acres, and 55% (56,192) are identified for noncommercial treatment. Both noncommercial and commercial PTAs in Alternative 3 total less than 60,000 acres, so treatments of hazard trees may or may not make up the difference. Depending on the extent of hazard trees within the identified roadside corridors over the life of the project, fewer total acres may be treated in Alternative 3, ranging from ~46,000-60,000 acres commercially to 56,192-60,000 acres noncommercially.

All treatment types and methods would remain the same as in Alternative 2.

Chapter 1 of this EIS identifies the purpose and need for the proposed actions as well as related National and Forest-level policy and direction. Given this purpose and need, the Deciding Official (Forest Supervisor) reviews the project record and analysis, the proposed action, issues identified during scoping, the alternatives, and the environmental consequences of implementing the proposed action and alternatives disclosed in this EIS. This forms the basis for the Deciding Official to make the following determinations:

- Whether or not the proposed action, alternatives, and effects analysis address the issues, are responsive to National policy/guidance/law and Forest Plan direction, and meet the purpose of and need for action described in the SBEADMR EIS;
- Whether or not the information in this analysis is sufficient to implement the proposed activities;
- Which actions, if any, to approve.

Table of Contents

List of Tables

CHAPTER 1. PURPOSE AND NEED FOR ACTION

Document Structure

The Forest Service has prepared this Draft Environmental Impact Statement (DEIS) in compliance with the National Environmental Policy Act (NEPA) and other relevant Federal and State laws and regulations. This Environmental Impact Statement discloses the direct, indirect, and cumulative environmental impacts that would result from the proposed action and alternatives. The document is organized into four chapters:

Chapter 1. Purpose and Need for Action: The chapter includes information on the history of the project proposal, the purpose of and need for the project, and the agency's proposal for achieving that purpose and need. This section also details how the Forest Service informed the public of the proposal and how the public responded.

Chapter 2. Alternatives, including the Proposed Action: This chapter provides a more detailed description of the agency's proposed action as well as alternative methods for achieving the stated purpose. These alternatives were developed based on significant issues raised by the public and other agencies. This discussion also includes mitigation measures. Finally, this section provides a summary table of the environmental consequences associated with each alternative.

Chapter 3. Affected Environment and Environmental Consequences: This chapter describes the environmental effects of implementing the proposed action and other alternatives. This analysis is organized by resource area.

Chapter 4. Interdisciplinary Team Membership: This chapter provides a list of team members who participated to prepare this DEIS.

Appendices: The appendices provide more detailed descriptions of fundamental components of actions common to all alternatives.

Index: The index provides page numbers by topic.

Additional documentation, including more detailed analyses of project-area resources, may be found in the project planning record located at Grand Mesa, Uncompahgre, and Gunnison National Forests, 2250 Highway 50, Delta, CO 81416.

Background

The Grand Mesa, Uncompahgre, and Gunnison (GMUG) National Forests are located on the western slope of the Southern Rockies and into the Colorado Plateau. Elevations of the 3,161,900 acre GMUG range from about 5,800 ft. (1,770 m) on the west foothills of Battlement Mesa, to over 14,200 ft. (4,330 m) on the high peaks of the San Juan and Saguache Mountains. All of the Grand Mesa, Uncompahgre, and Gunnison National Forests are on the western slope, as the Continental Divide forms the eastern and southeastern boundaries of the National Forests.

The GMUG includes diverse vegetation ranging from semi-desert, sagebrush, piñon-juniper, mountain shrublands, and ponderosa pine to lodgepole pine, Engelmann spruce, subalpine fir and quaking aspen to the alpine zone.

Annual precipitation on the GMUG ranges from about 10 inches (25.4 cm) per year in the bottom of the Gunnison Basin, to over 50 inches (127 cm) per year on the high peaks of the San Juan and Elk Mountains. Precipitation largely parallels elevation, with some notable exceptions in the rain shadows in the bottom of the Upper Gunnison Basin and the Cochetopa Hills area. Thus the higher precipitation areas are those associated by the higher mountain ranges – the Elk and West Elk Mountains, the San Juan Mountains, and the Grand and Battlement Mesas. The Cochetopa Hills and the Uncompahgre Plateau are on the low end of precipitation range for the Forests.

The GMUG has experienced approximately 223,000 cumulative acres of spruce beetle mortality and 229,000 acres of Sudden Aspen Decline accumulated over the past decade. Neighboring San Juan and Rio Grande National Forests have been experiencing a massive spruce beetle outbreak for the past decade. The spruce beetles have spilled over the Continental Divide into the GMUG. From 2013-2014, the cumulative acreage affected by spruce beetles increased by approximately 64,000 acres on the GMUG (pers.comm. Tom Eager). The landscape south and east of Gunnison, Colorado bordering the Rio Grande National Forest, is one of the highest spruce mortality areas on the GMUG. Mortality in spruce stands is expected to continue at relatively high levels for several years to come.

Similarly, aspen forests have been affected by Sudden Aspen Decline (SAD). SAD was first noticed in southwestern Colorado in 2004 (Worrall et al. 2008). On the San Juan National Forest, large and growing patches with of crown thinning, branch dieback, and mortality were found. It occurred on a landscape scale and rapidly increased in area and severity. Over the next few years, SAD spread to the GMUG and throughout Colorado. Approximately 33% (over 229,000 acres) of the GMUG's 712,000 acres of aspen vegetation was affected from 2000 to 2010. In 2009, the detection of new areas dropped considerably, and little new area has been mapped since then. However, stands currently exhibiting SAD continue to decline.

Furthermore, these disturbances are occurring in the context of a changing climate. Over the past 100 years, Southwestern Colorado temperatures have increased, and modeled climate projections for the region include warmer and longer frost-free summers, snowline moving up in elevation, earlier snowmelt, and consequently, a longer fire season.

Due to predicted warming, spruce beetle outbreaks could be more likely in the future. Higher summer temperatures can foster spruce beetle outbreaks by allowing beetles to reproduce every year rather than every two years (Bentz et al. 2010). Additionally, anticipated more frequent drought conditions place water-stressed stands at greater risk of insect and disease.

Climate changes could lead to larger fires and possibly fire with more high-severity area than in previous decades (Westerling et al. 2006, Agee 2007, Funk 2012). Modeled climate scenarios for the Gunnison Basin by 2035 indicate potential for the fire season to increase by one month; for fire frequency in high-elevation forests to increase from 4 to 12 times as often as experienced between 1971-2000; and for fire extent to increase from 6 to 11 times the extent burned between 1971-2000. These scenarios model severity and frequency irrespective of tree mortality (Rangwala and Rondeau, *Southwest Colorado Social-Ecological Climate Resilience (SECR) Project*).

