SPRUCE BEETLE EPIDEMIC-ASPEN DECLINE MANAGEMENT RESPONSE PROJECT (SBEADMR) SCIENCE TEAM MONITORING QUESTIONS, RESULTS, AND INTERPRETATION
GRAND MESA, UNCOMPAHGRE, AND GUNNISON NATIONAL FOREST

January 2022 UPDATE *(New information is highlighted below)*

## 1. Impacts of spruce bark beetle and subsequent salvage in Engelmann spruce and Engelmann spruce-aspen forests of the Gunnison National Forest on forest structure and tree regeneration

**Lead: Battaglia**

**Years Measured: 2015, 2016, 2017, 2018, 2019, 2020**

| *Ongoing Monitoring* | | | |
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| **Question** | **Indicators/Methods** | **Current Findings** | **Science Team Interpretation** |
| a. Did unmanaged and previously managed stands respond differently to the spruce beetle epidemic? | 1) Tree density<br>2) Stand Basal Area<br>3) Species Composition<br>4) Seedling regeneration density | **SPRUCE STANDS**<br>• Spruce beetle induced tree mortality was similar among the previously managed and unmanaged stands<br>• Average Live Trees per acre for unmanaged and previously managed stands about 383 to 472<br>• Average Live Basal Area for unmanaged and previously managed stands about 26 to 28 ft2/ac<br>• Live trees are dominated by sizes less than 4 inch dbh<br>• Previously managed stands have significantly more seedlings (<dbh) than the unmanaged stands.<br>• 4 to 7% of live trees are cull<br>• Species composition dominated by Engelmann spruce<br>**SPRUCE-ASPEN STANDS**<br>• Spruce beetle induced tree mortality was similar among the previously managed and unmanaged stands<br>• Average Live Basal Area for unmanaged and previously managed stands about 78 to 79 ft2/ac<br>• Previously managed stands have twice as many live trees per acre than unmanaged stands (1104 vs 517)<br>• Live spruce trees are dominated by sizes less than 4 inch dbh<br>• Live aspen trees now dominate the overstory<br>• No difference in the amount of seedling regeneration (<dbh); 3106 to 3627 per acre | In spruce dominated stands, both unmanaged and previously managed areas had similar high rates of overstory mortality. This suggests that the shelterwood cuts in the 1990s didn't help the trees resist the beetle outbreak. However, these earlier treatments did aid in establishing spruce regeneration in the 1990s, allowing for these areas to be ahead in stand development and now are closer to reproductive age. The unmanaged stands also responded with an increase in seedling establishment during the beetle outbreak. Furthermore, both areas had a multi-cohort forest structure (i.e. multiple tree sizes). The beetles targeted spruce trees > 4 inch dbh. This suggests that diversity in tree sizes is important to enhance resilience to spruce bark beetle.<br><br>In spruce-aspen mixed stands similar trends were observed as in the spruce dominated stands. However, there is more living basal area in these forests due to the aspen not being impacted by the spruce bark beetle. These forests are now dominated by aspen in the overstory. Areas that were previously managed in the 1990s have twice as many live trees per acre with a mix of spruce and aspen. Both areas had a multi-cohort forest structure (i.e. multiple tree sizes). The beetles targeted spruce trees > 4 inch dbh. This suggests that diversity in tree sizes is |

