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Forest Health Protection
1617 Cole Blvd
Lakewood, CO 80401

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# Biological Evaluation of Mountain Pine Beetle in Lodgepole Pine: Wilder, Gunnison Highlands, and Gunnison National Forest

Amy Lockner, Forest Entomologist
Kendra Schotzko, Forest Entomologist
Bradley Lalande, Forest Pathologist
Suzanne Marchetti, Biological Tech

Gunnison Service Center
216 N. Colorado St.
Gunnison, CO 81230
970-641-0471, amy.lockner@usda.gov

## *Abstract*

In 2019, a mountain pine beetle (MPB) outbreak was identified in the Beaver Creek Drainage in Taylor Canyon on private and National Forest land. Beetle monitoring traps set in 2020 captured 100's to 1000's of beetles per trap in the heart of the outbreak, but few outside of the known outbreak area. The beetle flight ramped up quickly in early July, stayed high into August, and was negligible after September. Transect data shows the outbreak is still most intense in the northwest quadrant of the project area and is spreading to the south and east. Aerial, ground, and road surveys showed approximately 600 acres of affected stands. Removal of infected lodgepole pine occurred on private land within the active outbreak prior to July 1, 2020 (Phase I) and on mostly Forest Service land during fall 2020 (Phase II) totaling 260 acres. Continued removal of infested trees, prior to the mountain pine beetle flight in July 2021, will help suppress the beetle population. Limitations for managing the outbreak include the expansion into the nearby Fossil Ridge Recreation Management Area (RMA), landowner cooperation, cost of logging, and land accessibility. The following report is based on the Gunnison Service Center Forest Health Protection field assessments.

***Figure 1****.* Red (dying) lodgepole pine killed by mountain pine beetle mixed with green (live) lodgepole pine and aspen, Gunnison National Forest 2020. Photo: Forest Health Protection.

***Figure 2****.* Photographs from the Phase I cut at Wilder-Gunnison Highlands. Top left: Logging equipment at the base of the first cut (Gunnison Highlands); Top right: mountain pine beetle monitoring trap adjacent to the selection cut of lodgepole pine over 5 inches in diameter; Bottom left: blue stained timber; Bottom right: Helicopter logging on Wilder hillside.

## *The Wilder-Gunnison Highlands Outbreak*

In 2019, Forest Health Protection (FHP) observed pockets of red lodgepole pines (Figure 1) in scattered areas in the Gunnison Basin, the largest area being in Taylor Canyon that included the Wilder and Gunnison Highlands housing developments and adjacent National Forest land (referred to as Wilder-Gunnison Highlands project area). In 2019, aerial detection survey (ADS) identified pine stands in the northwest section of the Wilder-Gunnison Highlands project area having widespread mortality. Transects completed in 2019 showed epidemic levels of mountain pine beetle (Carlin, 2019). In addition, engraver beetles (*Ips* spp.) are frequent in small diameter lodgepole (typically eight inches and below) and dwarf mistletoe (*Arceuthobium americanum*) is commonly found. Some of the mistletoe brooms have died in recent years. Stand and drought conditions are favorable to developing mountain pine beetle epidemics.

Land managers and cooperators quickly mobilized to reduce the risk of the outbreak spreading into a larger landscape epidemic. Partners included USDA Forest Service, Colorado State Forest Service, National Forest Foundation, West Region Wildfire Council, and private landowners of the Wilder and the Gunnison Highlands communities. Sanitation and host reduction included selection cuts of lodgepole above a five-inch diameter, and helicopter logging of infested trees in steep areas (Figure 2). In June 2020, the Phase I treatments were completed on approximately 100 acres private land before beetle flights began in July. During the 2020 field season, FHP characterized the outbreak and defined its current boundaries. This included: mountain pine beetle trapping to determine when and where beetles were active, ground surveys to identify newly affected stands, transects to measure growth characteristics of the outbreak, and plots to measure stand susceptibility. In October, Phase II cutting was mostly conducted on Forest Service land and some small cuts on private land in the Gunnison Highlands subdivision. Treatments totaled 260 acres for 2020 (Figure 4).

The Wilder-Gunnison Highlands project area is a mosaic of even-aged lodgepole pines stands interspersed with large areas of sage and aspen. The elevation ranges from approximately 8,200 ft to 10,500 ft. The lodgepole pine is mostly in sheltered north-facing slopes, surrounded by aspen, with sage dominating south-facing slopes. Most trees are pole-sized with pockets of sawtimber trees. Average age of the pole-sized trees is estimated at 100 to 160 years old. Sawtimber is estimated at 200+ years. The fire history of the area shows that the interior of these north facing stands were burned, while the trees on the outer edge, bordering aspen, were preserved in the most recent fires, leaving larger older lodgepole around the edge. Average stand stocking levels are in excess of 150 sq.ft. basal area (personal communication with Art Haines, Gunnison NF Silviculturist, 2020). Older Douglas-fir trees are interspersed with the lodgepole pine. As you move farther south, Engelmann spruce and subalpine fir intermix with lodgepole pine. Adjacent to the east of the infested area are nearly 300,000 acres of mature, susceptible lodgepole pine forest unaffected by the most recent mountain pine beetle epidemic in Colorado (Figure 3).