The GMUG forest managers have developed the SBEADMR alternatives with the help of the public, partners, scientists and resource specialists to treat areas impacted by – and likely to be impacted by – insects and diseases in spruce and aspen forested ecotypes. The following sections contain a detailed description of the existing vegetation conditions in spruce-fir and aspen on the GMUG, the spruce beetle and SAD epidemics, and how changing climate impacts these species.

Spruce

Engelmann spruce (*Picea engelmannii*) is an important species in the Southern Rockies. Engelmann spruce has value not only as timber, but also through the jobs and labor income connected to the harvesting of that value. The spruce-fir forests of the Southern Rockies provide "shade and shelter that help to maintain the winter snow pack and prevent quick runoff during the spring melt and summer storms" (Western Bark Beetle Strategy). Additionally, spruce-fir forests provide recreational opportunities to hikers, hunters, mountain bikers, campers, four-wheelers and skiers as well as outstanding scenic views. Engelmann spruce and subalpine fir on the GMUG serves as valuable habitat for the Canada lynx, a federally listed endangered species, plus several other species which are either endangered, threatened or under consideration of being protected. Additionally, spruce-fir stands also provide habitat for the main prey species of lynx (snowshoe hares) and its secondary prey item, red squirrel.

A detailed description of existing vegetation types for the five geographic areas encompassing the GMUG are available in comprehensive assessments completed in 2006 (USDA Forest Service, 2006e). Geographic areas (GA) are the Gunnison Basin, Uncompahgre Plateau, San Juan Mountains, Grand Mesa and the North Fork of the Gunnison River (See Figure 6).

Habitat structural stages at the time of the assessment (2006) for spruce-fir for each geographic area are presented in Table 1. Data used to complete the assessment has had only minor adjustments since 2006. Overall, spruce-fir was dominated by mature and dense stand conditions (4B and 4C) across all GA. Where age data existed, most spruce-fir ranged in age from 100-200 years old. The highest percentage (>80%) of stands in a mature condition existed on the Grand Mesa, San Juan Mountains and the Uncompahgre Plateau. However, more than 50% of spruce-fir stands were in a mature condition for each of the GAs on the GMUG. Note that acres affected by beetles since 2006 are not reflected in this data. The following section, Spruce Beetles and Spruce Mortality, concludes with a discussion of how the GMUG spruce beetle epidemic has shifted the habitat structural stages.

Table 1. Spruce-Fir Vegetation Characterization for the GMUG by Geographic Area, 2006.

GA	**Cover Type**	**Composition of GA** (% is of GA)	**Age Distribution**	**Habitat Structural Stages**[1]	**Canopy Conditions**
Gunnison Basin	Spruce-fir	354,300 acres (25%)	Most spruce-fir is between 120 to 200 years.	3A - 7% 3B – 20% 3C – 2% 4A- 10% 4B – 42% 4C – 19%	21% single-storied 79% multi-storied 98% continuous canopy
Grand Mesa	Spruce-fir	93,300 acres (26%) (58% without aspen in species mix, 42% with aspen in the species mix)	Ranges from 10 to 210 years. Most spruce-fir is between 100-160 yr. old	3A – 1% 3B – 5% 3C – 1% 4A – 7% 4B- 41% 4C- 46%	34% - single-storied 71% - multi-storied 97% - continuous canopies
San Juan Mountains	Spruce-fir	135,900 acres (36%)	Age data not available	3A -5% 3B- 4% 3C-<1% 4A- 10% 4B – 50% 4C- 31%	85% - single-storied 15% - multi-storied 79% - continuous canopies
North Fork Gunnison River	Spruce-fir	121,800 acres (23%)	Age data not available	3A – 5% 3B – 14% 3C – 2% 4A – 13% 4B – 38% 4C- 27%	28% - single-storied 72% - multi-storied 99% - continuous canopies
Uncompahgre Plateau	Spruce-fir	43,100 acres (7%)	Most spruce is between 80–140 yr. old Most subalpine fir is between 40-120 yr. old.	3A – 1% 3B- 7% 3C – 3% 4A – 4% 4B -47% 4C- 37%	54% - single-storied 46% - multi-storied 92% - continuous canopies

GA	Cover Type	Composition of GA (% is of GA)	Age Distribution	Habitat Structural Stages[1]	Canopy Conditions

[1]Habitat Structural Stage	Size Class	Diameter	Crown Cover Percent
1T/1M	Grass-Forb	Not applicable	0 – 10%
2T/2S	Shrub-Seedling	< 1 inch	0 - 10%
3A	Sapling-Pole	1 – 9 inches	11 – 40%
3B	Sapling-Pole	1 – 9 inches	41 - 70%
3C	Sapling-Pole	1 – 9 inches	71 - 100%
4A	Mature	9+ inches	11 – 40%
4B*	Mature	9+ inches	41 - 70%
4C*	Mature	9+ inches	71 – 100%

**These structural stages are considered most susceptible to spruce beetle infestation.*

To evaluate how current conditions compare to historic ranges, the 2006 assessments on the GMUG used the Vegetation Dynamics Development Tool (VDDT). Current knowledge on disturbance intervals and succession pathways were used to build models for the timber, woodland, and some shrub PNV types on the GMUG. Current conditions were then compared to model results to see where departures exist (Table 2). Generally speaking, the spruce-fir cover type was dominated by late-mid and late seral stages as compared to modeled PNV. The natural and human disturbance histories for the different geographic areas were reflected in the current conditions as of 2006. Areas with more recent activities/disturbances had higher percentages in the earlier seral stages. Areas where disturbance regimes had been interrupted (i.e., fire suppression) tended to have higher percentages in the later seral stages, typically much higher than would have occurred historically when disturbances were not suppressed. Note that changes due to spruce beetle activity since 2006 are not reflected in this data.

Table 2. Succession (Seral Stages) in Spruce-fir and Spruce-fir Aspen PNV Types by GA, 2006.