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| | | • Seedling regeneration is about 50:50 Aspen and Engelmann spruce<br>• 1% of live trees are cull | important to enhance resilience to spruce bark beetle. Furthermore, the diversity in tree species increased this stand type's resilience. |
| b. To what extent did salvage impact forest structure? | 1) Tree density<br>2) Stand Basal Area<br>3) Species Composition<br>4) Seedling regeneration density | **SPRUCE STANDS**<br>• Salvage substantially reduced amount of dead BA and TPA<br>• Live tree BA and TPA was reduced to 8-10 ft2/ac and 152 to 165 tpa<br>• Seedling density in salvaged units similar to unmanaged and previously managed stands<br>• Seedlings (<dbh) averaged 1228 tpa in salvaged units<br>• Seedling density in roadside salvage treatments only averaged 105 tpa<br>• Species composition dominated by Engelmann spruce<br>**SPRUCE-ASPEN STANDS**<br>• Waiting for remeasurements on Quill. Plots installed 2019 | In spruce-dominated stands, salvage reduced dead tree density substantially, reducing the amount of future coarse wood inputs. Some live trees were lost to windthrow. While density is lower than in the unmanaged and previously managed stands, salvage stands still have saplings and new regeneration densities that exceed stocking guidelines. Salvage logging activities did a good job protecting the advanced regeneration that will contribute to future stand structure. These activities should continue to protect any live trees in the stand to facilitate stand recovery. |
| c. Do unmanaged, previously managed, and salvaged stands have different survival and growth rates of the advanced regeneration after the spruce beetle epidemic and salvage? | 1) Tree Survival<br>2) Surviving Tree Growth Rates<br>(Remeasurement of tagged trees at forest inventory plots) | **SPRUCE STANDS**<br>• **Spruce overstory** (> 5in dbh) survival ranged 64% to 91%<br>• Lowest **spruce overstory** survival in salvaged stands, no difference in survival between previously managed and unmanaged stands (both 91%)<br>• No difference in **Aspen overstory** survival across treatments (92% - 100%)<br>• **Spruce sapling** (<5 in dbh) survival ranged 80% to 100%.<br>• Lowest **spruce sapling** survival in salvaged stands, no difference between previously managed and unmanaged stands (~100%)<br>• 100% **aspen sapling** survival across all treatments<br>• No difference in **spruce seedling** (<dbh) survival across all treatments (88% - 94%)<br>• Lowest **spruce survival** rates (pooled across treatments) in 0-4 inch size class (86%)<br>• No difference in **aspen seedling** survival across treatments (93% - 100%)<br>**SPRUCE-ASPEN STANDS**<br>• Caveat: still waiting for 6 plots to be harvested<br>• 100% **Spruce overstory** (> 5 in dbh) survival across all treatments<br>• 97% - 100% **Aspen overstory** survival across treatments<br>• 100% **Spruce sapling** (< 5 in dbh) across all treatments<br>• 99% to 100% **Aspen sapling** survival across all treatments<br>• 98% - 100% **Spruce seedling** (<dbh) survival in previously managed and salvaged stands, 91% survival in non-managed stands<br>• Lowest **Spruce seedling** survival rates in 0-4 inch and 4-8 inch size classes, pooled across treatments (95%) | In spruce dominated stands, spruce trees had high survival post-beetle. However, there was a decrease in survival (to 64%) for spruce in the salvage treatment, due to some windthrow and other agents. Spruce Seedling survival also remained high for the different treatments surveyed. Aspen survival across size classes remained high as well.<br><br>Preliminary results from the spruce-aspen mixed stands indicate survival is high for both spruce and aspens. However, sample sizes are still low and we will be sampling summer 2023 to increase our ability for inference.<br><br>Growth of surviving trees has not been assessed yet since we need several years of post-beetle/salvage response to fully understand the impacts. |

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| | | • 97% to 100% **Aspen seedling** survival in previously managed and salvaged stands, 83% survival in non-managed stands<br>• Lowest **Aspen seedling** survival rates in 0-4 inch and 4-8 inch size classes, pooled across treatments (~88%). | |
| e. Do unmanaged, previously managed, and salvaged stands impact snowshoe hare use after the spruce beetle epidemic and salvage? | 1) Snowshoe hare presence (pellet counts) | **SPRUCE STANDS**<br>• In 2018 Mean hare density highest in unmanaged sites (0.19 hare/ha) and previously managed sites (0.17 hare/ha)<br>• Mean hare density lowest in salvage (0.02 hare/ha)<br>• No statistical difference between treatments.<br><br>• Same trends in 2019 – highest in unmanaged (0.18 hare/ha), followed by previously managed (0.15 hare/ha), and salvaged (0.04 hare/ha)<br>• No statistical differences between treatments<br><br>• In 2020, mean hare density highest in unmanaged (0.19 hare/ha), followed by previously managed (0.13 hare/ha) and salvage (0.007 hare/ha)<br>• Salvaged sites significantly different than unmanaged ($p = 0.005$) and previously managed ($p = 0.012$) sites<br><br>**SPRUCE-ASPEN STANDS**<br>• Mean hare density in 2019 highest in unmanaged stands (0.51 hare/ha), followed by previously managed (0.10 hare/ha), and salvage (0 hare/ha)<br>• Unmanaged statistically different from salvaged ($p < 0.01$) and previously harvested ($p < 0.01$)<br>• In 2020, mean hare density highest in salvaged stands (0.27 hare/ha), followed by unmanaged stands (0.16 hare/ha), and previously managed stands (0.12 hare/ha).<br>• This differs from previous trends<br>• No statistical difference between sites | Over the past three years, monitoring of hare pellets in the Engelmann spruce dominated stands has demonstrated that snowshoe hares continue to utilize areas that were impacted by the spruce beetle. However, this past year, field data suggested that salvage areas had lower hare density. Hare pellet counts in the salvage areas were always lower in the previous years, but not significant.<br><br>In contrast to the Engelmann spruce dominated stands, areas that had a mix of Engelmann spruce and Aspen showed that initially hares favored the unmanaged and previously managed stands. However, in 2020, salvaged stands had higher hare pellet counts (I.e. higher hare use), although the variability did not detect significant differences among treatments.<br><br>Based on these variable results, exploration of options to mitigate impacts to dense horizontal cover during salvage is should be considered. It is critical to continue to steer salvage away from high-quality Canada lynx habitat. A significant outstanding question at this time is the longevity of salvage impacts on hare density and why is varies from year to year. |
| f. Do unmanaged, previously managed, and salvaged stands have different air and soil temperature after | 1) Microclimate (air and soil temperature) (temperature dataloggers) | **SPRUCE STANDS**<br>• Summer air temperatures are higher in salvaged areas<br>Earlier snowmelt in salvaged areas but with a much larger range of melt dates<br>**SPRUCE-ASPEN STANDS** | There are too few sample points at this time to have confidence that a recommendation is needed. However, if the relationship between salvage and higher temperatures is further established, exploring options to use patch attributes (e.g. shape, |

