United States Department of Agriculture

Forest Insect and Disease Conditions in the Rocky Mountain Region, 2022

Forest Service Rocky Mountain Region
Forest Health
R2–RO–23-01
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Due to the nature of aerial surveys, these data will only provide rough estimates of the location, intensity, and resulting trend information for agents detectable from the air. Many of the most destructive diseases are not represented in the data because these agents are not detectable from aerial surveys. The maps and data presented should only be used as a partial indicator of insect and disease activity and should be validated on the ground for actual location and causal agent. The insect and disease data are available digitally from the USDA Forest Service, Region Two Forest Health Protection group. The cooperators reserve the right to correct, update, modify, or replace GIS products. Using these data for purposes other than those for which they were intended may yield inaccurate or misleading results.

The information shown is based on data compiled as of December 2022.

Cover photo: Ponderosa pine trees killed by bark beetles, primarily roundheaded pine beetle, on the Dolores Ranger District of the San Juan National Forest in SW Colorado, Photo by Justin Backsen, USDA-Forest Service.

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Conditions in Brief

2022 Weather Summary for the Rocky Mountain Region

In 2022, the USDA Forest Service (USDA-FS) Rocky Mountain Region (Region 2 or R2) experienced varied amounts of precipitation. Due to an active monsoon during the summer, portions of the region received more widespread rainfall than the previous year. However total moisture was highly variable and some portions of the region remain in severe drought status (Fig. 1). Colorado reported the third warmest summer on record in 2022. This year also saw one of the strongest La Niñas since 2000 which may be partially responsible for increased monsoon flow as well as an increased number of days with severe winds.

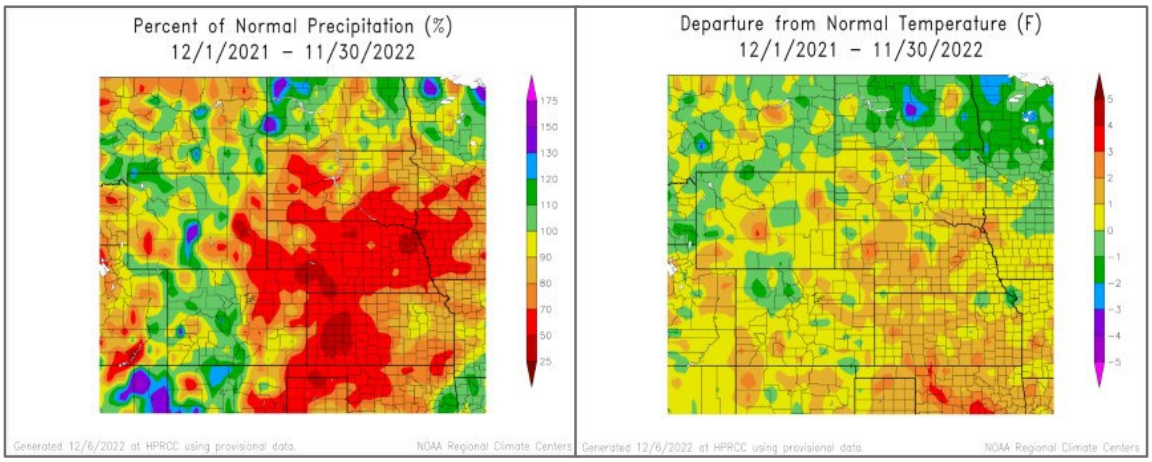

Figure 1. Percent of normal precipitation (left) and departure from normal temperature (right) for Region 2. Source: High Plains Regional Climate Center.

Aerial Survey Summary

Each year during the summer and early fall, the R2 USDA-FS State, Private and Tribal Forestry (SPTF) group, Forest Health Protection (FHP), and its state partners conduct aerial surveys to map forest insect and disease activity in R2. Aerial surveys provide an annual snapshot of forest health conditions over large areas more efficiently and economically than other methods. To conduct the survey, observers in small aircraft record areas of activity using a digital aerial sketch mapping system that incorporates a tablet computer, geographic information systems, and global positioning system technology. Aircraft used for these flights in Region 2 are typically small high-wing planes such as the Quest Kodiak 100 and Cessna T206. Aircraft fly in either a grid pattern over relatively flat terrain or following the contours of the terrain in mountainous or deeply dissected landscapes. The USDA-FS partners with state cooperating agencies in conducting the annual survey. In 2022, 47 million acres were surveyed in R2 (Fig. 2).

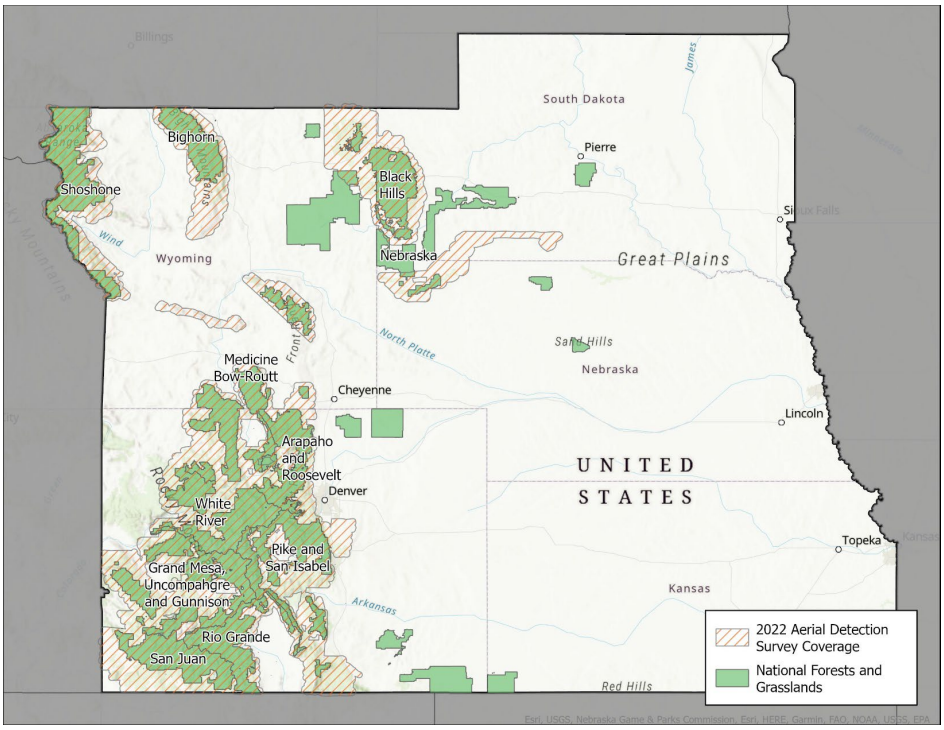

Figure 2. Flown areas from the 2022 aerial detection survey. Map by Nathan Edberg, USDA-FS.

Bark Beetle Summary

Across the Region, total acres mapped with new tree mortality attributed to major bark beetles increased for some agents and decreased for other agents when compared to 2021. Epidemics of spruce beetle and a complex of bark beetles infesting ponderosa pine (roundheaded/western/mountain pine beetles) in southwest Colorado continue to expand. Aerial survey numbers reported in Tables 1 and 2 include acres with varying intensities of fading trees mapped in 2022.

Table 1. Acres of Bark beetle[1] activity by state from aerial detection surveys in 2021 and 2022 in Region 2.