Spruce-Fir PNV	Early Seral	Early-Mid Seral	Late-Mid-Seral*	Late Seral*
VDDT Model - PNV	*27-32%*	*20-24%*	*12-13%*	*31-40%*
Existing Vegetation Condition				
Grand Mesa	8%	40%	52%*	
Gunnison Basin	5%	49%	45%*	
North Fork Valley	14%	32%	53%*	
San Juans	1%	43%	56%*	
Unc. Plateau	3%	45%	52%*	
VDDT Model - PNV	*13-19%*	*22-29%*	*13-16%*	*35-49%*
Existing Vegetation Condition				
Grand Mesa	5%	63%	32%*	
Gunnison Basin	4%	63%	33%*	

Spruce-Fir PNV	Early Seral	Early-Mid Seral	Late-Mid-Seral*	Late Seral*
North Fork Valley	6%	69%	25%*	
San Juans	1%	24%	75%*	
Unc. Plateau	3%	45%	52%*	
**These seral stages are considered most susceptible to spruce beetle infestation.*				

Spruce Beetles and Spruce Mortality

The spruce beetle (*Dendroctonus rufipennis*) is the primary disturbance agent for mature spruce trees at high elevation. On the GMUG, spruce beetles are currently infesting mostly Engelmann spruce; they prefer mature, large-diameter spruce trees, but will infest smaller trees once most of the larger trees are exhausted within a stand. The spruce beetle outbreaks are a natural event that eventually lead to the death of old stands and the initiation of new stands; however, warmer winters in recent years have allowed a larger number of beetles to survive. Substantial wind throw events in 2011 and 2012 created prime breeding habitat for spruce beetles, exacerbating the problem. Consequently, the beetle flight (when new adult beetles emerge from the dead tree) in recent summers has been the largest witnessed by entomologists in decades (USDA Forest Service 2013d, Forest Health Protection).

Once attacked by beetles, most trees typically die and eventually fall to the ground, adding dead and dry fuels that can increase wildfire hazard. Standing infected trees also increase the risk of wildfire; in the first two-three years of a bark beetle outbreak when dead trees still have needles, the likelihood of crown fires and ember lofting are higher. The dead needles that cling to the trees provide fuel that can ignite quickly during weather conditions conducive to fire (Page and Jenkins 2007). The short-term burst in elevated fire hazard associated with the dead needle phase poses an increased safety hazard for wildland firefighters engaged in tactical suppression of wildfires that threaten WUI and infrastructure outside WUI. Furthermore, unlike other species affected by bark beetle, spruce branches are fine enough that even when needles drop, the standing dead trees – with flammable fine branches – remain an elevated fire hazard. Though spruce-fir wildfire severity, including extent and frequency, is driven by climate, wildfire *behavior* in recently-dead spruce-fir and areas with heavy fuel loadings can create more unpredictable fire behavior that is more hazardous to manage.

Falling dead trees also have the potential to cause property damage and pose risks to human safety. Trees falling across roads and trails could block ingress/egress during emergency operations, such as during wildfire suppression operations. Falling tree hazards continue to increase the longer dead trees remain standing. In WUI areas, fuel treatments can increase defensible space and provide safe locations from which firefighters can initiate fire management actions.

Beetle outbreaks commonly occur following windthrow events. Several current spruce beetle activity centers on the GMUG are known to have been initiated by windthrow. These types of events are referred to as “eruptive” because beetles are produced locally in response to on-site conditions (e.g. blow-down of trees creating ideal habitat for beetles). Eruptive populations typically result in patchy mortality and infestation is at a much slower rate. Beetle activity on the Grand Mesa is currently operating as an eruptive population. Other spruce beetle activity centers have apparently originated from the beetles themselves dispersing during wind events. Sustained dry, windy weather over the past ten years has contributed to the epidemic (Pielke et al. 2005, Worrall et al. 2013, Worrall and Rehfeldt 2013). In these types of events, beetle populations are referred to as “inundative” because beetles are emigrating en masse from other locations. Inundative populations typically result in much higher tree mortality as seen on the southern-end of the Gunnison Ranger District. Tree ring records and recent weather data indicate that the past decade has been the hottest and driest in centuries (Worrall et al. 2013, Worrall and Rehfeldt 2014).

In addition, there are several documented climate trends across the western United States creating conditions conducive to beetle outbreaks:

- More precipitation in the form of rain, and less in the form of snow (Knowles et al. 2006), coupled with declining snowpack (Mote et al. 2005).
- Earlier peaks in streamflow (Stewart et al. 2005). This can already be seen in recent streamflow records set in the last few years in the area below the GMUG.
- Earlier spring onset (Cayan et al. 2001).

These climate patterns, together with disturbance such as windthrow and vast areas of susceptible forest, are supporting huge outbreaks across the landscape.

Each year the USDA Forest Service and the Colorado State Forest Service work collectively to aerially monitor insect and disease caused tree mortality or damage across all ownerships of Colorado’s forested land. From 2002-2009, spruce beetle damage averaged in the range of 50,000 to 100,000 acres annually. The 2014 aerial forest health survey highlights revealed that the number of acres damaged has increased dramatically, rising to 485,000 acres statewide, an increase of 232,000 new acres. Spruce beetle expansion on the Gunnison National Forest alone was 54,000 new acres affected on 79,000 active acres (USDA Forest Service 2014d, Forest Health Protection), rising to a cumulative total of 223,000 affected acres to-date, or approximately 30% of the total spruce-fir vegetation on the GMUG. This increase in activity is indicative of a rapidly expanding outbreak. Based upon patterns of bark beetle kill that have occurred on adjacent Forests, continued and rapidly increasing mortality can be expected (Worrall et al. 2013, Worrall and Rehfeldt 2013).

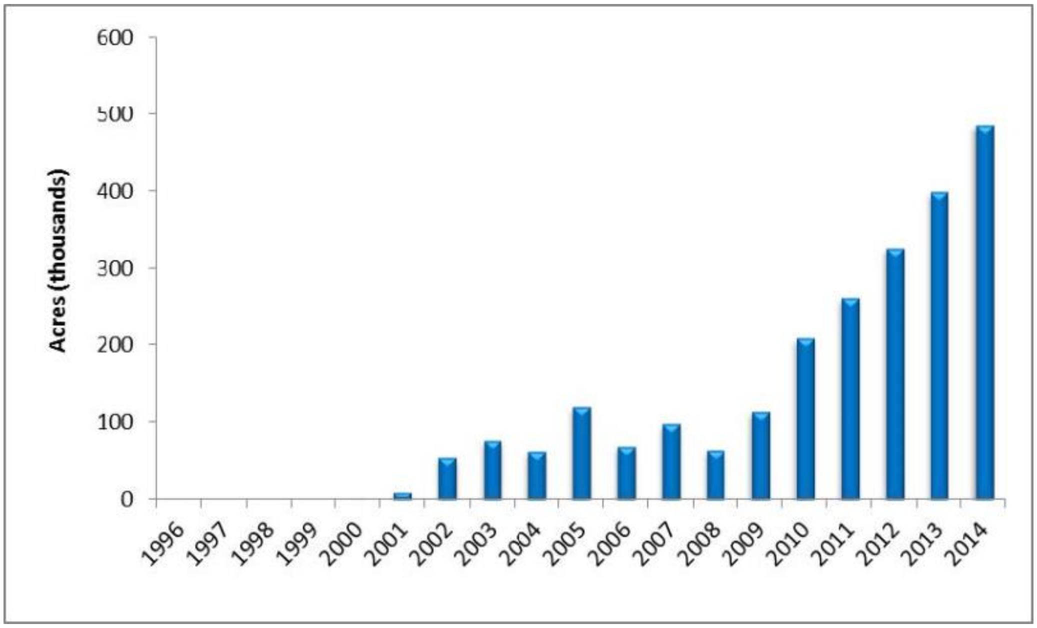

Figure 1. Annual acres affected by spruce beetle in Colorado (USDA Forest Service 2014d, Forest Health Protection).