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| the spruce beetle epidemic and salvage? | | | orientation) to mitigate impacts on temperature would be recommended. |

***Completed Monitoring***

| Question | Indicators/Methods | Current Findings | Science Team Interpretation |
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| d. Do unmanaged, previously managed, and salvaged stands have different seed production rates after the spruce beetle epidemic and salvage? | Seed production (seed traps) | **SPRUCE STANDS**<br>• 28 seed traps were collected 2017 – 2018<br>• Previously managed sites averaged 7 seeds per plot, unmanaged 2 seeds per plot, and salvage <1 seed per plot in 2018.<br>  • 428 potential seed producing trees in plots (overstory and sapling, live or hit by beetles), only one greater than 11.8 in (30cm) dbh in 2018.<br><br>• Seed was collected from 10 plots (49 traps) 2018-2019<br>• Previously managed sites averaged 61 seeds per plot, unmanaged 28 seeds per plot, and salvage 33 seeds per plot in 2019<br>• No statistically significant differences between treatments in 2019<br><br>• Seed was collected from 10 plots (49 traps) 2019-2020<br>• Previously managed sites averaged 7 seeds per plot (60,984 seeds/acre), unmanaged 6.3 seeds per plot (55,177 seeds/acre), and salvage 7.3 seeds per plot (63,888 seeds/acre)<br>• No statistically significant differences between treatments in 2020<br><br>**SPRUCE-ASPEN STANDS**<br>• Seed was collected from 10 plots (50 traps) 2018-2019<br>• Previously managed sites averaged 49 seeds per plot, unmanaged 33 seeds per plot, and salvage 40 seeds per plot<br>• No statistically significant differences between treatments in 2019<br><br>• Seed was collected from 13 plots (64 traps) 2019-2020<br>• Previously managed sites averaged 15.4 seeds per plot (134,165 seeds/acre), unmanaged 20.7 seeds per plot (180,048 seeds/acre), and salvage 5.6 seeds per plot (48,787 seeds/acre).<br>No statistically significant differences between treatments in 2020 | Over the past 3 years, seed production has varied. This annual variability is to be expected as Engelmann spruce seed production is known to vary in space and time. While one year (2018 seed production year) is higher than the other two years, it is important to recognize that the treatments (unmanaged, previously harvested, and salvaged) had similar seeds per plot found. This suggests that Engelmann spruce seeds are still present and dispersing on the landscape. |

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| g. Do unmanaged, previously managed, and salvaged stands have different surface fuel loads after the spruce beetle epidemic and salvage? | Surface Fuel Loads (Brown's transects/ Litter-duff depth measurements) | **SPRUCE**<br>• Average coarse wood fuel loads between 10 to 15 tons/acre; currently not different among treatments<br>• Unmanaged and previously managed: Standing dead trees average 145 to 150 ft2/ac and 341 to 393 trees per acre (future inputs into Coarse Wood loads)<br>• Salvage: Amount of standing dead is low (i.e. future inputs minimal)<br>**SPRUCE-ASPEN**<br>• Unmanaged and Previously managed stands: Average coarse wood fuel loads between 10 to 15 tons/acre<br>• Unmanaged and Previously managed stands: Standing dead trees average 72 to 77 ft2/ac and 288 to 354 trees per acre (future inputs into Coarse Wood loads) | Current coarse wood fuel loads aren't different and are within normal ranges among the treatments. However, as dead trees begin to fall the areas that were not salvaged will have significant amounts of heavy fuel loads. |

## 2. Developing and implementing resiliency treatments in Engelmann spruce and Engelmann spruce-aspen forests of the Grand Mesa and Gunnison National Forest