State	Spruce Beetle	Spruce Beetle	Mountain Pine Beetle	Mountain Pine Beetle	Douglas-fir Beetle	Douglas-fir Beetle	Western Balsam Bark Beetle	Western Balsam Bark Beetle
Year	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
Colorado	53,000	29,000	1,500	2,400	8,000	9,700	29,000	35,000
Kansas	0	0	0	0	0	0	0	0
Nebraska	0	0	0	0	0	0	0	0
South Dakota	0	0	0	40	0	0	0	0
Wyoming[2]	15,000	5,000	140	70	710	330	11,000	5,900
Region 2 Total[3]	**68,000**	**34,000**	**1,640**	**2,500**	**8,710**	**10,000**	**40,000**	**41,000**

[1]Only major bark beetle and mortality agents are shown. Agents detected with lesser activity may not be represented in the table.
[2]Includes only the Region 2 portion of Wyoming.
[3]Sum of individual values may differ from totals due to rounding and multiple agents occurring in the same location.

Table 2. Bark beetle[1] activity by National Forest (NF) in acres from aerial detection surveys in 2022.

National Forest[2]	Spruce Beetle	Mountain Pine Beetle	Douglas-fir Beetle	Western Balsam Bark Beetle	Bark Beetle complex in Ponderosa Pine
Arapaho and Roosevelt NF	350	5	10	3,200	0
Bighorn NF	190	50	0	180	0
Black Hills NF	0	60	0	0	0
Grand Mesa, Uncompahgre, and Gunnison NF	7,400	1,000	1,100	3,600	1,700
Medicine Bow and Routt NF	300	30	20	9,800	0
Nebraska NF	0	0	0	0	0
Pike and San Isabel NF	9,900	800	1,800	980	0
Rio Grande NF	400	40	1,300	50	0
San Juan NF	3,600	1	1,200	230	3,800
Shoshone NF	4,700	5	260	510	0
White River NF	210	20	1,600	9,600	0

[1]Only major bark beetle and mortality agents are shown. Agents detected with lesser activity may not be represented in the table.
[2]Values based on proclamation boundaries, thus any inholdings within the Forest boundary are included.

Defoliation and Abiotic Injury Summary

Defoliation can be caused by insects, diseases, and abiotic events. Specific causal agents can be difficult to differentiate when conducting aerial surveys. Abiotic events such as avalanches and windthrow can cause locally catastrophic damage. Tree stress caused by multiple years of defoliation can lead to tree mortality directly or can predispose trees to bark beetle attack. Visible defoliation detected from aerial surveys in 2022 is listed in Tables 3 and 4. Windthrow events were uncommon between the 2021 and 2022 aerial surveys. The most notable event occurred in southern Colorado on and around the Pike-San Isabel National Forest. Areas of windthrown trees may warrant ground monitoring for bark beetle activity depending on the species and size of impacted trees as well as trees in adjacent stands.

Table 3. Major defoliators, diseases, and abiotic[1] activity by state in acres from aerial detection surveys in 2022.

State	Aspen Defoliation and Discoloration[2]	Western Spruce Budworm	Windthrow
Colorado	29,000	112,000	1,600
Nebraska	0	0	0
Kansas	0	0	0
South Dakota	160	0	0
Wyoming[3]	300	33,000	0
Region 2 Total[4]	**30,000**	**145,000**	**1,600**

[1]Only major defoliators, diseases, and abiotic agents are shown. Agents detected with lesser activity may not be represented.
[2]Aspen defoliation and discoloration include damage primarily by Marssonina leaf spot, western tent caterpillar, and large aspen tortrix.
[3]Includes only the Region 2 portion of Wyoming.
[4]Sum of individual values may differ from totals due to rounding and multiple agents occurring in the same location.

Table 4. Major defoliators, diseases, and abiotic[1] activity by National Forest (NF) in acres from aerial detection surveys in 2022[2].

National Forest[3]	Aspen Defoliation and Discoloration[4]	Western Spruce Budworm	Windthrow
Arapaho and Roosevelt NF	10	310	30
Bighorn NF	0	1,300	0
Black Hills NF	2	0	0
Grand Mesa, Uncompahgre, and Gunnison NF	8,600	27,000	30
Medicine Bow and Routt NF	1,200	2,900	170
Nebraska NF	0	0	0
Pike and San Isabel NF	4,500	30,000	840
Rio Grande NF	6,500	3,000	0
San Juan NF	780	3,000	30
Shoshone NF	40	16,000	0
White River NF	1,400	4,500	0

[1]Only major defoliators, diseases, and abiotic agents are shown. Agents detected with lesser activity may not be represented in the table.
[2]Sum of individual values may differ from totals due to rounding and multiple agents occurring in the same location.
[3]Values based on proclamation boundaries, thus any inholdings within the Forest boundary are included.
[4]Aspen defoliation and discoloration include damage primarily by Marssonina leaf spot, western tent caterpillar, and large aspen tortrix.

Disease Summary

Tree diseases such as dwarf mistletoes, root diseases, rusts, and cankers, typically persist within stands over many consecutive years causing continuous damage that can add up, resulting in extensive damage over the years. Diseases can quickly or gradually kill a tree. As many R2 conifers live for up to 600 years, this slow mortality often results in less distinct aerial signatures compared to insect damage, making diseases difficult to identify using aerial surveys. Discoloration and abnormal crowns key surveyors into specific locations that may be caused by disease. However, ground surveys are needed to truly identify causal agents. Tree diseases of note in the region are discussed in the “Status of Major Diseases” chapter.

Status of Major Bark Beetles

Spruce Beetle

Dendroctonus rufipennis
Hosts: spruce

Spruce beetle (SB) populations continue to expand where there are suitable hosts in Region 2, particularly in the San Juan, Gunnison, Shoshone, and Arapaho/Roosevelt National Forests (Fig. 3, 4 and 5). There are many large areas where SB activity has subsided due to host depletion that have little mature spruce remaining.

In Colorado, 29,000 acres of SB activity were observed (Fig. 4). New spruce mortality caused by SB is occurring on both sides of the Continental Divide in and around Rocky Mountain National Park. On Mt Evans and Guanella Pass, SB activity continues near areas of blowdown. The largest areas of activity are found in southern Colorado. Low-intensity activity continues on the West Elk Mountains, southern sections of the Wet Mountains and the Sangre de Cristo Range. The Sawatch Range SB population continues to move north, with new areas of mortality between Aspen and Leadville. Moderate and high-intensity activity occurred in the San Isabel, Gunnison, and San Juan National Forests. Spruce beetle activity east of Telluride and Durango in the San Juan National Forest remains active and apparent from the air and ground. The USDA-FS continues active sanitation and salvage harvesting (removal of infested and standing dead trees) in the suitable timber base in the Grand Mesa, Uncompahgre and Gunnison (collectively referred to as the GMUG) and San Juan National Forests.