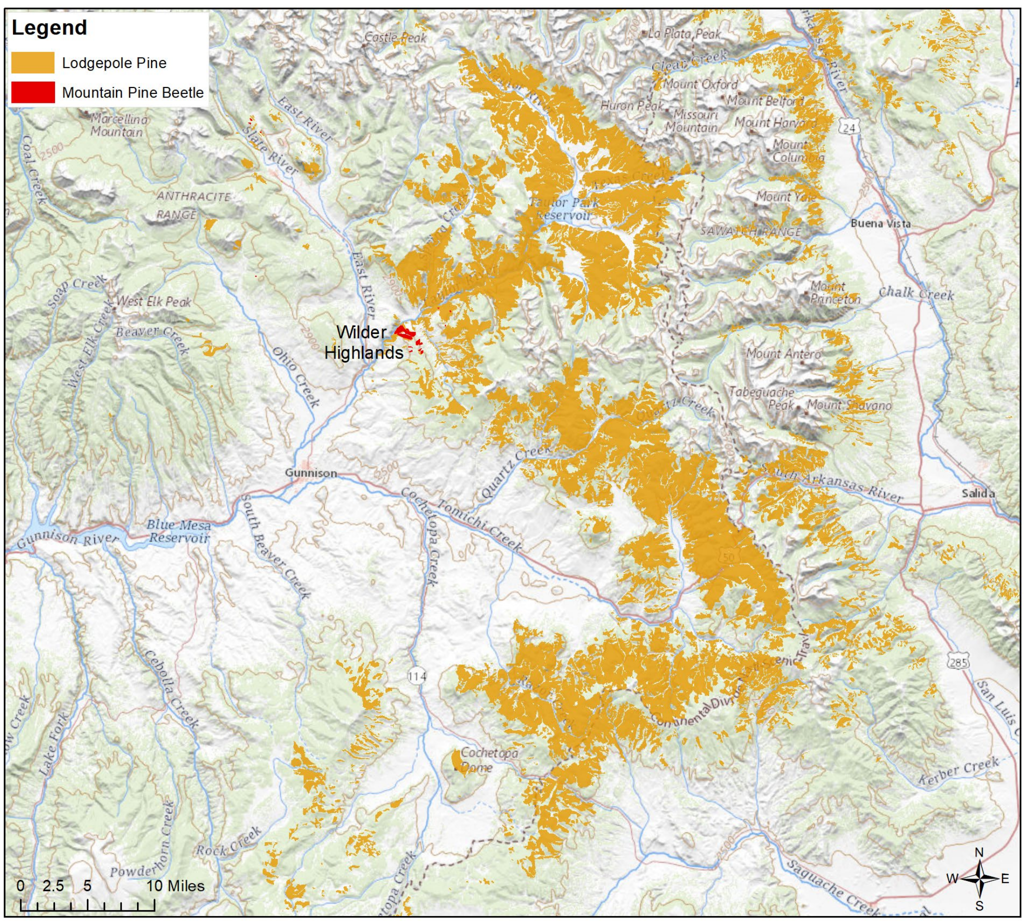



*Figure 3:* Nearly 300,000 acres of susceptible lodgepole pine (yellow) near the current Wilder-Gunnison Highlands outbreak (red).