### Lead: Battaglia

### Years Measured: 2020,2021

| ***Ongoing Monitoring*** | | | |
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| **Question** | **Indicators/Methods** | **Current Findings** | **Science Team Interpretation** |
| a. How do different group sizes implemented in group selection influence successful regeneration establishment and growth? | 1) Tree density<br>2) Stand Basal Area<br>3) Species Composition<br>4) Seedling regeneration density<br>5) microclimate | • In Summer 2020, we measured the pretreatment forest inventory for the Rainbow treatment area (West of Gunnison).<br>• Once the area is harvested we can report changes in the forest structure and tree regeneration | No results to base interpretation on at this time. |
| b. How do modified shelterwood cuts and | 1) Tree density | • 25 out of 30 planned pre-treatment plots were established in Bald TS in 2021. The remaining five plots will be established in 2022. | No results to base interpretation on at this time. |

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| group selection cuts influence successful regeneration establishment and growth in spruce-dominated forests? | 2) Stand Basal Area<br>3) Species Composition<br>4) Seedling regeneration density<br>5) microclimate | • Results will be available after the timber sale is implemented. | |

**3. Landscape-scale impacts of spruce bark beetle and climate on forest change**
**Lead: Sibold**
**Years Measured: 2015, 2016, 2017, 2018, 2019, 2020,2021**

| ***Ongoing Monitoring*** | | | |
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| **Question** | **Indicators/Methods** | **Current Findings** | **Science Team Interpretation** |
| a. How are topographic influences on weather shaping patterns of forest change in Engelmann spruce-dominated forests of the Gunnison Basin? | Topographic influences on weather/climate, and forest change. (Temperature dataloggers installed at FIA plots with a spruce component) | • We installed sensors at 40 FIA plots<br>No results at this time.<br><br>Note: This is a coarse-scale study at the landscape-scale. We are also pursuing similar questions at a finer scale within a subsection of valleys in the Gunnison Drainage that will increase the value and interpretations of this study.<br><br>FIA sensors were not collected in 2020 (Covid) but 106 sensors from the Elk/West Elk study area were collected and downloaded. Data are being cleaned winter 2020-21. | No results to base recommendation at this time. |
| b. How are spruce-dominated forests changing in response to the spruce beetle outbreak? | LiDAR and field data documenting pre-outbreak forest conditions in the Elk Mountains.<br>Re-measuring four large (40x40m) plots (first est. 2015) and installing 70 new (20x20 m) plots throughout the study area to calibrate remotely sensed data. Temperature loggers will be installed in plots. | Large plots were re-located and re-sampled in 2018. The most notable change is the continued mortality of subalpine fir on the landscape. Subalpine fir mortality began in the GMUG, Colorado and the Rocky Mountains in the early 2000s and continues today. Subalpine fir is the least drought adapted tree species on the GMUG landscape and mortality is related to frequent high-severity drought conditions that stress trees directly and facilitates other stressors such as western balsam bark beetle.<br><br>In summer 2019 we installed 68 intensive plots within the Elk/West Elk study area. Within plots we measured seedlings, saplings, trees, dense horizontal cover (DHC). In the four directions where we measured DHC(N,E,S,W), we also measured cover density in 1x1m square 2m high volumes and counted hare pellets within the transect. We also installed temperature sensors at 1.8m and ground level, mapped site coordinates with a very high-resolution GPS (<20cm), and installed seed traps.<br><br>53 of 68 plots from 2019 were revisited in 2020 to change temperature sensors and count hare pellets.<br>Based on data from 2019 and 2020:<br>1) As expected, hare pellet densities in spruce-fir dominated forests that have not been impacted by spruce beetle, tend to increase with increasing DHC. However, | These results are just from a very small sample size, with the larger sample size being analyzed in 2020. Nonetheless, the considerable decline in subalpine fir reinforces what is evident on the broader landscape. Although subalpine fir is of relatively low value in the context of timber, it does provide highly valuable habitat for species including Canada lynx.<br><br>The increase in pellet counts at 20% suggests that lower levels of DHC could provide valuable hare habitat in spruce-fir forests that have not been impacted by spruce beetle.<br><br>The heterogeneous nature of DHC at relatively fine scales (<100-200m) stresses the challenges of quantifying DHC within treatment areas.<br><br>Fine-scale heterogeneity in DHC and hare pellet counts means that it is challenging to identify large areas that are key for Canada lynx conservation. |