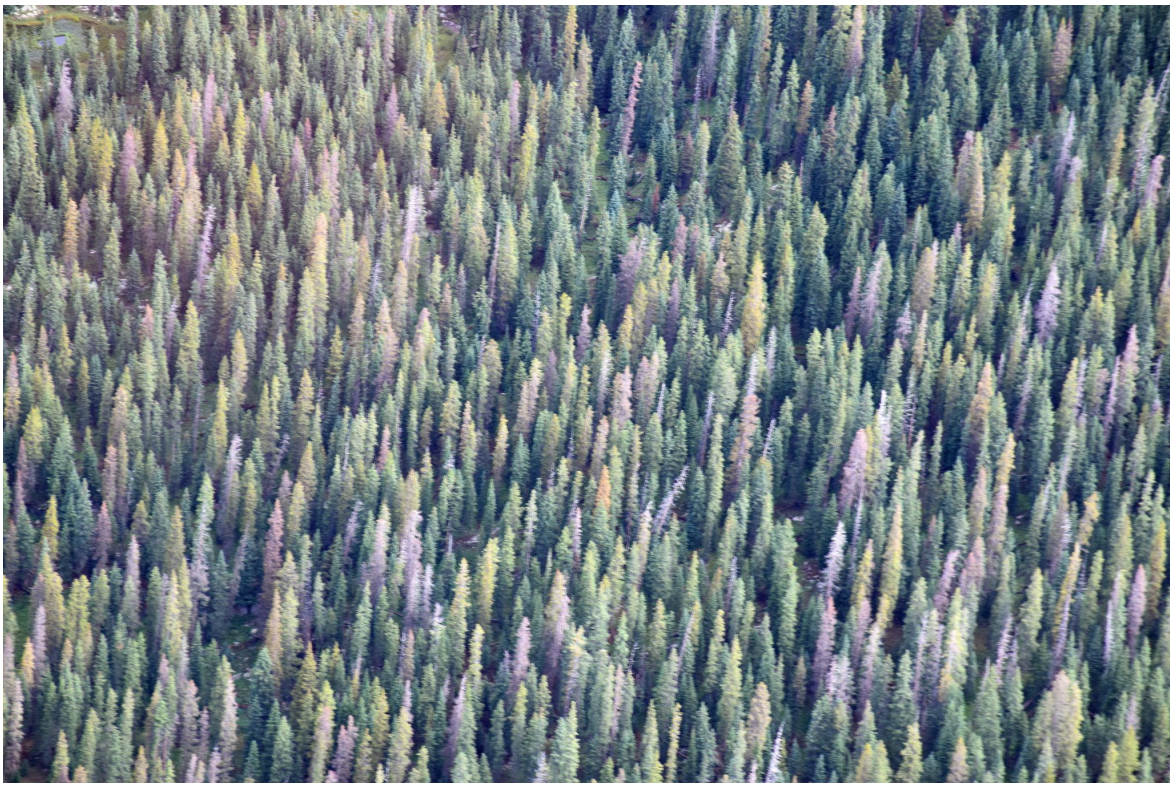

Figure 3. Englemann spruce fading and standing dead from spruce beetle attack on the San Juan National Forest. Photo by Justin Backsen, USDA-FS.

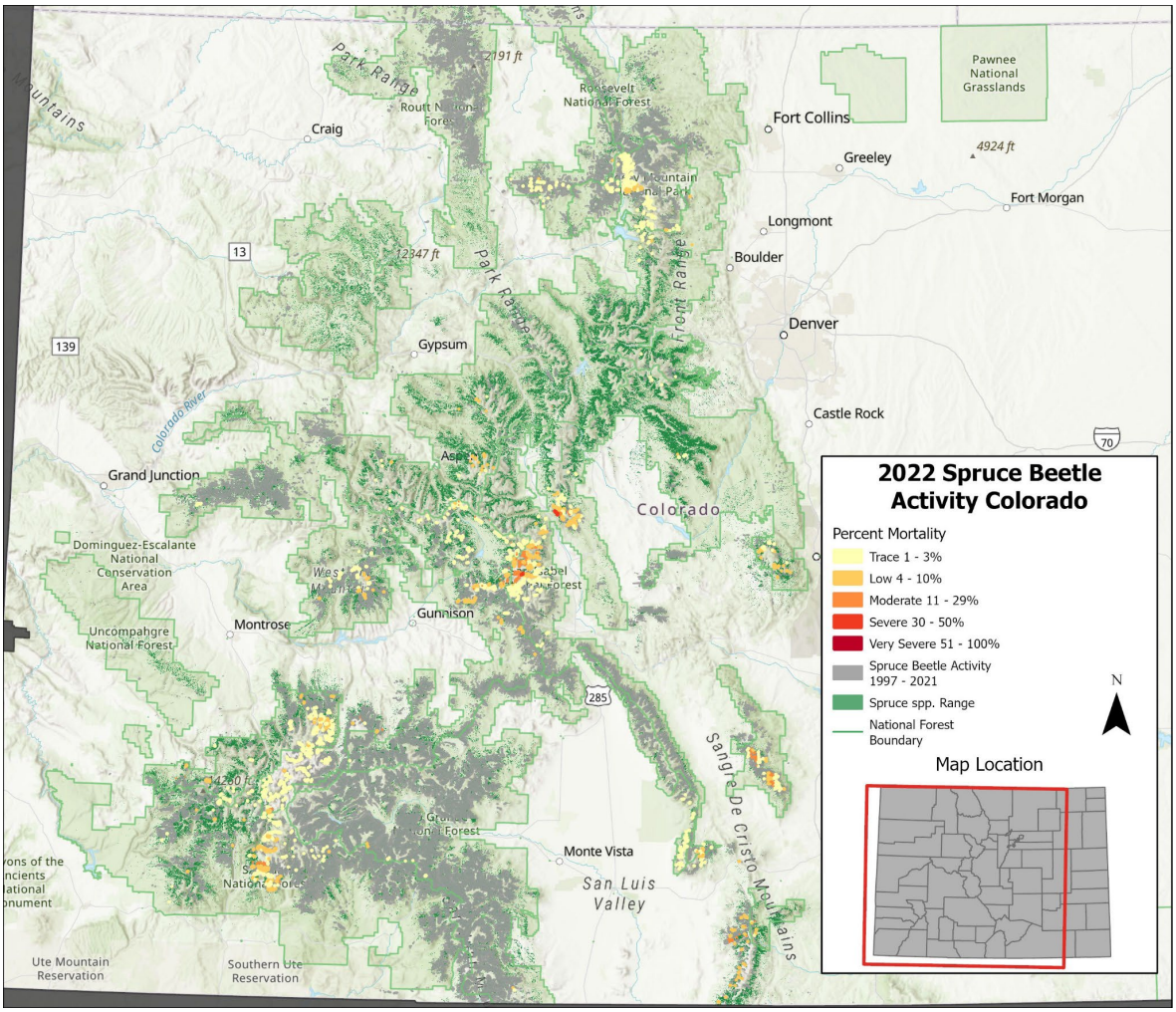

Figure 4. Spruce beetle-affected areas in Colorado vary in intensity as observed by the 2022 aerial detection survey. Spruce host is shown in green and previously mapped damage is in grey. Map by Nathan Edberg, USDA-FS.

In Wyoming, the Shoshone National Forest continues to experience low to moderate levels of mortality caused by spruce beetles on the Wind River Ranger District. Small groups of spruce beetle-attacked trees are scattered in the northern Bighorn Mountains in the Burgess Junction area (Fig. 5). Additionally, the Crater Ridge fire that burned in the summer of 2021 in the northwest Bighorn National Forest resulted in log piles (created during fuel break construction) and fire scorched trees. Spruce trees that had been cut and piled were heavily infested with *Ips* beetles in the summer of 2022, with only rare occurrences of spruce beetle (Fig. 6). Standing Engelmann spruce in the area that were weakened by being partially scorched in the Crater Ridge fire were being attacked by spruce beetle in the summer of 2022 (Fig. 7). Trees that are being attacked in 2022 could lead to increased spruce beetle activity in the area as beetle populations may increase when the next generation of adult beetles emerge and move on to infest surrounding trees in the coming years. Aerial surveys mapped spruce mortality on 5,000 acres in the R2 portion of Wyoming (Fig. 5).