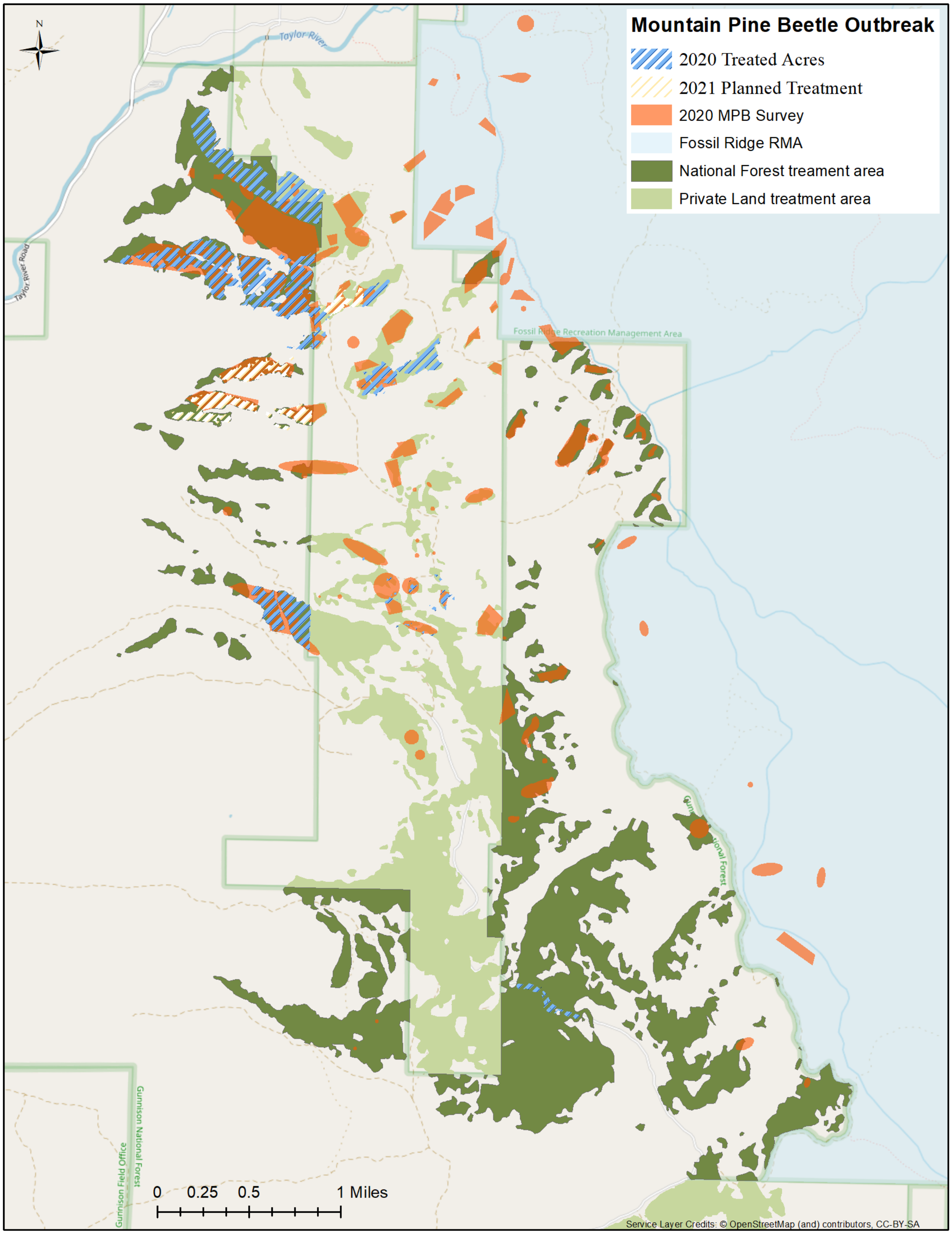



***Figure 4.*** 2020 mountain pine beetle survey in the Wilder-Gunnison Highlands area, including areas treated in 2020.

## *Biology of Mountain Pine Beetle*

Mountain pine beetle (*Dendroctonus ponderosae* Hopkins) (Figure 5A) is the most destructive bark beetle in western North America (Furniss and Carolin 1977). This native insect feeds on the inner bark of host trees, and is able to utilize lodgepole, ponderosa, limber, and Rocky Mountain bristlecone pines in Colorado (Gibson et al. 2009). Mountain pine beetles kill trees by physically girdling the phloem, and by introducing microorganisms and blue stain fungi that obstructs the xylem.

Adult beetles seek out host trees from July through September. During this period, beetles emerge from the tree where they developed and fly to a new host tree. Female beetles initiate attack and produce pheromones that attract other beetles to mass attack. Beetles chew through the outer bark and into the inner bark (phloem). The tree produces resin (pitch) that may pitch out the beetles. Pitch tubes (Figure 5B) on the trunk of the tree may contain dead beetles but mass attack can give the beetles the advantage. Successful beetle attack is characterized by boring dust beneath the pitch tube, on the bark, and at the base of the tree. In 2020, there were many infested trees that were drought stressed and could not produce pitch tubes. Boring dust on and at the base of the tree indicated successful attack by mountain pine beetle (Figure 7).

Successful beetles tunnel upward in the phloem creating galleries (Figure 5C), mate, and lay eggs. Larvae emerge and feed in the phloem through late summer and early fall. Depending on developmental rates, larvae, pupae, and/or callow adults overwinter under the bark of host trees. Beetle maturation is completed in one year and new adults fly the following summer to attack new hosts trees (Figure 6A and B).

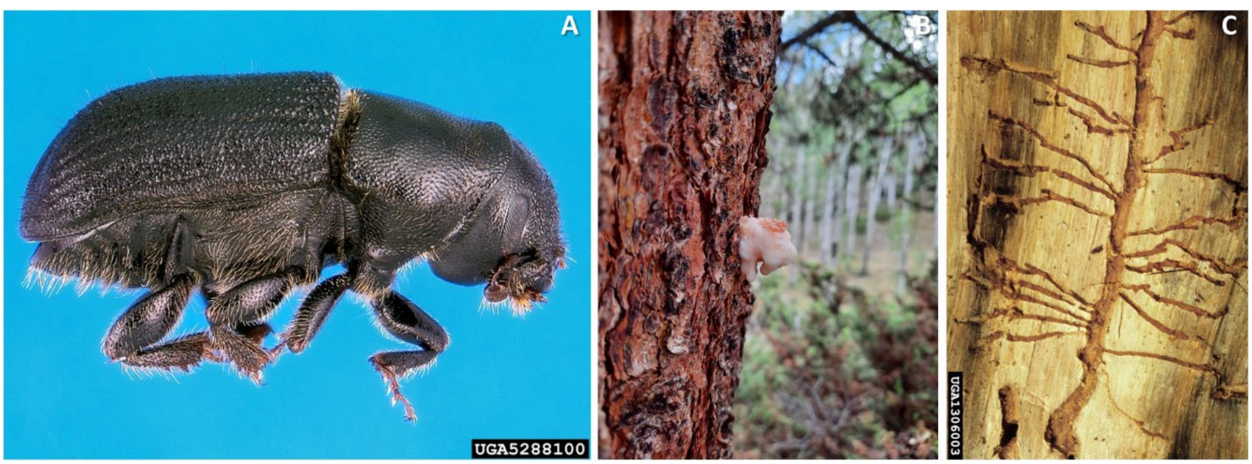



**Figure 5**. Adult mountain pine beetle (A), pitch tube produced by lodgepole pine after mountain pine beetle attack (B), and a mountain pine beetle gallery (C). Photos: Erich G. Vallery, FS-SRS-4552, Bugwood.org (A), Gunnison Service Center Forest Health Protection (B), and Leslie Chong, Simon Fraser University, Bugwood.org (C).

Endemic populations reproduce in stressed or weakened trees. They cause scattered (and often insignificant) tree mortality (Gibson et al 2009). Mountain pine beetle populations, however, can increase dramatically to epidemic or outbreak levels.

Epidemics can cause significant changes in forested stands, including reductions in average stand diameter and stand density (McCambridge et al. 1982), changes in stand structure, and shifts in stand composition. Endemic and epidemic beetle populations are generally defined as follows (Schmid et al. 2007):

- Endemic where less than one tree is attacked per five acres per year, occasionally two trees per five acres attacked per year.
- Incipient epidemic where two or more groups of three to four trees are attacked on 40 to 320 acres for 2 to 3 consecutive years.
- Epidemic where several groups of four or more trees are attacked on 20 to 320 acres over 2 to 3 consecutive years.