| Ongoing Monitoring | | | |
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| **Question** | **Indicators/Methods** | **Current Findings** | **Science Team Interpretation** |
| | | pellet counts do not increase linearly but instead increase rapidly at 20% DHC and stays high. The 20% threshold is lower than expected.<br>2) DHC is extremely heterogeneous on the landscape, with close plots (200m) with similar slope, aspect, elevation and fire history often having large differences in DHC measurements. This is hypothesized to reflect fine scale variability in soils, soil water availability and canopy closure.<br>3) DHC and hare pellet densities are heterogeneous at fine scales (100-200m).<br><br>**January 2022 update:** I compiled all DHC plots from within the Lidar footprint for this question. After QA/QC work, I am using approximately 200 plots in the model. I am using the Forest-Based Classification and Regression model in the Spatial Analyst toolbox of ArcGIS Pro to analyze and predict DHC for this footprint. The Lidar data is consistently a top predictor of DHC along with topographic features, broad-scale climate conditions, soils and productivity (Landsat derived NPP). I am currently working to improve the model and might have to change to a “boosted” model. Specific concerns with the current model are its limited ability to differentiate DHC in middle ranges of DHC values (35-65% DHC). Nonetheless, I do have a landscape-scale predictive model of DHC for this footprint. The current model is broadly in agreement with the Canada lynx usage model created by Dr. David Theobald for this area.<br><br>The first draft of the topoclimate model will have a similar footprint to the Lidar footprint and should be available to incorporated into this model in February, 2022. This should improve the model, currently the only climate data in the model are long-term precipitation data and no temperature data are included. While the predictive model will be useful for management within this footprint it also demonstrates the potential value of Lidar for predicting habitat conditions/DHC in for the broader GUMG landscape. | I am still digesting these results and will update this shortly. |
| c. Is the spruce beetle outbreak changing the extent or location of high-quality lynx habitat in the Gunnison Basin? | 1) Recent work on lynx habitat usage in response to spruce beetle-altered forest conditions in the Rio Grande NF | In December, 2019 USFS GTAC shared a draft version of the change detection work which will be a critical resource for this work. The draft was very complete and was in agreement with patterns of changes that are evident on the landscape. A final version of the work is expected in February which will include data transfer. | Spruce and connectivity modeling provides spatial information on where spruce habitat, critical for Canada lynx, and corridors will persist into the future under different warming scenarios. This information could be used to identify locations on the landscape where spruce would be anticipated to persist into the future or where management |

| *Ongoing Monitoring* | | | |
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| **Question** | **Indicators/Methods** | **Current Findings** | **Science Team Interpretation** |
| | 2) Landscape-scale change-detection work by the USFS to create a new layer of high-quality lynx habitat. | In 2020 I focused on modeling future patterns of spruce forest distributions under different climate scenarios (A1 = continued warming; B1/B2 not as rapid of warming) for different climate projections for the years 2060 and 2090. The range of future climate projections (different scenarios and models) should provide relatively robust end points for best- and worst-case scenarios for spruce, which is being used as a proxy for Canada lynx habitat. These results show that there is a very large range of potential future spruce cover scenarios – from a rapid decline to almost no spruce cover by 2060 and basically no cover in 2090 in the A1 climate scenario to relatively modest declines in the B1/B2 scenario. These models also show where on the landscape efforts to maintain spruce forests for habitat for Canada lynx and other subalpine species will most likely be successful.<br><br>I also modeled landscape connectivity for Canada lynx for the A1, and B1/B2 models for 2060 and 2090. These models continue to identify the eastern portion of the Gunnison basin as a critical area for connectivity for Canada lynx between the San Juan Mountains and northern Ranges in Colorado.<br><br>**January 2022 update**: Similar to the Lidar work above, I have compiled all recent (since 2017) DHC plots collected by my lab and USFS staff and USFS contractors that collected data for the change detection work. After QA/QC, I am working with about 440 plots and using the Forest-Based Classification and Regression model in the Spatial Analyst toolbox of ArcGIS Pro to analyze and predict DHC for the Gunnison Drainage. Because this area includes large areas of high-severity spruce beetle outbreak I am able to identify the landscape implications of the outbreak for DHC. Specifically, I am representing outbreak severity in the model as the change in Net Primary Productivity (NPP) from a baseline calculated for the early 20002 compared to 2017, when most of the DHC plots were sampled in the beetle-killed areas. Beetle outbreak severity, as represented as change in NPP, is consistently a top variable in the model. I am having similar success and challenges as within the Lidar footprint/study area, specifically that it is challenging to differentiate between middle ranges of DHC values.<br><br>While I have a predictive landscape-scale model of DHC for the Gunnison basin at this time, I am working to improve the model. I am also currently overlaying the current model with Dr. Theobald's layer of Canada lynx usage layer and the earlier | should focus on maintaining spruce on the landscape (corridors). This information can be used to identify appropriate treatments, exclusion of treatment or post-treatment management including reforestation.<br><br>I am still digesting these results and will update this shortly. |