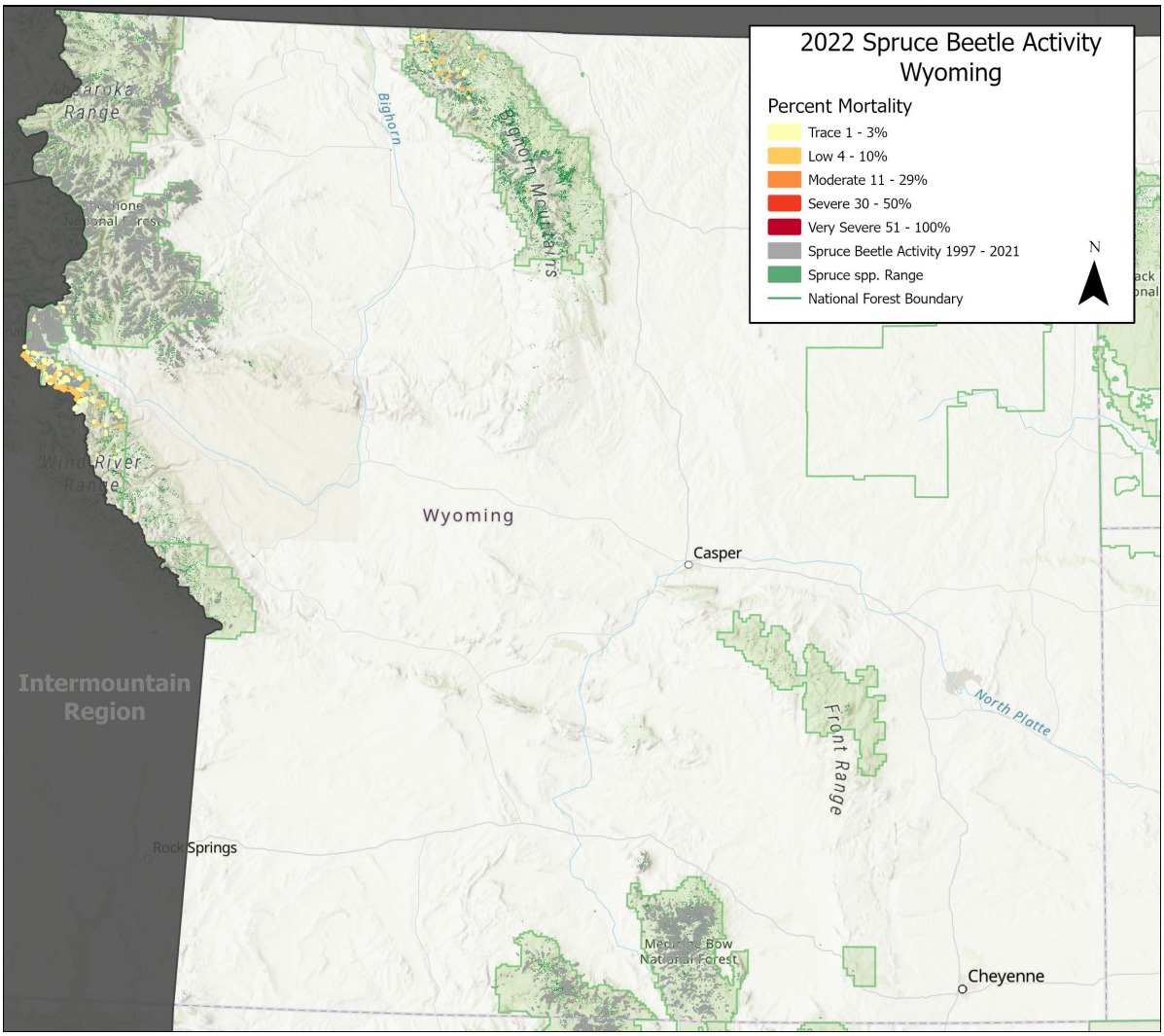

Figure 5. Spruce beetle-affected areas in Wyoming vary in intensity as observed from the 2022 aerial detection survey. Spruce host is shown in green and previously mapped damage areas are in grey. Map by Nathan Edberg USDA-FS.

Figure 6. From left to right: Englemann spruce and subalpine fir trees cut and piled after fire break construction, spruce log pile with orange *Ips* beetle boring dust on the surface, spruce log in fire break pine with *Ips* gallery above a spruce beetle gallery, spruce log in fire break pile with adult *Ips* beetle in gallery. All photos from the Bighorn NF. Photos by Kendra Schotzko, USDA-FS.

Figure 7. View of the edge of the Crater Ridge fire showing scorched Englemann spruce and subalpine fir trees, Bighorn NF. Photo by Kendra Schotzko, USDA-FS.

Mountain Pine Beetle

Dendroctonus ponderosae

Hosts: ponderosa, lodgepole, limber, whitebark, and bristlecone pine

Mountain pine beetle (MPB) activity is increasing in several areas within R2, primarily in southern Colorado. Most notable is an expanding outbreak on the Gunnison National Forest in lodgepole pine and an emerging outbreak scattered throughout the Uncompahgre National Forest in ponderosa pine.

The Gunnison National Forest outbreak is expanding into the West Elk Mountains, specifically in the Ohio Creek drainage area and around Crested Butte (Fig. 8).

An ongoing MPB outbreak that originated in and around the Wilder-Gunnison Highland developments in the lower Taylor River basin continues to expand and is now present on Bureau of Land Management-managed lands in the Fossil Ridge Recreation Management Area. USDA-Forest Service Forest Health Protection, Colorado State Forest Service and the National Forest Foundation continue to work together to monitor the expanding outbreak and to remove beetle-killed, infested trees in an effort to remove beetles from the stand (this type of timber harvest is refered to as “sanitation” Fig. 9). MPB activity is expanding between Salida and Leadville east of the Arkansas River in five-needle pines. A large area of activity is located in and adjacent to the Buffalo Peaks Wilderness to the north of Trout Creek Pass (Fig. 10).