While the mechanisms driving the shift from endemic to epidemic populations are not fully understood, stand conditions, climatic factors, and proximity to existing beetle populations may influence this transition (Gibson et al 2009). Extreme drought conditions in the late 1990’s and early 2000’s likely triggered the largest recorded epidemic in northern Colorado, killing mature pines on over three million acres through 2012. The pine forests of southern Colorado remain highly susceptible (Figure 3).


**Figure 6**. Red lodgepole pine killed by mountain pine beetle mixed with aspen (A), and an adult mountain pine beetle next to its gallery (B), Gunnison National Forest 2020. Photo: Forest Health Protection.

## *Methods*

In 2020, 25 funnel traps baited with mountain pine beetle lures (terpinolene) were deployed throughout the Wilder-Gunnison Highlands and surrounding areas to assess when peaks in mountain pine beetle flight occur, and where the beetles were most abundant. Trap catches were counted every one to two weeks. Abundance of clerid beetles, a common bark beetle predator, was also noted.

In order to find stands with active mountain pine beetle, we conducted multi-dimensional surveys. Aerial surveys, conducted in July 2020, reported 40 acres of newly infested lodgepole pine in the area. Road surveys on both sides of the Beaver Creek drainage helped identify additional areas with red or fading lodgepole pine. These were supplemented with 2019 NAIP imagery, to verify proper site location and areas difficult to access by road or trail. Walking surveys by Forest Health Protection, Colorado State Forest Service, and Gunnison timber crews added significant areas with recently attacked trees (Figure 4).

In August, September, and October of 2020, Forest Health Protection walked 27 transects throughout the Wilder-Gunnison Highlands and National Forest land to provide an estimate of current mountain pine beetle infestation levels. Each transect covered four acres (½ mile long and 1 chain wide). Along each transect, recently attacked trees were counted. These recently attacked trees were broken into two categories: trees attacked in 2020 (green trees with pliable pitch tubes present, referred to as green hits) and trees attacked in 2019 (trees fading with red needles and older pitch tubes, referred to as red hits). Dead trees with few or no needles were not counted. Paired t-tests were conducted using GraphPad.

To further understand the stand characteristic of this area, two 1/20th acre plots were measured along each transect (at the mid-point and end). Tree species, diameter at breast height (DBH), and condition of all mature trees within these plots was assessed. Regeneration was also tallied by species and defined as trees less than five inches DBH and taller than one foot. In total, 54 plots were measured.

***Figure 7.*** Lodgepole pine attacked by mountain pine beetle in 2020 where no (or only minor) pitch tubes were present, but frass was abundant around the base of infested trees. Photo: Forest Health Protection.

## *Results and Discussion*

### *Trap Data*

Trap data indicates when the mountain pine beetle was flying in the area, as well as estimating population levels. Mountain pine beetles captured by the baited funnel traps was variable and can be reduced by more attractive mass attacked trees in the area. Beetle flights ramped up quickly in the first week of July. While the peaks varied by location, they all occurred between early July and early August, after which the populations slowly declined into September. By October very few mountain pine beetle were found in the traps, and most traps were empty when checked (Figure 8).

Individual trap catches varied from almost zero to 1,200 per trap for the season, with a median of 100 (mean of 230). Over 6,500 total beetles were trapped for the season. Trap catches verified that the northwest quadrant of the Wilder-Gunnison Highlands project area still holds the largest populations of beetle. The base of the Wilder hill (which was helicopter-logged in June) showed very small populations by trap (light blue, Figure 8). The road at the top of the hill (yellow, Figure 8) had by far the most beetle captures and was treated in October 2020 after beetle trap monitoring was completed. At the base of the back hill, traps (grey and orange, figure 8) were installed in June, concurrent with Phase I spring cuts; a substantial number of beetles were captured in the area. The traps placed in the southern half (dark blue, figure 8) of the project area had relatively small catches, which is consistent with the smaller populations in the area. Clerid captures were low and varied from 0 to 40 with a median of 10. The populations of clerids did not show any obvious correlations with the mountain pine beetle populations.