| *Ongoing Monitoring* | | | |
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| **Question** | **Indicators/Methods** | **Current Findings** | **Science Team Interpretation** |
| | | work on future spruce cover under different climate scenarios. This will allow us to start to identify locations on the landscape that have high-quality habitat that is being used and expected to persist into the future under different climate scenarios. This will be helpful to identify potential management options in these areas. | |

| *Completed Monitoring* | | | |
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| **Question** | **Indicators/Methods** | **Current Findings** | **Science Team Interpretation** |
| d. How is the spruce beetle outbreak influencing Engelmann spruce and aspen regeneration? | 1) Spruce forest landscape change in response to the spruce beetle outbreak.<br><br>(Forest inventory plots) | • Pre- and post-outbreak spruce establishment is **not** related to elevation.<br>• 45% of post-outbreak seedling establishment can be explained by 1) site moisture (lower total solar exposure at landscape scale, and increased moisture retaining features (litter, moss at fine scales), and 2) increased regeneration in response to increased canopy mortality.<br>We also found a significant pulse of regeneration in 2015 that is associated with the record-setting cool, wet spring and summer of that year. | • Elevation is a poor guide to predicting the future of spruce on the GUMG landscape in the context of the combined impacts of spruce beetle and climate change.<br>• Identifying the influence of salvage on spruce is more difficult than just taking into account elevational influences on temperature.<br>• Identifying species to replant following salvage should take into account other topographic variables instead of elevation. Specifically, replanting spruce on lower-elevation sites with moderately steep north-facing aspects is likely to be successful and help maintain spruce on the landscape in an era in which it is projected to see significant declines in extent. |

**4. Impacts of spruce bark beetle and subsequent salvage in Engelmann spruce and Engelmann spruce-aspen forests of the Gunnison National Forest on understory plant composition and surface fuels 1 to 2 years post treatment.**

**Lead: Coop and Mattson**

**Years Measured: 2017**

| ***Completed Monitoring*** | | | |
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| **Question** | **Indicators/Methods** | **Current Findings** | **Science Team Interpretation** |
| a. How is the spruce beetle outbreak and salvage influencing understory plant composition and surface fuels? | 1) Understory plant cover<br>2) species composition<br>3*)* Fine fuels | • Total vegetation cover decreased in salvage<br>• Species diversity decreased in salvage units<br>• Species richness did not differ<br>• Salvage increased fine surface fuel loads<br>• Salvage decreased litter and duff loads<br>• Salvage increased %wood cover<br>Salvage decreased %bare ground, %litter, and % moss cover | Short-term outcomes of salvage treatments demonstrated an increased in the amount of fine fuels and decreased total vegetation cover. The decrease in vegetative cover was a result of lower shrub cover. Exotic species cover was low and similar among salvaged and non-salvaged areas. Increases in fine fuels were evident in the salvage units, but values still are within normal ranges.<br><br>We expect over the long-term, vegetation will recover due to increased light availability and other resources. However, we do not know how understory plant cover and composition will shift. Longer-term monitoring of these sites will help understand this change. |

**5. Assessing socioeconomic impacts of SBEADMR**
**Lead: Cheng**
**Years Measured: 2020**

| *Ongoing Monitoring* | | | |
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| **Question** | **Measurement Method** | **Current Findings** | **Science Team Interpretation** |
| a. To what extent do USFS administrative costs change over the SBEADMR project timeframe? What issues affect costs? | □ Administrative cost data was gathered for the East zone for FY 17-18 which focused on salvage treatments. These costs were annualized to provide preliminary cost estimates and updated for 2020 wage adjustments.<br>□ Stumpage, Brush Disposal, Surface Rock replacement, and Road Maintenance Deposits collected.<br>□ Narrative from USFS timber staff about factors affecting costs | • **Preliminary Cost per acre treated (2020)**: Planning – treatment design, layout, road design: $327; Treatment Contract Administration - $89; Science Team $24; Adaptive Management Group $3; Non-road contracts (wildlife surveys, stand exams, etc.) $35; Road contracts (construction, re-construction, maintenance) $381. **Grand Total = $859.**<br><br>• **Preliminary Cost per volume (CCF) of timber produced (2020):** Planning – treatment design, layout, road design: $19; Treatment Contract Administration - $5; Science Team $2; Adaptive Management Group $1; Non-road contracts (wildlife surveys, stand exams, etc.) $2; Road contracts (construction, re-construction, maint.) $22. **Grand Total = $51**.<br><br>• **Stumpage and Deposits Collected from 20 treatments:** Stumpage - $1,091,659; Brush Disposal - $226,117; Surface Rock Replacement - $185,801; Road Maint. Deposits – 14,098<br>Note: Brush disposal, surface rock replacement and road maintenance deposits pay for required work in general treatment areas (e.g. replacing rock on haul routes, burning of slash piles and rehabilitating burn scars, etc.).<br><br>• **Personnel costs by percentage for East Zone FY 17-18**: 22% planning, 57% presale (layout, cruise, rx development, etc.), 21% treatment implementation.<br>  • Largest factor affecting sale administration cost is personnel time. | It is not clear at this point how administrative costs have changed over the course of the project. Personnel costs have been identified as the largest issue affecting cost with pre-sale activities being the largest component of cost. |
| b. To what extent does timber output and revenue change over the SBEADMR project timeframe? | Compile data from districts on:<br>□ Commercial timber: acres, timber volume<br>□ Commercial revenue per volume<br>□ Non-commercial: acres by treatment type and objective | • Acres treated/timber volume (CCF) produced:<br>***2017*** 3,985/59,818; ***2018*** 4,587/72,131; ***2019*** 4,014/83,167; ***2020*** (Q1 & Q2) 3,629/56,549<br><br>• Commercial Revenue per volume ($/CCF):<br>***2017*** $9.16; ***2018*** $11.14 (2019 and 2020 revenue TBD)<br><br>• There have not been any non-commercial treatments implemented to date. | |