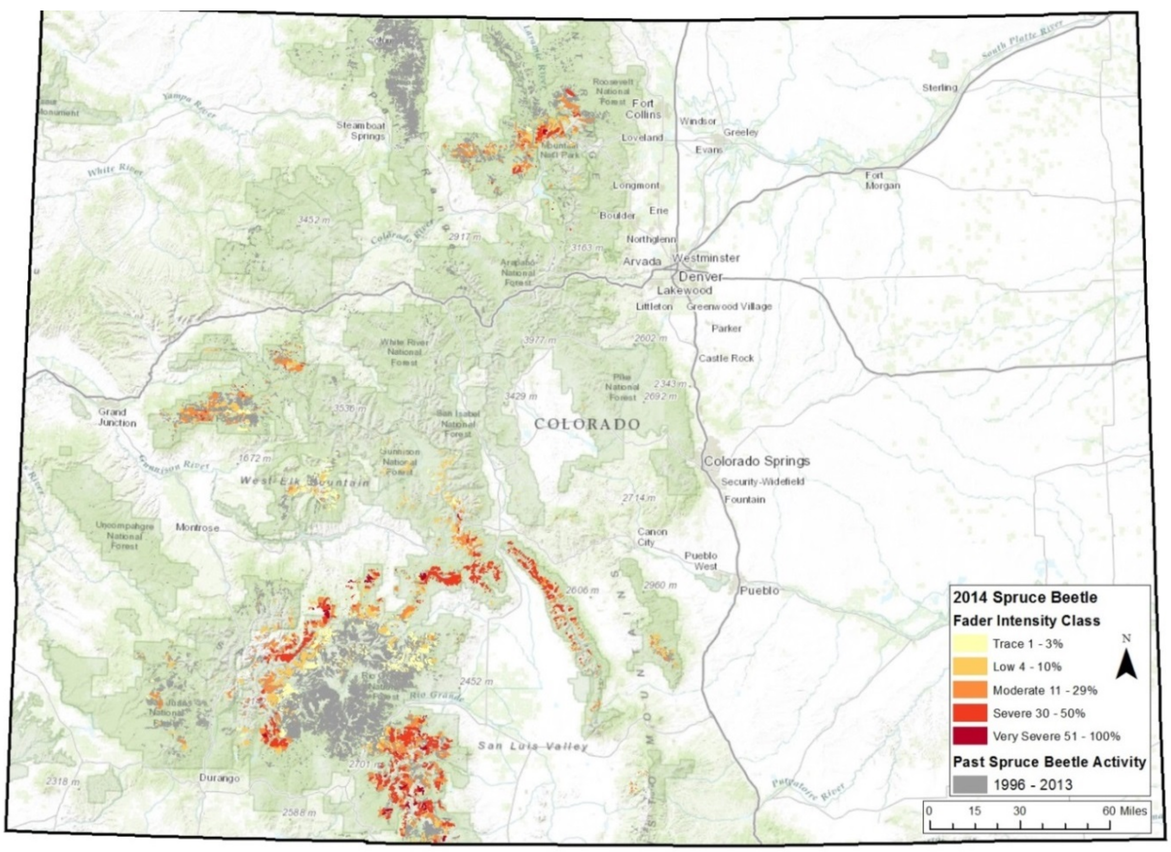

Figure 2. Spruce beetle activity in Colorado 1996-2014 (USDA Forest Service 2014d, Forest Health Protection).

Generally trees down to 8 inch dbh and in some cases smaller trees are being affected (Eager, pers. comm). Most (>90%) of mature over-story trees are dying from beetle infestation in affected areas, usually within 18 months to 2 years. Regeneration of the understory can be extensive in some instances and lacking in others. Where regeneration occurs, the stand is shifted from mature (habitat structural stage 4B and 4C) to shrub-seedling (habitat structural stage 2T/2S) or sapling pole (habitat structural stage 3A).

Effects of Climate Change on Engelmann Spruce

The warming trend on the GMUG is expected to continue, with temperatures increasing 5.4 F to 7.0 F by the years 2040 – 2060 (Mearns and Barsugli, 2009). Although there has been no major trend in the Gunnison River stream flow over the past 60 years, there has been a trend toward earlier snowmelt and peak stream flow, leading to a longer growing season, which in turn increases the demand for water needed for healthy forests. Projections for annual precipitation range from a 10% decrease to no change. Most research for mid-latitude locations indicates the greatest temperature change should be at high elevations, where spruce-fir forests tend to occur. Even with no change in precipitation, the longer, warmer summers could lead to severe moisture stress. In order to explore effective methods of forest management under changing climatic conditions, a bioclimatic model created by Rehfeldt, et al. (2006) was used to project changes in climatic suitability for spruce in the western United States. Results projected a 47% drop in suitable spruce habitat in the decade around 2060, and a 72% loss of spruce habitat by 2090. Only 23% of habitat was expected to persist in place through 2100 (Rehfeldt, et. al 2006).

For application on the GMUG, the bioclimatic model was rebuilt using local data, more topographical predictors, newer global climate models (GCMs) and carbon scenarios, and higher-resolution climate data (Rehfeldt et al. 2015). The decade surrounding 2060 was selected as the target timeframe. Projections are an average of those from three GCMs and three greenhouse gas emission scenarios.

Habitat for spruce was classified into the following four zones, using the decade 2060 as the target timeframe:

- Lost Habitat – future climate is so unfavorable that spruce is unlikely to survive the century.
- Threatened Habitat – future climate will be unfavorable, but climate-based seed transfer guidelines and low basal areas may allow spruce to persist.
- Persistent Habitat – future climate is expected to be minimally favorable to favorable, through 2060.
- Emergent Habitat – Future climate is expected to be suitable to spruce; these areas are currently outside spruce habitat.