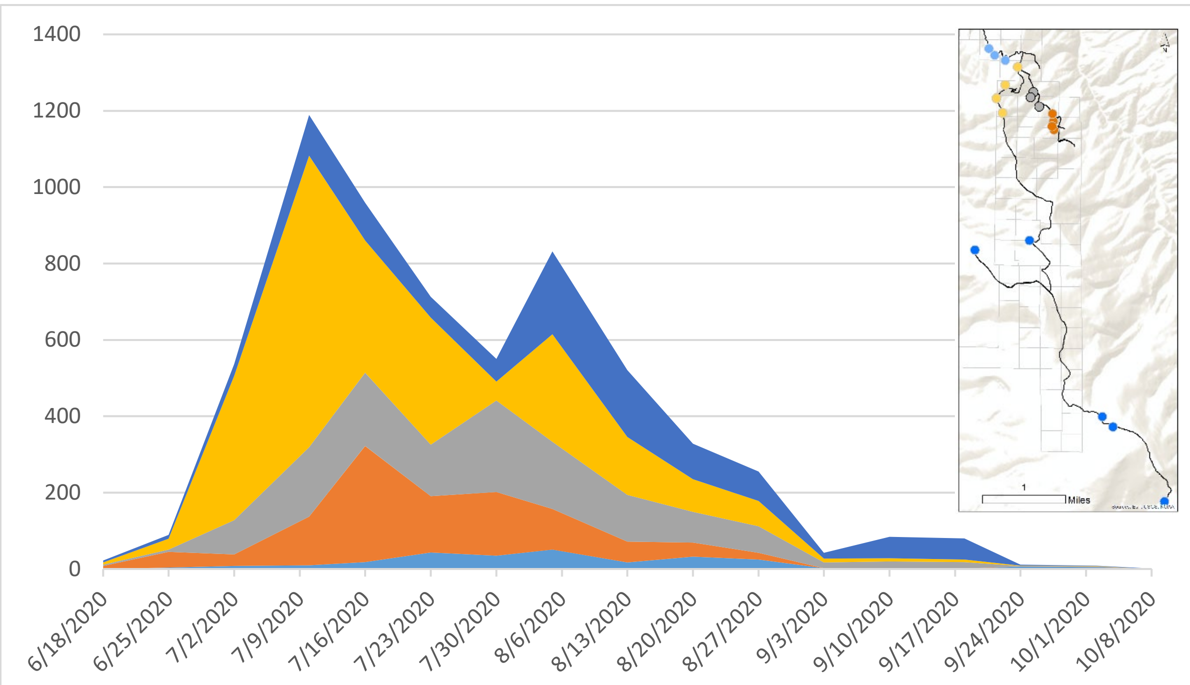


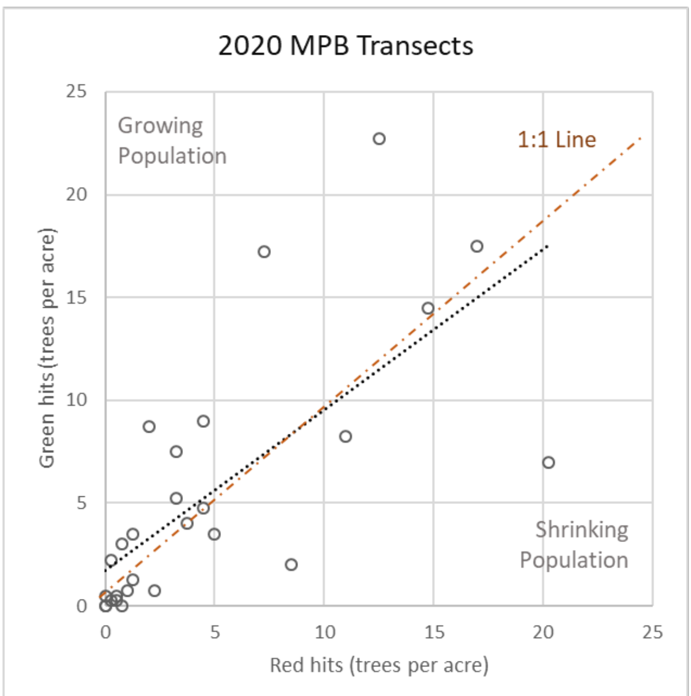

***Figure 8:*** Mountain pine beetle trap collections. The weekly number of mountain pine beetle captured in baited funnel traps from mid-June to mid-October 2020. Baited traps were collected weekly in and around the Wilder-Gunnison Highlands area. Traps were subtotaled by area: see map inset for trap locations and coordinating colors. The top lines indicate the total number of beetles captured each week, while each color inside indicates the number of beetles contributed by the subtotaled traps.

### *Mountain Pine Beetle Land Survey*

This survey indicated approximately 600 acres of mountain pine beetle activity in the Wilder-Gunnison Highlands area (Figure 4). Most areas had multiyear infestations. The severity was generally low with scattered pockets of mortality within a larger stand of lodgepole pine. Most of the mortality was found south/south-east of the main outbreak in the northwest. There is mortality scattered in the Recreation Management Area, especially on the western side of Beaver Creek. Figure 4 also shows Phase I and II treatment areas.

*Transect Data*

Transects showed 0 to 22 trees per acre hit per year, the majority of which had less than five trees hit per year (Figure 9a). Five transects showed significantly more hits in 2020, indicating growing populations. A small subset of transects indicated less hits in 2020, which can indicate either a shrinking population or few susceptible trees remaining in the stand (Figure 10). The average green hits (2020 mountain pine beetle attacked trees) per acre was 5.4 (SE±1.19) (Figure 9b). This is a slight increase from the number of trees per acre attacked by mountain pine beetle (red hits) in 2019, which was 4.6 (SE±1.10). The difference between green hits vs red hits was not statistically significant, meaning the overall epidemic growth remained stable. The very southern section of the study area had very small beetle populations with some hitting fewer trees in 2020 than the year prior. The middle section of the study area had the most growing populations. There were large, but more stable or shrinking populations in the northern section, which we attribute to both running out of susceptible cover type and sanitation efforts.