| *Ongoing Monitoring* | | | |
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| **Question** | **Measurement Method** | **Current Findings** | **Science Team Interpretation** |
| | □ No bid sales<br>□ Contracts issued by type and size: timber sale; stewardship contract; Indefinite Delivery-Indefinite Quantity (IDIQ) | • A single no-bid took place in 2020, Kannah Timber Sale, due to winter logging restrictions. Upon collaborating with the Grand Mesa Nordic Club, winter logging will be allowed through mid-December. Industry is now supportive and sale will be advertised in upcoming weeks<br>• Timber sales are transitioning from salvage harvest to more green (resiliency) operations in the SBEADMR project area.<br>• Over $1.5 million has been collected over project lifespan with Montrose Forest Products as the primary purchaser (88%), CSFS (12%), and others (<1%). | |
| c. In what ways does the SBEADMR project contribute wood volume to the wood products industry? | Compile data from districts on:<br>□ Wood utilization by producer size (e.g., small vs large mills);<br>□ Change in number of producers | • 60% of timber volume produced utilized by Montrose Forest Products (MFP). 26% by Colorado State Forest Service. 7% by the National Wild Turkey Federation. The remaining 7% went to various small purchasers.<br>• MFP produced 2" by 4" and 2" by 6" studs in 8', 9', and 10' lengths from Spruce, Lodgepole pine, Sub-Alpine fir and White fir harvested from SBEADMR timber sales.<br>• The number of producers has not deviated much over time. Only 6 documented producers from 2017-2020 dominated by MFP. | There are few small-scale producers utilizing timber from SBEADMR project. Majority of timber utilization is through sawlogs processed by MFP. |
| d. What are direct non-government employment impacts on wood producers from SBEADMR project implementation? | Compile data from wood producers on:<br>□ Annual assessment of producers' employment resulting from SBEADMR. | Montrose Forest Products reports that no additional manpower has been added to sawmilling staff nor have they added loggers or log truckers as a direct result of SBEADMR timber but without SBEADMR timber sales it would be difficult to continue operating the sawmill at current capacity. SBEADMR timber sales are reported as very important to maintain their current level of mill production. | SBEADMR has not had a significant impact on local producers' employment, but is noted as important for local mill supply chain. |

### 6. Assess progress and performance of the SBEADMR collaborative monitoring and adaptive management process
### Lead: Cheng, AMG
### Years Measured: 2021