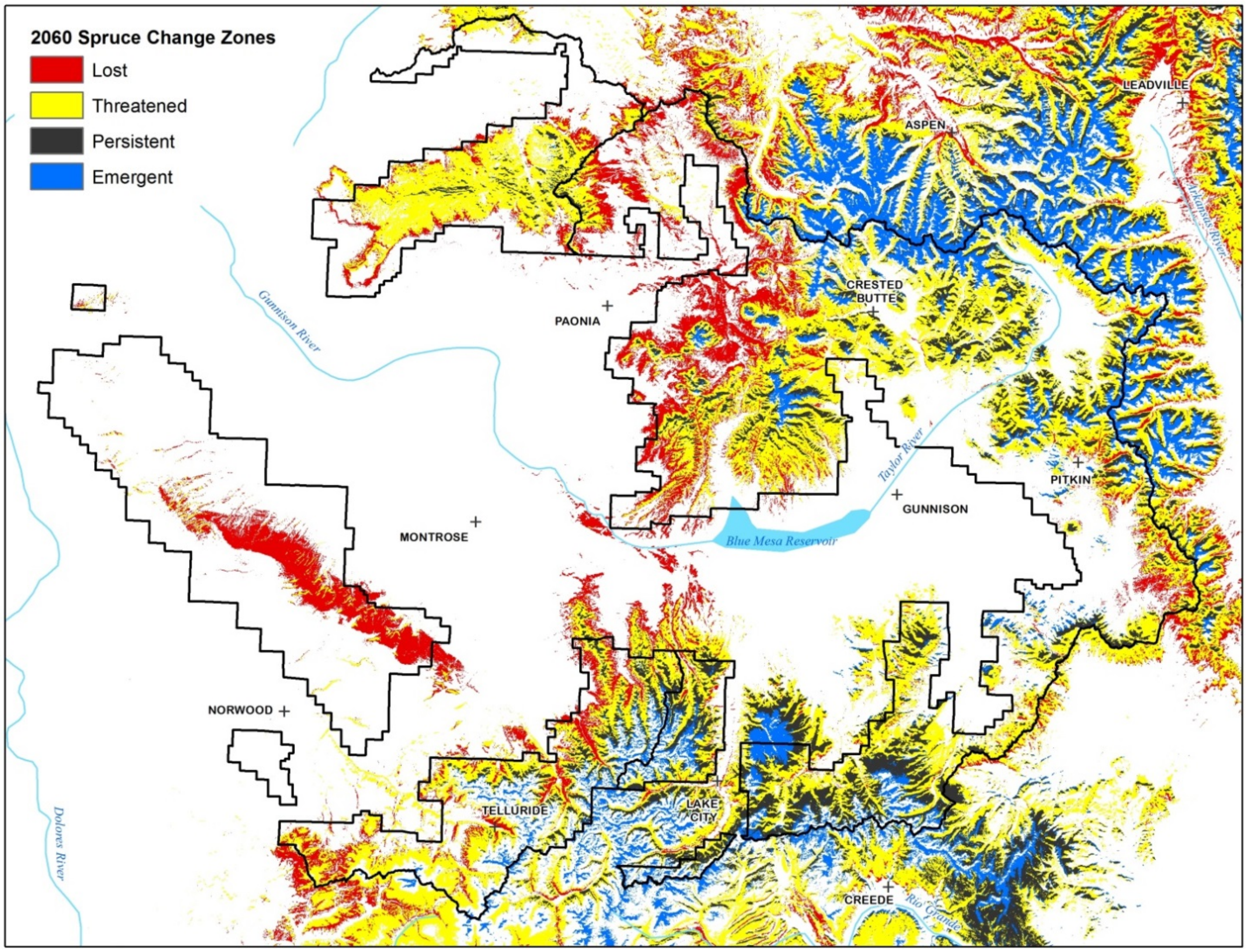

Figure 3. Future climatic habitat zones of Engelmann spruce.

The Rehfeldt (2015) model (Figure 3) projects little remaining habitat for spruce on the Uncompahgre Plateau, and substantial loss in the West Elk Mountains, east of Grand Mesa, and south of the Black Canyon/Blue Mesa Reservoir. Much of the Grand Mesa and low elevations elsewhere are in the threatened zone. Increases in suitability (emergent habitat) are expected in high elevations in the eastern part of the GMUG. About 22% of the current spruce distribution is classified as lost and 58% is classified as threatened, meaning that it is conceivable that 80% of current spruce distribution may not continue into the next century. Projected rates of climate change are faster than the response rate of natural systems (Davis, Shaw, and Etterson, 2005). Thus, if no forest management action is taken, it will most likely result in the gradual conversion of spruce forests in “lost” and threatened zones to other forest and non-forest cover types (Rehfeldt, et al., 2015).

Aspen

Aspen is an important component of GMUG’s forests. Over 712,000 acres of aspen-dominated forest type occur across the GMUG.

Aspen is a unique and important tree species in western North America, where aspen is the most diverse upland forest type. Of roughly 1,669 species of wood-decay fungi tallied in North America, Gilbertson (1980) noted 260 on aspen, more than on any other tree species, many of which are specialized on aspen. Bird species richness and total abundance are higher in aspen stands than in other North American montane habitats (e.g., Turchi *et al.* 1995), and many species show strong preferences for aspen trees or forests for nesting habitat (Flack 1976). Aspen modifies soil properties and microclimate in ways that foster luxuriant growth of varying herb and shrub layers, and are therefore major contributors to plant species diversity (Kuhn *et al.* 2011, Mueggler 1985). Aspen improves streamflow and habitat for plants and animals by improving water movement. Results of modeling based on rates of water movement by season in various tree species suggested significantly greater water yield from aspen than from conifer forests (Gifford *et al.* 1984). The importance of aspen communities to large ungulates such as elk is well known, and in dry forest ecosystems, patches of aspen are also hotspots of diversity for small mammals (Oaten & Larsen 2008). Thus, aspen is truly a keystone species, and as such its loss leads to substantial alteration of habitat conditions and loss of species diversity.

In addition, aspen forests have significant economic value based on tourism and fiber production. Esthetically, aspen contribute a major share of Colorado's scenic beauty. Tourism is the second largest industry in Colorado, with tourists spending $17 billion in the state in 2012 (Tourism Pays, Denver Convention and Visitor Bureau). The properties of aspen wood make it valuable for paneling, oriented strandboard, excelsior and chips (used in erosion control and oil-spill cleanup), all of which are or were produced in southwestern Colorado.

Finally, aspen forests, like other forest types, store considerable carbon in above- and below-ground biomass (and especially for aspen, in the soil). As aspen stands mature and regenerate, there is a cycle of carbon release and sequestration with a high net storage of carbon. If aspen forests are replaced by shrub or meadow communities with lower carbon storage capacities, the difference will contribute to atmospheric CO_2. Aspen mortality episodes in the aspen parkland of Alberta and Saskatchewan and in southwestern Colorado are expected to result in significant carbon release and positive feedbacks to climate change (Huang & Anderegg 2012, Michaelian *et al.* 2011).