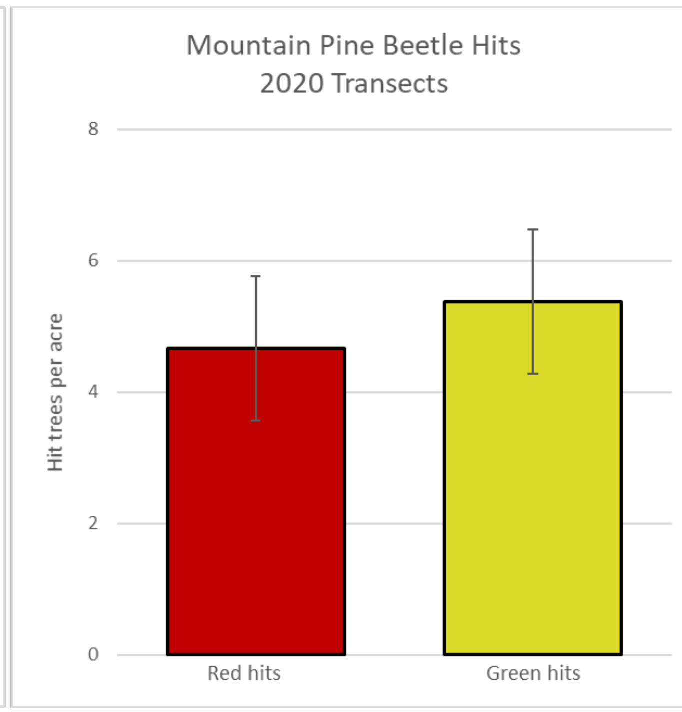




**Figure 9a** (left). Transect data from 2020. Twenty-seven transects were completed in the Wilder-Gunnison Highlands area. **Figure 9b** (right). Average number of lodgepole pine attacked by mountain pine beetle per acre in 2020. Green hits indicate a tree infested in 2020. Red hits indicate a tree infested in 2019. An average of 5 trees per acre per year indicates epidemic levels of beetles, though the epidemic is staying stable with treatment.

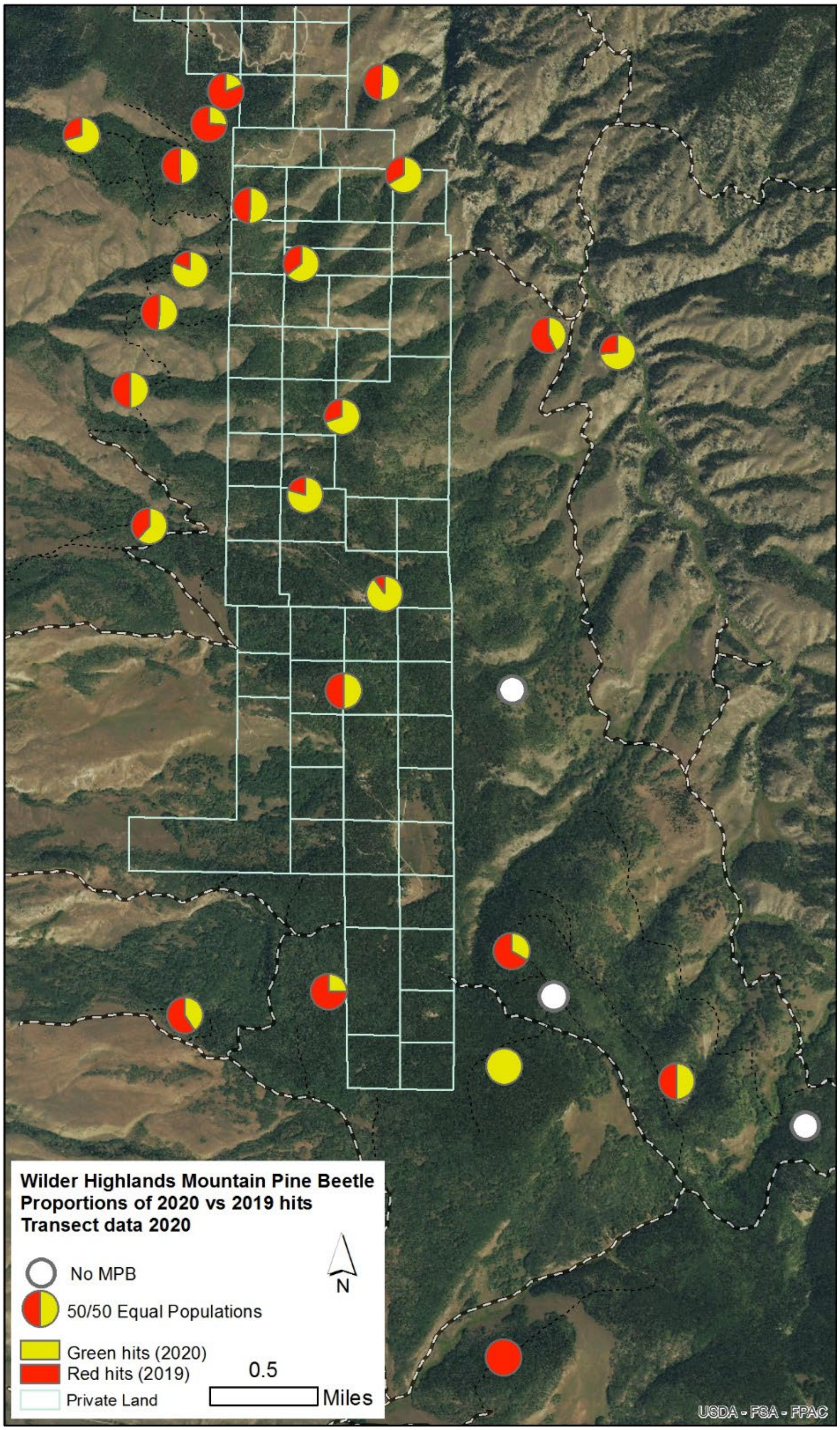



**Figure 10**. Transect map: approximate locations of each transect completed in the area.

Species composition of mature trees within our plots varied widely. On average, lodgepole pine was the most abundant species on plots making up 58% of the trees measured (Figure 11). The second most abundant species recorded on plots, on average, was aspen which comprised 34% of mature trees measured. Minor species recorded on plots included Douglas-fir, subalpine fir, Engelmann spruce, blue spruce, and limber pine, respectively.