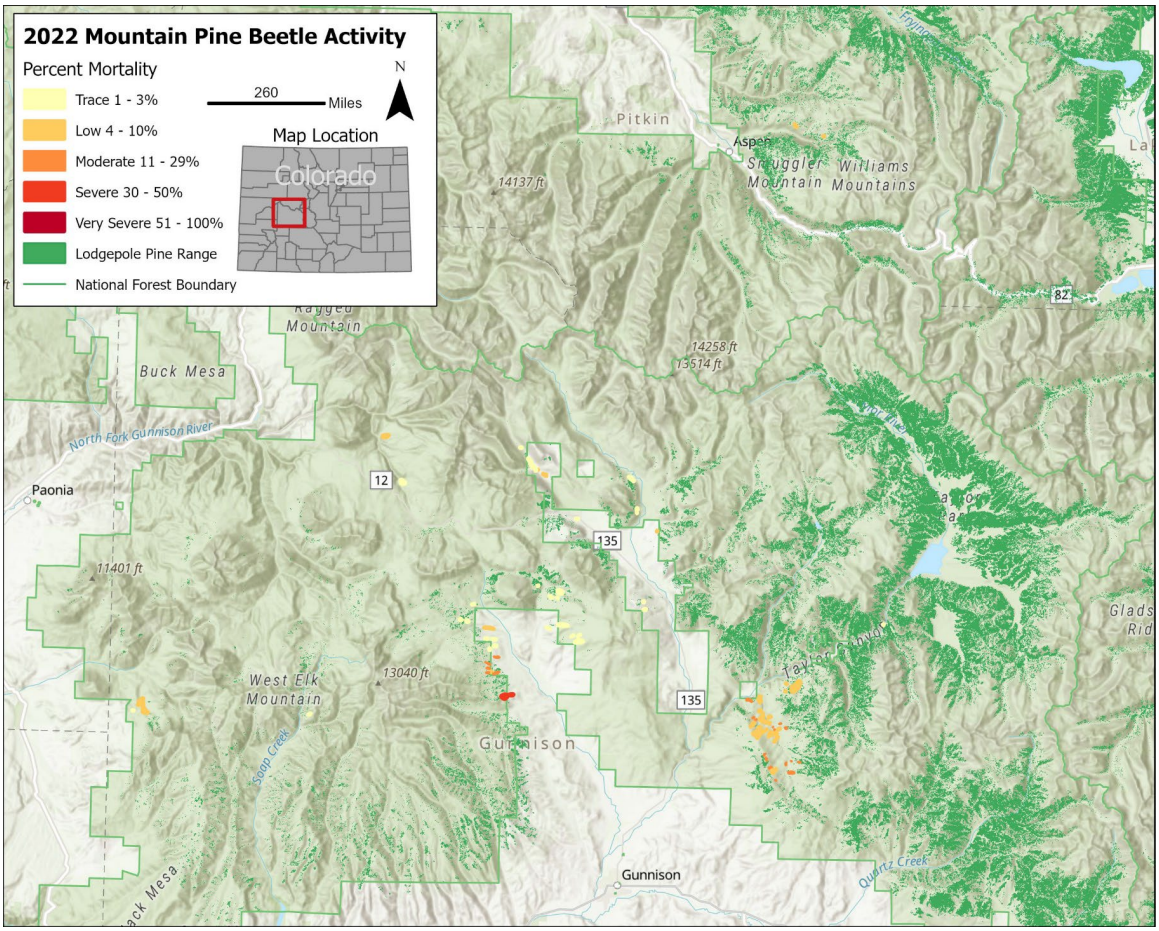

Figure 8. Mountain pine beetle activity in and around the Wilder-Gunnison Highland outbreak area in the lower Taylor basin, in the West Elk Mountains around Crested Butte and along Ohio Creek as observed from the 2022 aerial detection survey and nearby susceptible lodgepole pine forests. Map by Nathan Edberg, USDA-FS.

Figure 9. Mountain pine beetle-infested/killed lodgepole pine salvage harvesting (removal of beetle-killed standing dead trees, (left) and treated area (right) on the Wilder Gunnison Highlands project area. Photos by Suzanne Marchetti, USDA-FS.

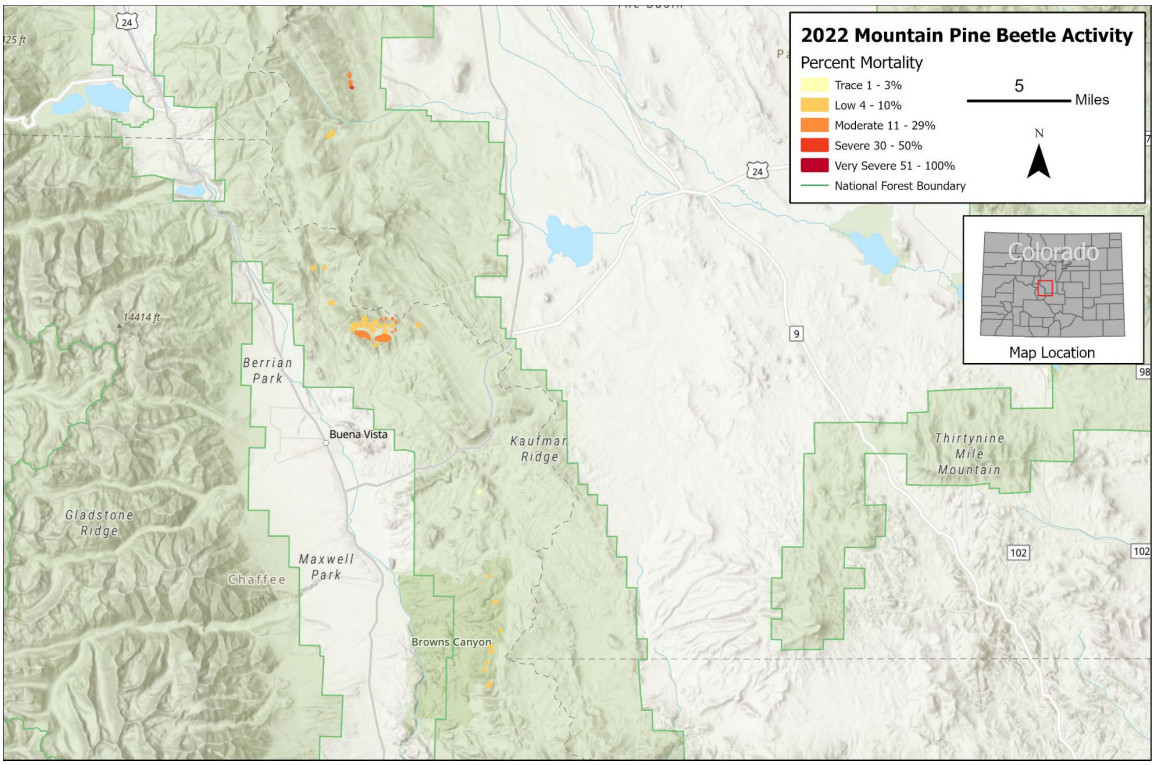

Figure 10. Mountain pine beetle is primarily attacking five-needle pines on the northern San Isabel National Forest as observed by the 2022 aerial survey. Map by Nathan Edberg, USDA-FS.

Smaller populations have been detected primarily in ponderosa pine through ground observation along the Front Range in and around the communities of Downieville, Idaho Springs and Black Hawk on private lands adjacent to and on the Arapaho National Forest. Additional populations have also been observed in multiple areas of the Pike National Forest. Populations along the Front Range remain at endemic levels but are showing an increase through both aerial and ground observations.

At this time, mountain pine beetle is at endemic levels across Wyoming and South Dakota. In Wyoming, mortality was detected in individual ponderosa and five-needle pines occurring infrequently across the landscape. In the Black Hills of South Dakota and Wyoming, since the last epidemic ended 8 years ago, MPB has been at very low (endemic) levels and attacked trees have been single, generally stressed trees that are found very infrequently on the landscape. In 2022 we noted significantly more new MPB killed trees than we have seen in the past 8 years. Not only are they easier to find, they are regularly occuring in small groups of 3-8 trees, also a sign that beetle activity has increased. While there is a noticeable increase, activity is still very light and scattered. At this point it appears to be mostly located in the Northern Hills from Lead to Hardy Guard and areas west from there including across the state line into WY (Fig. 11). Other parts of the forest still consist of rare, single trees attacked by MPB with additional mortality being caused by pine engraver (Ips) beetles.