| *Ongoing Monitoring* | | | |
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| **Question/Topic** | **Measurement Method** | **Current Findings** | **Science Team Interpretation** |
| a. Is the collaborative adaptive management process functioning as it was originally intended/expected by participants? | Questionnaire and/or focus group asking similar questions annually to track progress. | • 66% of respondents agreed or strongly agreed that the right people were engaged in the process (representative cross-section).<br>• A majority of respondents reported that the SBEADMR process increased their understanding or knowledge of ecological processes in spruce-fir and aspen systems (82%), the effects of treatments on ecological systems (70%), and the USFS decision-space in planning and implementation (74%). 61% agreed or strongly agreed that the SBEADMR processes increased their understanding of socio-economic conditions and processes related to forest management, while only half reported that the process increased their knowledge of the impacts of treatments on socio-economic conditions.<br>• A majority of respondents felt that: a) the collaborative process created a space for open communication and dialogue to achieve the stated goals of the record of decision (69%); b) participants agree about the key problems that impact their landscape (63%; and c) the process has helped participants identify shared priorities and strategies for treatment implementation (65%). Less agreed that participants agree about the strategies to solve problems and achieve goals (44%) and the "why" of the SBEADMR project (51%).<br>• A majority of respondents agreed or strongly agreed that the GMUG staff were responsive to collaborative and public input (74%), new scientific information (82%), changing conditions on the ground (77%), and whether they use lessons learned from monitoring and adaptive management to improve their management actions (77%).<br>• A majority of respondents agreed or strongly agreed that the GMUG staff were responsive to collaborative and public input (74%), new scientific information (82%), changing conditions | The SBEADMR process is generally meeting its goals of diverse participation, collaborative learning, developing shared understanding and agreement, transparency, responsiveness, trust- and relationship-building, and a participatory collaborative process. Yet, participants identified some areas that need improvement. For example:<br>• Participants suggested a number of individuals/organizations to invite or consult with on projects<br>• Learning and understanding of socio-economic forest management context<br>• Shared understanding and agreement around the priorities for achieving goals, and the "why" of the SBEADMR project. This may be due to turnover, shifts to resiliency treatments, among others.<br>• More opportunities to understand and inform annual implementation cycle – particularly treatment design and annual adjustments or adaptations that are made.<br><br>*Recommendations:*<br>• *Increased involvement and/or consultation with the following groups:* Colorado Parks and Wildlife, Tribes, the West Region Wildfire Council, water resources and water districts, WUI community groups, fisheries and aquatic resources groups, and other NGOs (e.g., the Great Old Broads, sierra club, western Colorado alliance). CO DNR; CO Fire Commission; CO Forest Health Council<br>• *Enhance opportunities for public outreach and engagement:* Continue to invest and/or enhance new and continue traditional modes of communicating SBEADMR updates (e.g., newspapers, radio, website, press releases, additional community engagement with district rangers/staff); hire a communication specialist.<br>• *Opportunities for learning and shared understanding*: Conduct pre- and post-treatment field trips in same location when applicable; Provide field-trip de-briefs with GMUG staff, AMG, and interested participants; Facilitate greater learning around the fuels management component of SBEADMR; Identify a common definition and understanding of resilience among the group, especially as move into |

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| | | on the ground (77%), and that they use lessons learned from monitoring and adaptive management to improve their management actions (77%).<br>• 44% and 63% of respondents agreed or strongly agreed that GMUG staff and other stakeholders collaborated as much as they would like in treatment design and monitoring and adaptive management, respectively. | green tree "resiliency" treatments; Develop onboarding processes for new and existing personnel<br>• *Transparency and responsiveness*: Make explicit connections between what design features are being used to mitigate the impacts to snowshoe hare, how science has informed that decision, and the outcomes of treatment in areas lynx and snowshoe hare may be impacted; Consider how to integrate new scientific information brought to the group that may be of concern to local participants but may be outside the scope of SBEADMR; Continue investing in note-taking during field trips.<br>• *Collaboration throughout the process*: Consider opportunities to provide more detail on planned treatments during out-year planning (year 2) so that participants can more meaningfully contribute to and inform treatment design and implementation; Increase opportunities for dialogue among AMG and FLT regarding what recommendations were considered, what adaptations were made, and why or why not; Enhance communication internally with GMUG staff so that all resource specialists are aware of new projects prior to public meetings.<br>• *Outputs to work towards in next two years:*<br>o Evaluate the successes and challenges of the process and recommendations for improvement and publish in reports, blogs, publications.<br>o Be ready to go after increased stand and federal funding to support wildfire mitigation. |
| b. To what extent has stakeholder participation changed over the project timeframe? | Track participation in the AMG and/or SBEADMR public engagement activities over time – an indicator of the "collaborative-ness" of the process. | • Majority of participants in AMG were active participants, meaning that they were present at 5 or more meetings (n-12), compared to 4 partial participants and 1 non-participant.<br>• The diversity of seats present at each meeting rose following the signing of the ROD (above 90%) at one point, though participation has declined since the Jan 2020 AMG meeting.<br>• Vacancy in regular and alternate seats remains a challenge. | A Core group of 'doers' has remained invested and committed to the collaborative adaptive management process. Some vacancies in key positions and intermittent participation in the AMG were observed. The logistical challenges of a large project spread out across a large geography, unpaid volunteers supporting efforts, and time required to fully engage in all annual activities was prohibiting. Further, there are currently several forest restoration initiatives in the region that compete for participants' time and energy (CFLRP, RMRI, Taylor AMG). |
| c. What adaptations have been made based on the results of administrative studies? | Document what and how scientific research and/or monitoring results and findings are brought into implementation and adaptation decision- | • No new results to add – Results forthcoming in the spring and will be updated annually. | • No new results to add – Results forthcoming in the spring and will be updated annually. |

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| | making, to demonstrate a clear link between monitoring/research and adaptive management decisions. | | |