Habitat structural stages for the aspen cover type for each geographic area on the GMUG, as assessed in 2006, are presented in Table 3 (USDA Forest Service, 2006e). Overall, aspen was dominated by mature and dense stand conditions (4B and 4C) across all GA. Where age data existed, most aspen ranged from 80 to 120 years old. The highest percentage (>70%) of stands in a mature condition existed on the Grand Mesa, San Juan Mountains and the Uncompahgre Plateau. The following section, *Sudden Aspen Decline (SAD)*, concludes with a discussion of how sudden aspen decline on the GMUG has shifted structural stages.

Table 3. Current Aspen Vegetation Characterization for GMUG by Geographic Area, 2006.

GA	Cover Type	Composition of GA	Age Distribution	Habitat Structural Stages[1]	Canopy Conditions
Gunnison Basin	Aspen	197,500 acres (14%)	Most aspen is between 80 to 120 years old.	3A - 9% 3B – 34% 3C – 10% 4A- 5% 4B – 22% 4C – 21%	26% single-storied 74% multi-storied 96% continuous canopy
Grand Mesa	Aspen	94,500 acres (26%) (60% pure aspen, 39% with spruce-fir in species mix, 1% with other tree species in mix)	Ranges from 16 to 131 years. Most aspen is between 80-120 yr. old.	2T- 2% 3A – 2% 3B- 10% 3C- 3% 4A – 1% 4B- 28% 4C- 54%	27% - single-storied 73% - multi-storied 98% - continuous canopies
San Juan Mountains	Aspen	76,200 acres 20%.	Age data not available	3A – 9% 3B – 12% 3C – 1% 4A – 4% 4B – 71% 4C – 3%	82% - single-storied 18% - multi-storied 71% - continuous canopies
North Fork Gunnison River	Aspen	212,600 acres 40%.	Age data not available	2T - <1% 3A – 7% 3B – 41% 3C – 6% 4A – 3% 4B – 16% 4C- 26%	40% - single-storied 60% - multi-storied 99% - continuous canopies
Uncompahgre Plateau	Aspen	160,100 acres 25% of NFS lands 4% of total GA 71% of aspen is on NFS land.	Most aspen is between 80-120 yr. old.	2T – 1% 3A – 9% 3B – 25% 3C- 3% 4A – 2% 4B – 44% 4C – 16%	65% - single-storied 35% - multi-storied 86% - continuous canopies

[1]Habitat Structural Stage	Size Class	Diameter	Crown Cover Percent
1T/1M	Grass-Forb	Not applicable	0 – 10%
2T/2S	Shrub-Seedling	< 1 inch	0 - 10%
3A	Sapling-Pole	1 – 9 inches	11 – 40%
3B	Sapling-Pole	1 – 9 inches	41 - 70%
3C	Sapling-Pole	1 – 9 inches	71 - 100%
4A	Mature	9+ inches	11 – 40%
4B	Mature	9+ inches	41 - 70%
4C	Mature	9+ inches	71 - 100%

Generally speaking, the aspen cover type was dominated by late-mid and late seral stages as compared to modeled PNV (Table 4; USDA Forest Service, 2006e).

Table 4. Succession (Seral Stages) in Aspen PNV Types by GA, 2006.

Aspen PNV	**Early Seral**	**Early-Mid Seral**	**Late-Mid-Seral**	**Late**
VDDT Model - PNV	*8-14%*	*23-26%*	*17-24%*	*23-43%*
Existing Vegetation Condition				
Grand Mesa	3%	15%	82%*	
Gunnison Basin	6%	43%	50%*	
North Fork Valley	5%	58%	36%*	
San Juans	4%	25%	72%*	
Unc. Plateau	13%	41%	46%*	

Sudden Aspen Decline (SAD)

SAD was first noticed in southwestern Colorado in 2004 (Worrall *et al.* 2008). On the San Juan National Forest, large and growing patches of crown thinning, branch dieback, and mortality were found. It occurred on a landscape scale and rapidly increased in area and severity. Over the next few years, SAD spread to the Uncompahgre Plateau, the Grand Mesa, and the Gunnison River basin. Aspen throughout Colorado was affected. In 2008, 543,630 acres were affected in Colorado (Worrall *et al.* 2010). About 45% of that area was rated as “severe,” indicating estimated mortality over 50% of the overstory.

From 2000-2010, 1,322,000 acres were impacted by SAD in the Southern Rockies ecoregion, with 1,216,000 acres in Colorado (an estimated 17% of the aspen cover type in the state) (Worrall *et al.* 2013). The GMUG was affected more severely, with approximately 31% (over 229,000 acres) of the GMUG’s aspen affected from 2000 to 2010. In 2009, the detection of new areas dropped considerably, with few new areas mapped since that time. However, stands currently exhibiting SAD continue to decline, so aspen mortality continues.