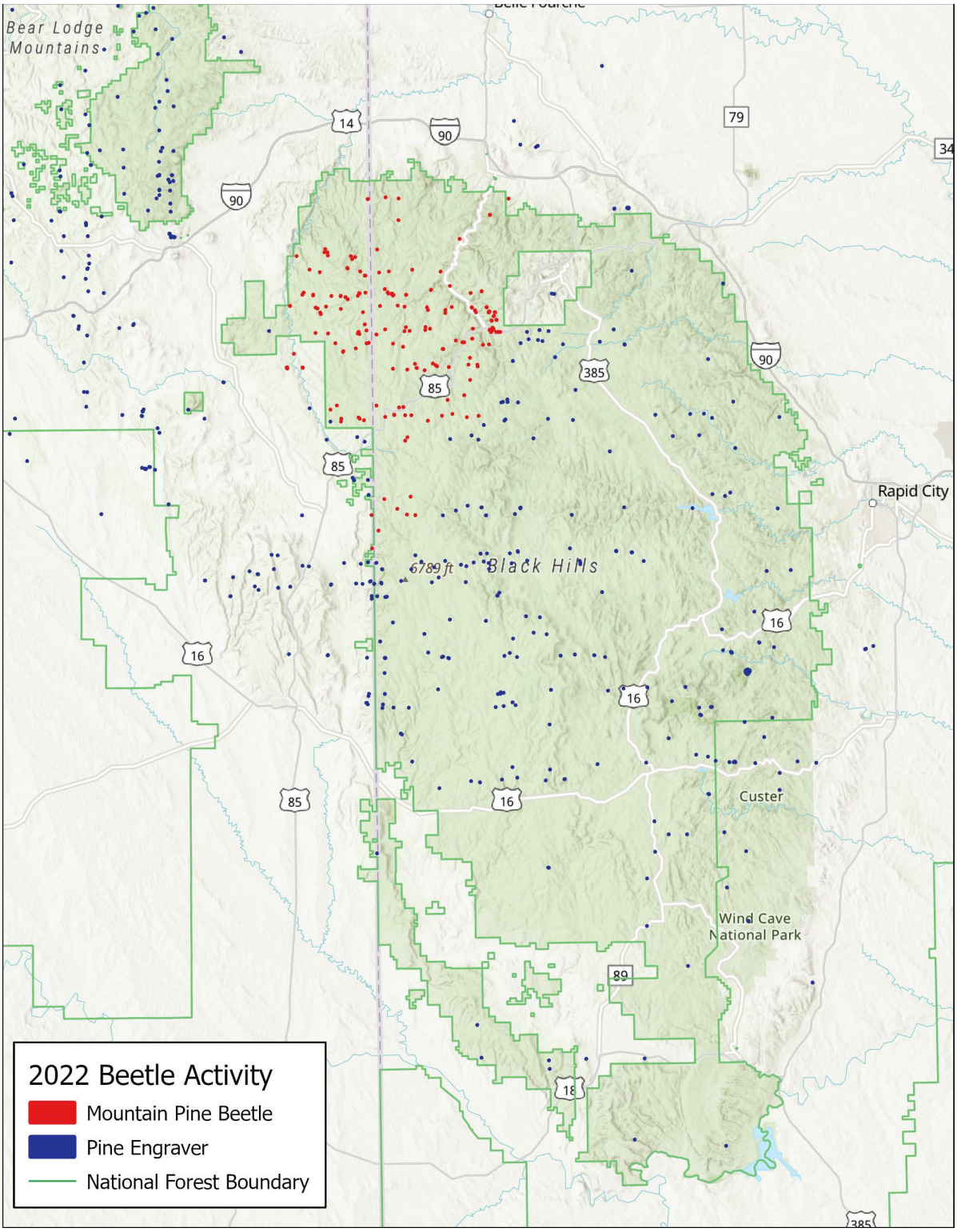

Figure 11. Mountain pine beetle in the northwest and pine engraver (Ips) beetle activity throughout the Black Hills National Forest as observed by the 2022 aerial survey. Map by Nathan Edberg, USDA-FS.

Roundheaded Pine Beetle Complex in Ponderosa Pine

Roundheaded pine beetle, *Dendroctonus adjunctus*
Western pine beetle, *Dendroctonus brevicomis*
Mountain pine beetle, *Dendroctonus ponderosae*
Host: ponderosa pine

Roundheaded pine beetle (RHPB) continues its expansion in southwestern Colorado. An epidemic of primarily RHPB mixed with western pine beetle (WPB), as well as some MPB, and engraver (*Ips*) beetles continues to spread in the San Juan National Forest, Dolores Ranger District (Fig. 12). Populations are expanding across the area known as “the glade” and continue to expand north towards the edge of ponderosa forest type (Fig. 13 and 14). Forest Health Protection contributed funding to support removal or “sanitation” of infested trees and thinning efforts in this timber management area on the San Juan National Forest. RHPB activity has increased near Lone Cone on the Uncompahgre National Forest, Norwood Ranger District this year. Ground surveys indicate the complex is increasing in severity. RHPB has also been detected as far north as Iron Springs on the Uncompahgre Plateau in the ‘Iron Beetle Toe’ treatment area on the Ouray Ranger District. Trapping and ground surveys conducted in 2022 indicated mountain pine beetle is the predominant agent in the Iron Springs complex with the other species present.

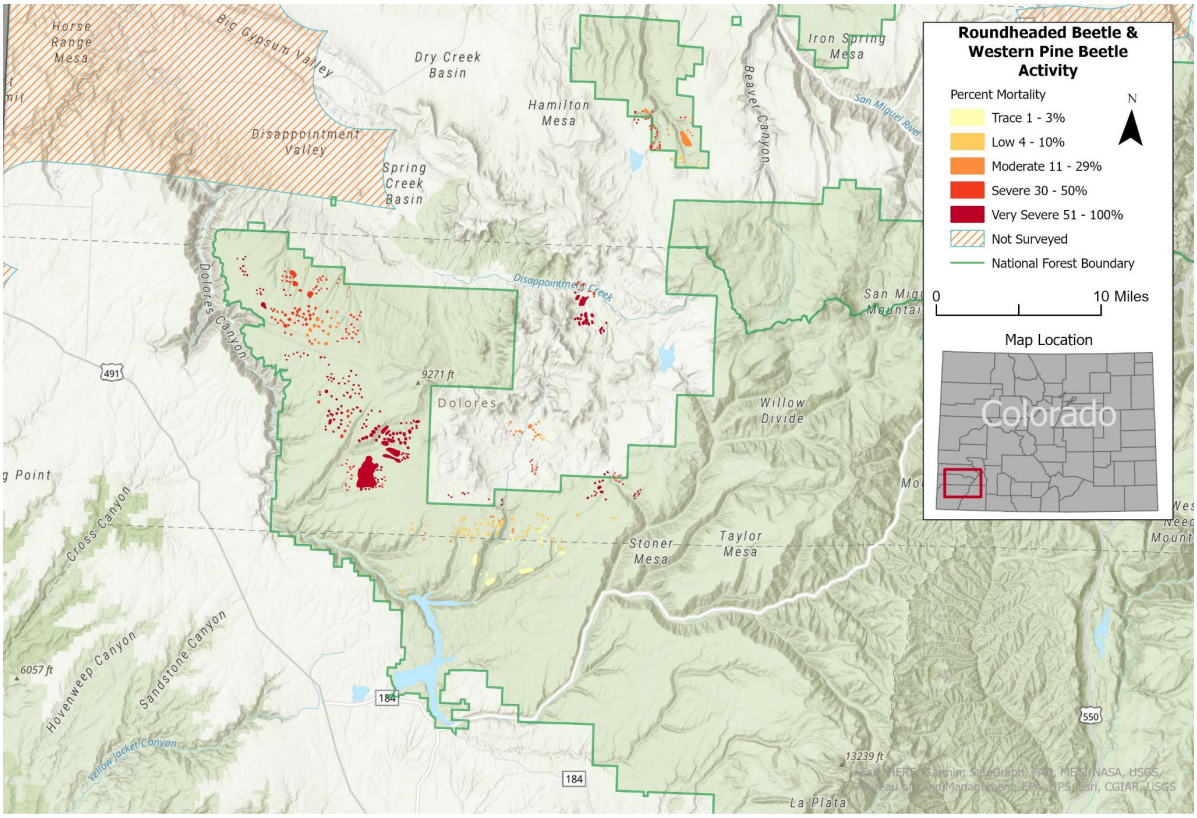

Figure 12. Roundheaded and western pine beetle activity in and around the San Juan NF in southwestern CO as observed from the 2022 aerial detection survey. Map by Nathan Edberg, USDA-FS.