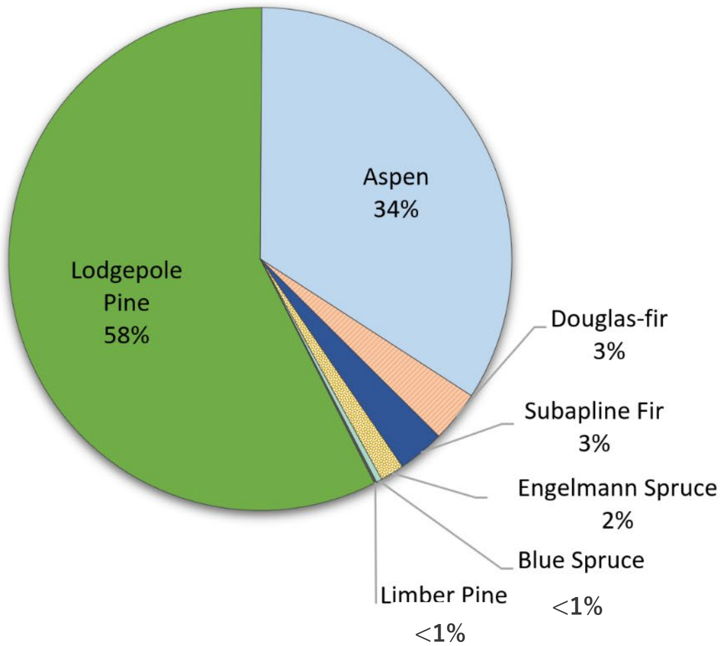



***Figure 11***. Photo of mixed stand conditions with mountain pine beetle caused mortality of lodgepole pine (left) and pie chart of average species composition of 1/20th fixed radius plots (right). Photo: Forest Health Protection.

The average TPA of lodgepole pine was about 49 (SE±4.58). For the lodgepole pine component, 84% of lodgepole pine measured within plots were alive and not attacked by mountain pine beetle. Among the dead lodgepole pine (which represented 16% of all lodgepole pine), 30% were attacked by mountain pine beetle in 2020, 20% had been killed by mountain pine beetle in 2019, 27% were killed by mountain pine beetle prior to 2019, and for the remaining 23% a mortality agent was not apparent.

The average DBH of live lodgepole pine not attacked by mountain pine beetle was 9.3 inches (SE±0.14). This was a smaller average DBH than that of lodgepole pine attacked by mountain pine beetle in 2020, which was 10.6 (SE±0.46), as well as the average DBH of lodgepole pine attacked by mountain pine beetle in 2019 which was 10.1 (SE±0.70). For lodgepole pine killed by mountain pine beetle prior to 2019, the average DBH was 9.7 (SE±0.89). Other minor damages found impacting lodgepole pine on plots (listed in order of prevalence) included dwarf mistletoe (*A. americanum*), *Ips* (pine engraver beetles), various mechanical damages such as stem wounds and dead or broken tops, needle cast (*Lophodermella* spp.), and western gall rust (*Endocronartium harknessi*). For the aspen component of stands, live trees tended to be larger with an average DBH of 7.4 inches (SE±0.13) compared to dead aspen (average DBH 6.9 inches (SE±0.15)). Roughly one third of aspen measured on plots were dead (35%). The most common damage agents observed on dead aspen were Cytospora canker (*Valsa sordida* or *Cytospora chrysosperma*), Sooty-bark canker (*Encoelia pruinosa*), aspen bark beetles (*Trypophloeus populi*), wood borers (Buprestidae spp. and Cerambycidae spp.), and aspen trunk rot (*Phellinus tremulae*).

While both live and dead regeneration was measured on plots, most regeneration was alive (Figure 12). The highest levels of regeneration mortality were found in aspen, lodgepole pine, and Engelmann spruce, respectively. Aspen regeneration made up the majority (52%) of regeneration measured on fixed area plots (Figure 12), followed by lodgepole pine (33%). On a stems per acre (SPA) basis, aspen regeneration density was about 70 live SPA (SE±10.65) and lodgepole pine 45 SPA (SE±10.69).