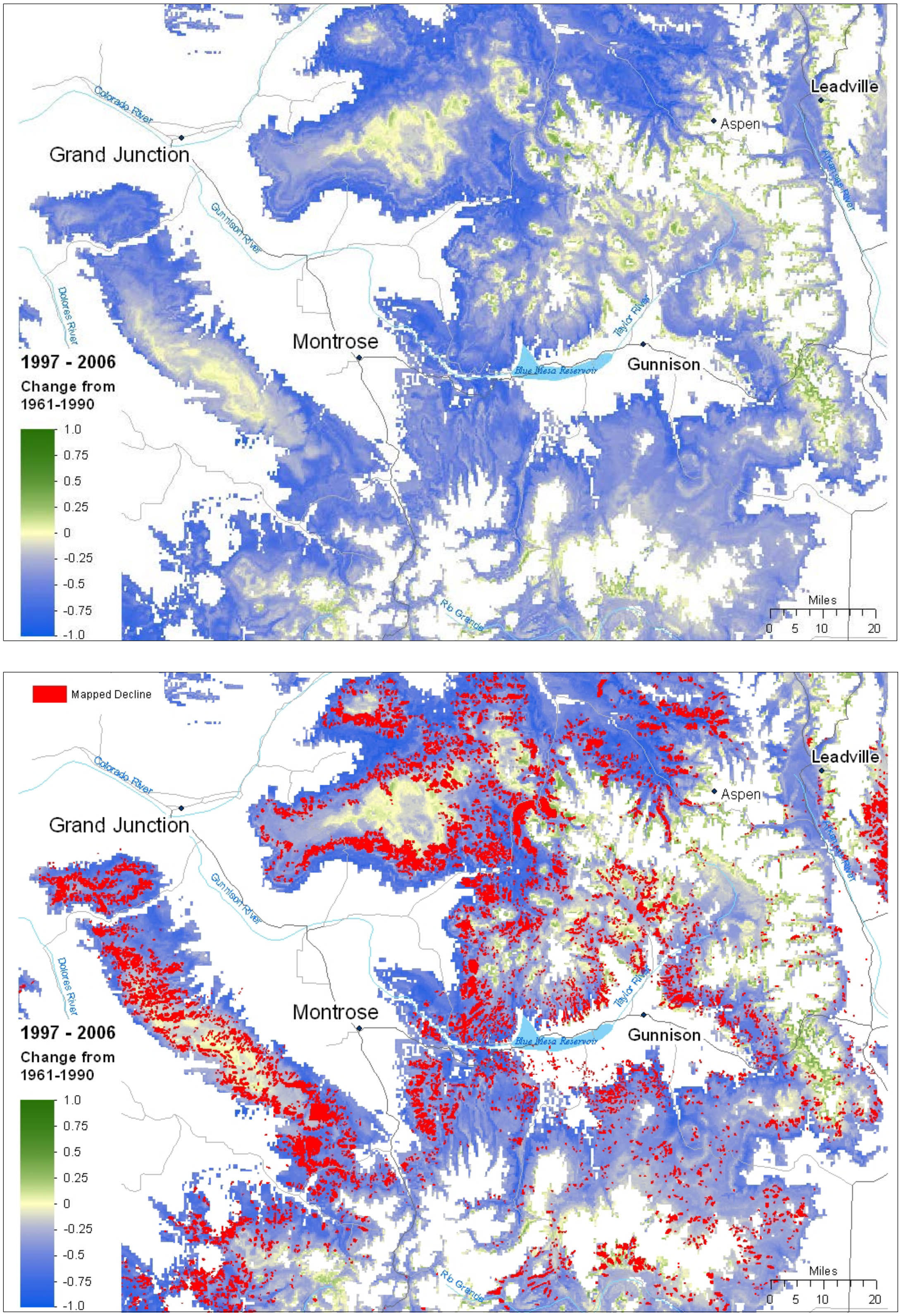

Figure 4. Change in climatic suitability for aspen (top) and overlying mapped aspen decline (bottom) (Worrall et al. 2013).

In Figure 4, the top map and underlying layer of bottom map indicates change in climatic suitability for aspen between the reference period, 1961-1990, and the decade preceding and accompanying the recent episode of SAD, 1997-2006 (provided by Andreas Hamann, Univ. Alberta). Blue indicates decrease in suitability; green an increase. SAD tended to occur where climate suitability decreased (blue areas do not necessarily have significant aspen). The mapped decline of aspen, show in red on the bottom map, is from aerial survey data gathered 2000-2010.

Although the cause of SAD was initially unknown, examinations of outbreaks found a link between moisture stress and SAD. Damage was highest at low elevations, where temperature is high and precipitation is low (Dudley 2011, Worrall *et al.* 2008). Damage tended to be high on south and west-facing slopes and on the shoulders and summits of slopes (Huang & Anderegg 2012, Worrall *et al.* 2008). Southwestern Colorado had a drying trend from the mid-1980s to 2002, culminating in a record drought in much of Colorado (Pielke *et al.* 2005). In 2002, areas with SAD had lower values of climate moisture index than did aspen areas that remained healthy (Worrall *et al.* 2010). Various moisture indices showed that the area underwent a protracted, severe moisture deficit (Worrall *et al.* 2013). Climatic suitability for aspen generally decreased around the time of SAD, and SAD tended to occur in marginal sites where suitability decreased the most (Figure 4).

While the evidence that severe, warm drought incited SAD was clear, a broader view gives a more comprehensive concept of the cause. Stand conditions, especially low density and openness, may have also predisposed stands to damage. Aspen bark beetles, bronze poplar borer, poplar borer, and Cytospora canker killed trees that had been stressed by drought (Marchetti *et al.* 2011). Thus, the predisposing and contributing factors played important roles, in addition to the inciting factor, drought.

A ground survey in 2007 and 2008 sampled the entire GMUG and the Mancos-Dolores Ranger District of the San Juan National Forest (Worrall *et al.* 2010). Areas identified as SAD by aerial survey had an average 54% recent crown loss and 45% mortality. SAD plots had higher root mortality than healthy plots (Worrall *et al.* 2010), and regeneration counts showed no evidence of increased suckering in response to the overstory damage (Dudley 2011, Worrall *et al.* 2010). Some patches of aspen at the lower-elevation fringe were completely dead with no regeneration. Remote sensing over 2009-2011 suggested that 30% of the total aboveground aspen biomass was dead in a large section of southwestern Colorado, with the resulting carbon emissions expected to provide an amplifying feedback to climate change (Huang & Anderegg 2012).

Approximately 54%% of the stands on the GMUG are experiencing regeneration, shifting the stand to a younger age class. Approximately 46% of the affected stands have limited (<120 stems/acre) or no regeneration.

SAD vs. "Aspen Decline"

As described, sudden aspen decline is a rapid, landscape-scale deterioration of overstory aspen incited primarily by drought and warm temperatures. It is often confused with an older concept of "aspen decline". The latter refers to a long-term (over many decades) decrease in the area of aspen due primarily to succession (Bartos 2001, Bartos & Campbell 1998). Factors that have been suggested to lead to it include a large increase in aspen associated with fires during the time of European settlement, subsequent fire exclusion, and overgrazing (Bartos & Campbell 1998, Kulakowski *et al.* 2004).

Effects of Climate Change on Aspen

Due to expected increases in dry weather, especially drought, more cases of SAD are expected. Suitability for aspen in the Southern Rockies is expected to deteriorate rapidly through the rest of the century. Rehfeldt's (2015) bioclimatic model (Figure 4) and studies on climatic change point to a complete loss of aspen in some lower-elevation sites and on south slopes, while at the other extreme, aspen habitat is expected to persist and newly suitable habitat may emerge at higher elevations and north slopes.

As with spruce, aspen were also classified into suitable habitat by geographic zones based on expected climatic changes (Rehfeldt *et al.* 2015) .

- Lost Habitat– future climate will be so unfavorable that aspen is unlikely to survive the century.
- Threatened Habitat– future climate will be unfavorable, but young stands will probably survive. Opportunities would exist to treat to distribute young patches on landscape and to help SAD stands recover.
- Persistent Habitat – future climate will remain suitable for aspen. No climate-change adaptation needed, but normal management may proceed. Opportunities would exist to promote existing aspen near emergent habitat.
- Emergent Habitat – future climate will become suitable; areas are currently outside distribution. Opportunites to facilitate migration into this zone would exist, via allowing or creating disturbance (mechanical and/or fire).