Figure 13. Roundheaded pine beetle-killed ponderosa pine trees on the Dolores Ranger District. Photos by Amy Lockner, USDA-FS.

Figure 14. Roundheaded and western pine beetle-caused tree mortality in southwest Colorado on the Dolores Ranger District, San Juan National Forest. Photo by Justin Backsen, USDA-FS.

Douglas-fir Beetle

Dendroctonus pseudotsugae
Host: Douglas-fir

Douglas-fir beetle (DFB) activity is scattered and widespread in Wyoming and Colorado (Fig. 15). DFB is favored by prevailing drought conditions and years of heavy western spruce budworm (WSBW) in both states. Aerial surveys recorded DFB activity on 9,700 acres in Colorado and 330 acres in Wyoming.

Defoliation caused by WSBW in northern Wyoming in the Clarks Fork area on the northern Shoshone National Forest has been extensive, and the Douglas-fir beetle acreage was higher than indicated by aerial surveyors. The lack of foliage due to severe defoliation prevented aerial surveyors from identifying Douglas-fir infested by Douglas-fir beetle.

Ground observations indicate Douglas-fir beetle populations are increasing in the Clarks Fork of the Shoshone National Forest (Fig. 16). In the Bighorn National Forest, scattered single-tree Douglas-fir beetle caused mortality was observed during ground surveys on the western side of the forest.

In southwest Colorado, significant amounts of Douglas-fir have been lost to the combination of defoliation by WSBW and attack by DFB. DFB mortality is declining in the Gunnison National Forest due to host depletion. Observations on the Grand Mesa National Forest indicate that north-facing slopes are most affected. The San Isabel National Forest had substantial DFB mortality both in the Wet and Sangre De Christo Mountains.

There is also a significant amount of new activity on the Aspen-Sopris Ranger District on the White River National Forest (Fig. 17). A synthetic form of the anti-aggregation pheromone methylcyclohexane (MCH) can be used to discourage DFB from attacking trees in local, high-value stands of trees. MCH is being deployed by the Aspen-Sopris Ranger District in cooperation with Colorado State Forest Service and Forest Health Protection personnel on Douglas-fir in select campgrounds, ski areas, and developed sites in an attempt to reduce DFB mortality in these areas.

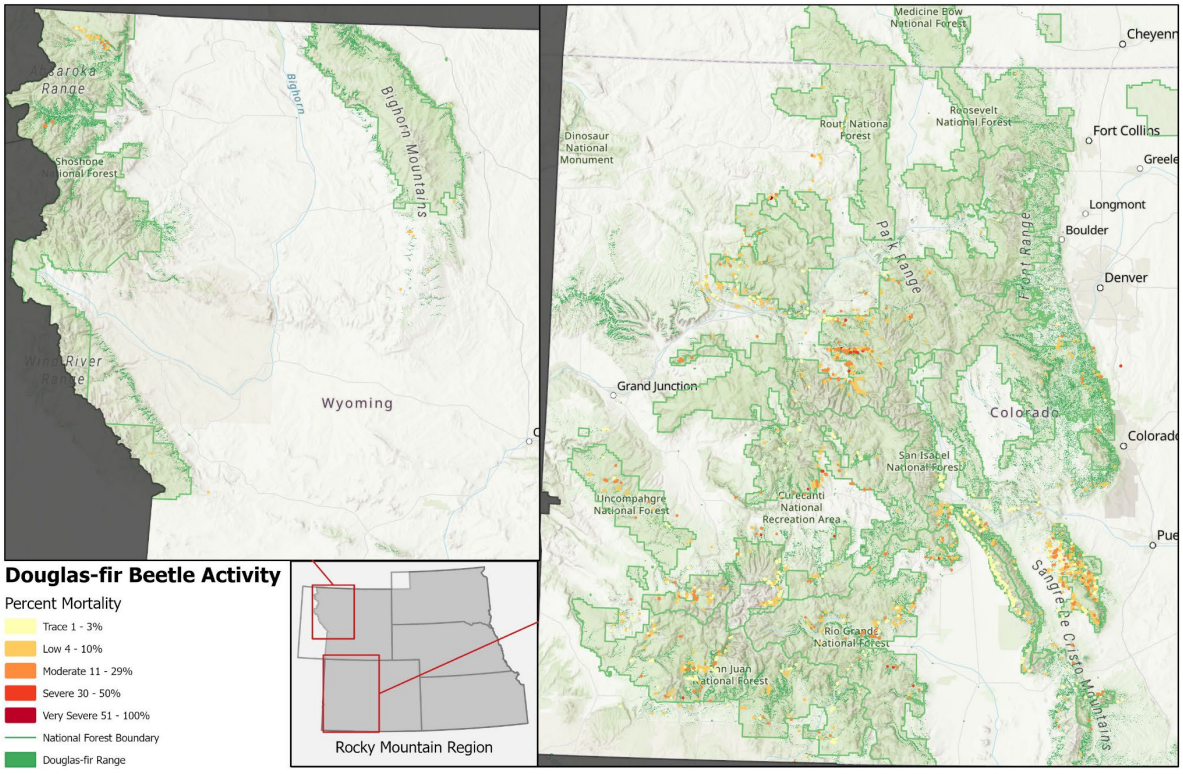

Figure 15. Scattered Douglas-fir beetle-caused tree mortality as observed from the 2022 aerial detection survey in Wyoming and Colorado is increasing in intensity with stress caused by drought and western spruce budworm defoliation. Map by Nathan Edberg, USDA-FS.

Figure 16. Douglas-fir infested with Douglas-fir beetle (red trees), Clarks Fork Ranger District, Shoshone National Forest. Photos by Kendra Schotzko and Kurt Allen, USDA-FS.

Figure 17. Douglas-fir beetle-killed trees near Ruedi Reservoir on the White River National Forest. Photo by Amy Lockner, USDA-FS.

Fir Engraver

Scolytus ventralis

Host: white fir

Fir engraver has been an ongoing issue causing mortality of white fir in southern Colorado for many years (Fig. 18). Aerial surveys detected 4,600 impacted acres in 2022, most notably around the town of Ouray, where fir engraver has been active for several years. More recently, fir engraver activity has been observed north of Durango, on Hwy 550 where the 416 Fire burned in 2018 (Fig. 19). Trees that survived the burn have been subjected to increased insect activity due to environmental stressors. Amphitheater campground in the Ouray Ranger District on the Uncompahgre National Forest has experienced a huge hit by fir engravers – the campground alone has removed over 1,000 white fir in the last decade. This outbreak has been compounded by annosus root disease which is also being treated by the Ranger District after harvesting white fir. Forest management activities have been favoring more resilient tree species through planting pines and protecting existing Douglas-fir trees from DFB by deploying MCH in high-value stands.

Figure 18. White fir mortality caused by fir engraver beetles (left) and horizontal egg and vertical larval galleries of fir engraver beetle in the inner bark of white fir (right). Photos by Amy Lockner, USDA-FS.