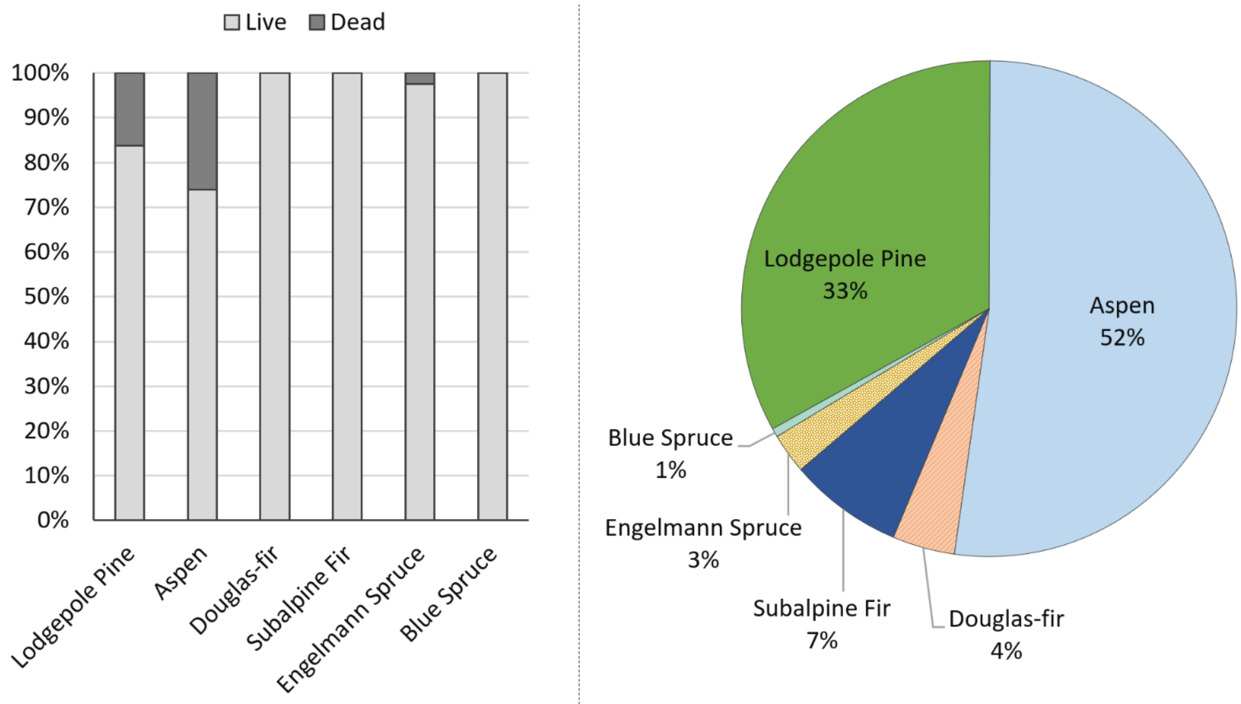



**Figure 12**. Regeneration found on 1/20th acre fixed radius plots, in terms of both the percent of each species that was alive or dead (left), and the average composition (live regeneration only) of those species (right).

## *Conclusions*

Based on the number of recently attacked trees, either current attacks or one year old attacks, there is a mountain pine beetle epidemic occurring in the Wilder-Gunnison Highlands area and adjacent National Forest land. Much of the activity is concentrated in larger groups of beetle-killed trees (an average of five trees hit per year, another indicator of epidemic conditions). There is abundant highly susceptible host material still available in the Gunnison Valley, roughly 300,000 acres of mature lodgepole pine. The large number of beetles combined with large areas of susceptible hosts creates a high probability for a continuing and increasing mountain pine beetle epidemic.

Outbreaks of mountain pine beetle frequently develop in lodgepole pine stands that contain large diameter trees (Gibson et al. 2009). Highly susceptible stands of lodgepole pine are those with the following characteristics: average diameter at breast height > 8 inches; average age > 80 years; and a suitable climate for beetle development based on a low elevation-latitude combination (Amman et al. 1977; Schmid and Amman 1992). As stand susceptibility to mountain pine beetle increases with time, the effectiveness of natural control decreases and outbreaks develop (Furniss and Carolin 1977).

Extreme drought conditions in 2020 are very favorable to increasing and expanding mountain pine beetle populations. One of the trees major defense against bark beetle attack is access to water. With healthy trees, they are able to produce more resin under the bark in the phloem. This resin can pitch out the beetle. In a dry year, or several dry years, the tree defenses are weakened, and beetles are then able to easily overcome that natural defense and have mass attacks on trees. Indication of a drought stressed tree that has been mass attacked is boring dust around the base of the tree (Figure 7), with very few or no pitch outs seen on the bole.

There are a variety of methods available for treating stands affected or in danger of being attacked by mountain pine beetle. They range from no-action to active silvicultural treatments. Doing nothing will likely lead to further expansion of mountain pine beetle mortality in the area. Silvicultural treatments can be implemented in stands that are currently being infested and in nearby un-infested stands.

***Figure 13.*** Lodgepole pine stand harvested in June 2020 to reduce landscape-level mortality of lodgepole pine caused by mountain pine beetle. Treatment photo. Photo: Forest Health Protection.

In stands that have currently infested trees, sanitation and treatment of the infested trees can slow the growth of the beetle population locally. Treatment of infested logs can be in the form of removal from the site, peeling off the bark, or burning of the logs on site while the beetle larvae are still developing in them. Currently infested trees should be identified in late summer (after peak beetle flight) and sanitation treatments carried out before the next flight in the early summer (before July). Sanitation efforts often require returning to the same stand for two to three years consecutively as infested trees are frequently missed.

Larger scale silvicultural treatments, including thinning or clearcutting, can be used in both infested and un-infested stands. Forest management, such as maintaining a diversity of age classes, diversity of species where possible and reducing basal area where it fits management objectives, is the best way to minimize extensive losses to the beetle over long periods of time. When applied over a larger landscape, these types of treatments provide a longer-term reduction in hazard to beetle infestation.

Forest Health Protection's recommendations depend on time of year and feasibility. Forest sanitation should be continued and completed before the beetle flight in early July 2021. Infested trees should then be removed from site, burned, or masticated. Do not leave felled trees on site as the beetles will continue development and infest standing trees. Debarking is labor intensive and not recommended on a forest scale but is an option for few trees.

If sanitation cannot be completed by the end of June 2021, it is recommended to wait until beetle flight has finished and sanitize the area of all infested trees in the fall. These trees can then be removed from site, burned, or masticated before the following flight in 2022.

***Figure 14.*** Landscape vista dotted with red (dying) lodgepole pine killed by mountain pine beetle mixed with green (live) lodgepole pine, and aspen, Gunnison National Forest 2020. Photo: Forest Health Protection.

## *Acknowledgment*

Gunnison Service Center Forest Health Protection would like to thank the rapid response to the Wilder-Gunnison Highlands project from our partners: Colorado State Forest Service, National Forest Foundation, the USDA Forest Service, West Region Wildfire Council, and the private communities of Wilder and Gunnison Highlands. A total of 260 acres were able to be treated in 2020, with an estimated 47,500 infested trees removed from the site. Slash was accumulated in burn piles with anticipated burning to occur in winter of 2021/2022. The next phase will begin in May 2021. Thank you again to everyone for all of the hard work involved. We look forward to next year and what more we can accomplish. Please reach out to our Service Center if you have any questions or additional needs.

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