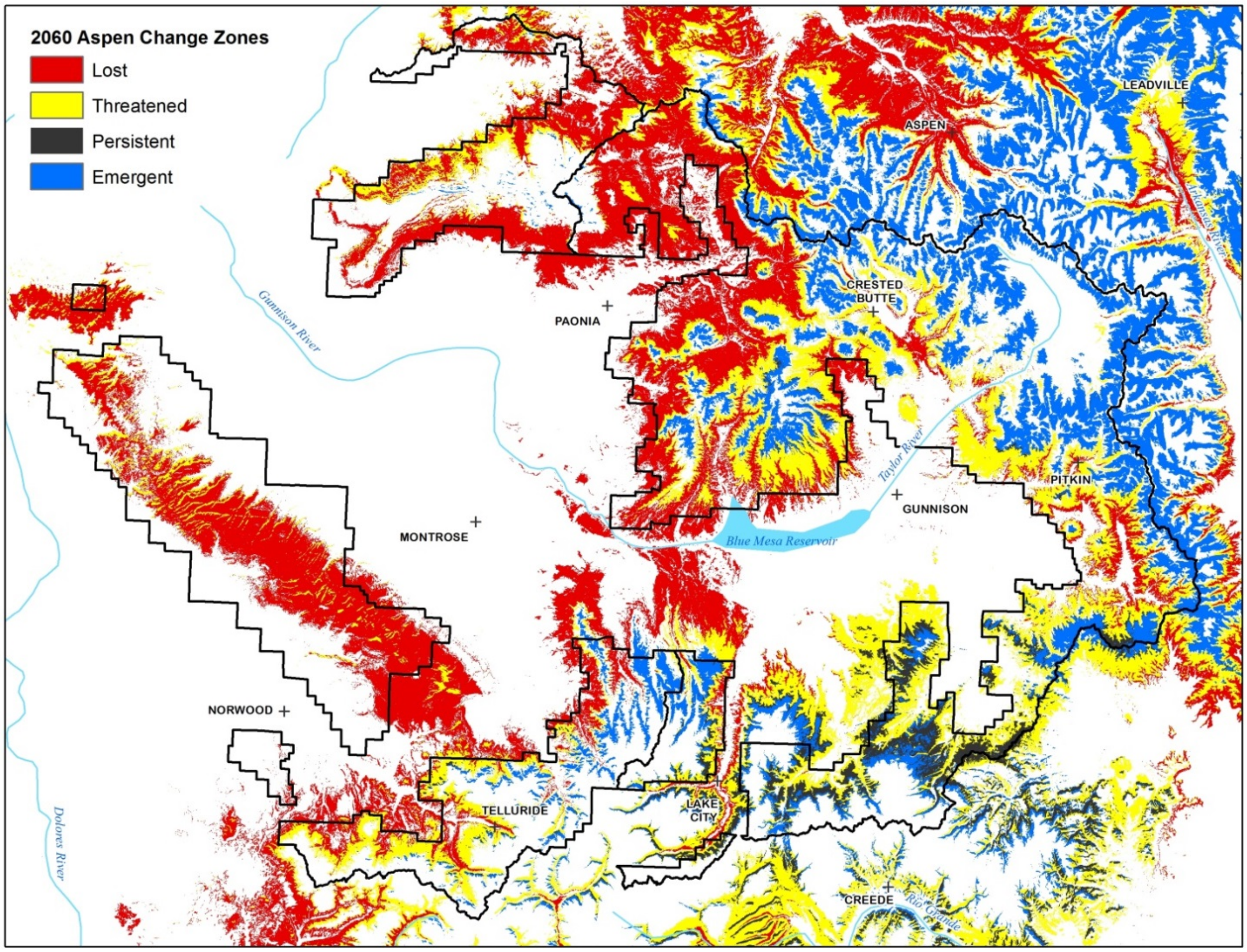

Figure 5. Future habitat zones of aspen.

Results of the bioclimatic model show that 52% of the current aspen distribution on the GMUG is in the lost category and 42% is in the threatened category, meaning it is conceivable that 94% of current aspen distribution may not continue into the next century (Figure 5). In general, habitat will be lost at low elevations, especially on south aspects, while new habitat will emerge at elevations above the current distribution of aspen. Little suitable habitat is expected to remain on the Uncompahgre Plateau, the southern and eastern fringes of the Grand Mesa, and the western West Elks. The remainder is largely threatened, as persistent habitat is mostly limited to the southeastern portion of the GMUG. However, there are substantial areas of Emergent habitat in the higher elevations.

The following tactics have proven effective for aspen management:

1. Aspen stands dying from SAD can be regenerated when less than 50% of the stand has been affected. Stands can be treated by removing overstory through coppice cuts and prescribed fire.

2. Young stands of less than 40 years old have been found to be more resilient to drought; ensuring that there are significant patches of aspen under 40 years old will increase resilience of aspen clones.
3. Preparing a seed source and seedbed can facilitate aspen migration into newly suitable habitat.

The following strategy for aspen management is recommended by Worrall, et al. (2014) to employ the climate change projections:

1. **Resilience**: regenerate patches of mature aspen, or mixed stands with an aspen component in threatened habitat zone to increase younger component on the landscape.
2. **Recovery**: Treat previously affected SAD stands to aid recovery and regeneration, but treatments in the "lost" zone may not be durable.
3. **Migration**: Conduct treatments and/or allow natural disturbances to proceed in the persistent and emergent habitat zones in order to facilitate self-migration of aspen.

During extreme climate periods causing new SAD episodes, it may be necessary to prioritize resilience treatments in new SAD patches before canopy loss reaches 50%. Such treatments should also concentrate on the threatened habitat zone.

It should be recognized that while the bioclimatic model is quite effective at replicating the distribution of spruce and aspen at large scales, at smaller scales, errors of omission (predicting absence where spruce/aspen occur) and errors of commission (predicting presence where no spruce/aspen occurs) can be seen. Climate projections are based on a representative carbon pathway that may not represent the actual future trend in greenhouse gasses. For example, conditions projected for 2060 could occur sooner if emissions are higher than projected or later if they are lower. For these reasons, although boundaries between future habitat zones are mapped as though precise, ideally they should be regarded as a best estimate and the timing of projected changes as likely but uncertain.

Project Area

The Spruce Beetle Epidemic and Aspen Decline Management Response project (SBEADMR) includes stands affected by the spruce beetle epidemic and sudden aspen decline, including those that are considered threatened or at high risk. The area covered by this project includes spruce, aspen, and spruce/aspen mix on National Forest System (NFS) lands within the GMUG, excluding designated Wilderness Areas, Roadless Areas, or are designated as a special area (Research Natural Areas, Botanical Areas, etc.). Consistent with previous Forest-wide planning efforts, the SBEADMR FEIS divides the GMUG Forests into distinct Geographic Areas (GAs; see **Error! Reference source not found.**). Throughout the FEIS, proposed actions are summarized and depicted by GA in order to provide more context both for analysis and for the interested public.