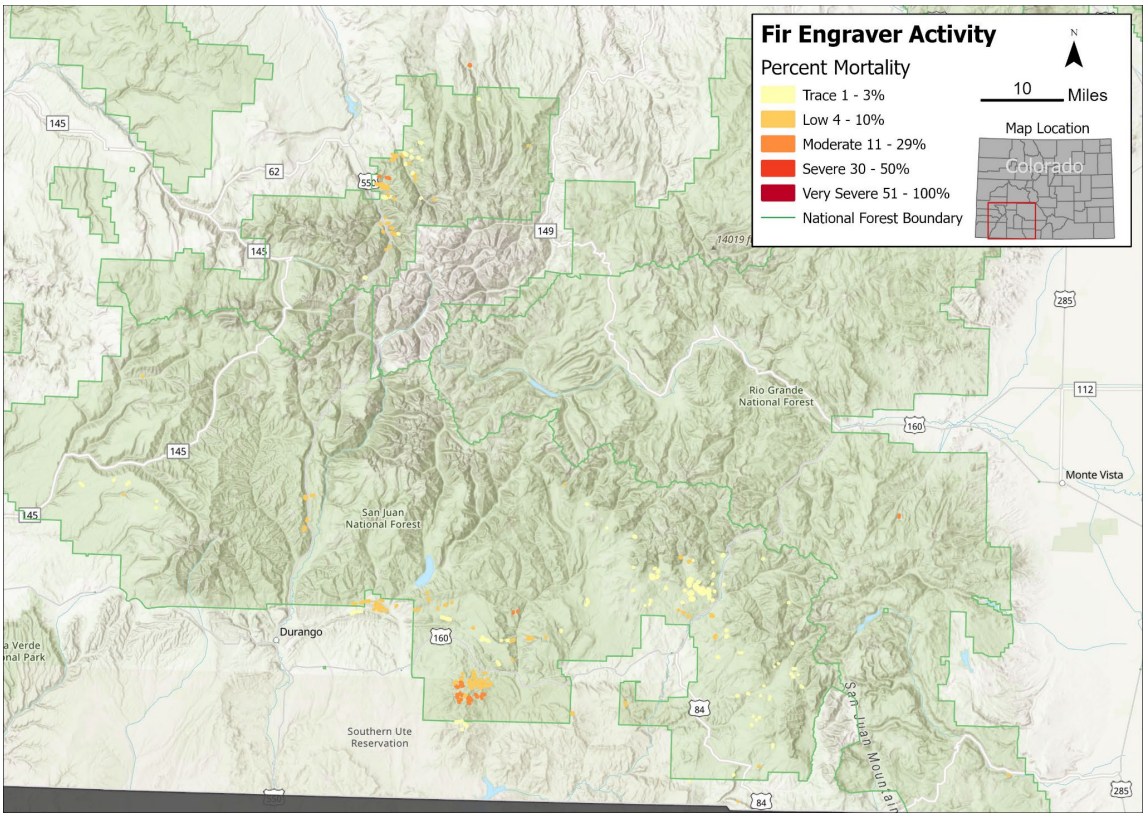

Figure 19. Fir engraver-caused mortality of white fir in and around the San Juan and Rio Grande National Forests as observed by the 2022 aerial surveys. Map by Nathan Edberg, USDA-FS.

Engraver Beetles and Twig Beetles in Pines

Ips spp., *Pityophthorus* spp., and others
Hosts: ponderosa, lodgepole, limber, and pinyon pine

Engraver (*Ips*) beetles typically cause mortality in host trees that are stressed, most often due to drought. Most species of these beetles can have multiple generations in a single year so outbreaks can grow in size substantially over relatively short time periods when conditions are favorable.

In Colorado, over the past five years, persistent drought has created favorable conditions for increased engraver activity in pine species. Special aerial surveys conducted in 2022 over southwest Colorado reported nearly 4,600 acres of pinyon pine mortality and drought-related juniper mortality (Fig. 20). Pinyon *Ips* (Fig. 21) activity at the Colorado National Monument and northeast of the Uncompahgre Plateau has persisted for several years and has decreased since 2021. The population continues to slowly work around Ridgway Reservoir. South of the Uncompahgre Plateau there is an expanded hot spot around Nucla. Pinyon *Ips* has expanded on the Southern Ute Reservation south of Durango and Bayfield.

Pine engraver beetles, which include a complex of multiple *Ips* species, have all been active in the Black Hills and Nebraska National Forests in ponderosa pine (Fig. 22-23). Trees of all sizes are being killed. The pattern of mortality on the landscape ranges from scattered individual trees to the occasional larger group. Population increases have been observed throughout the Pike National Forest for both *Ips pini* and twig beetles in

ponderosa pine, specifically within and around the United States Air Force Academy campus.

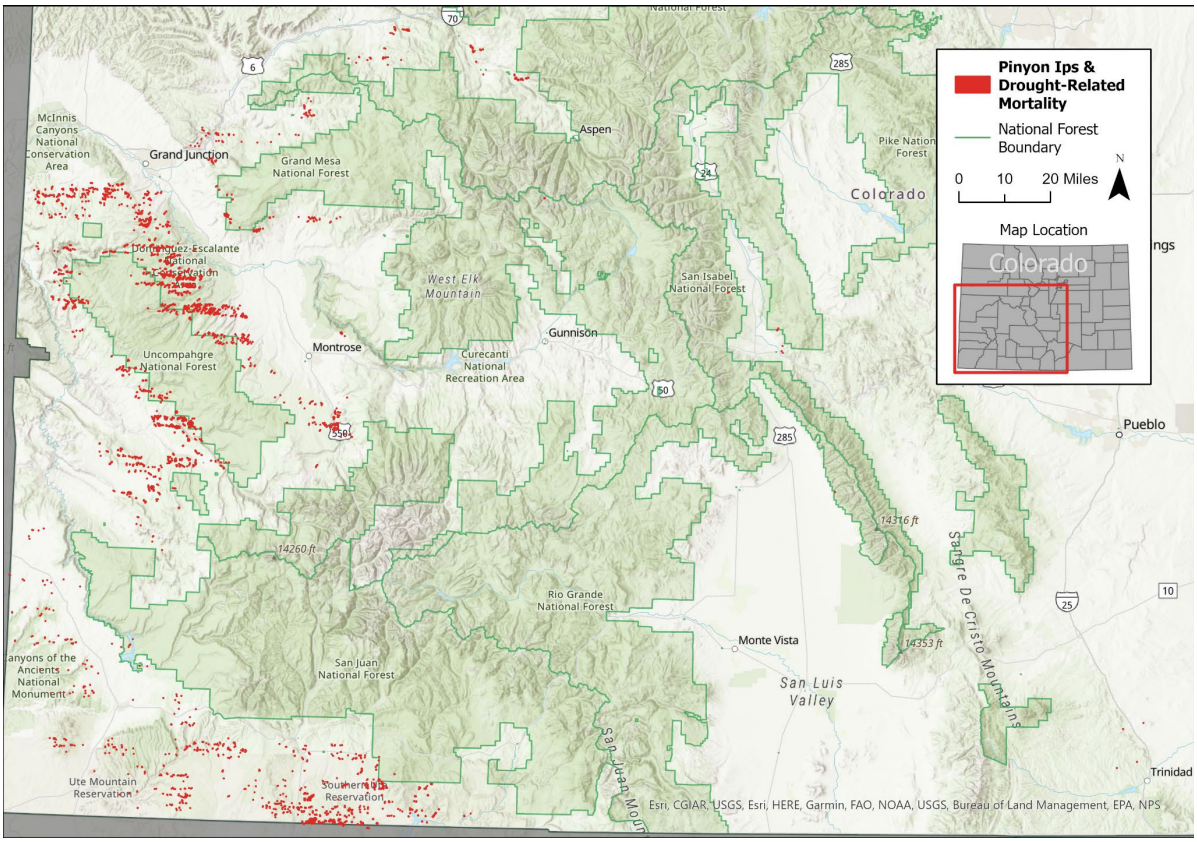

Figure 20. Pinyon *Ips* and drought-related juniper mortality observed by special aerial surveys in southwest Colorado. Map by Nathan Edberg, USDA-FS.

Figure 21. Pinyon killed by pinyon *Ips* (left), pitch tubes on the bole of a pinyon tree characteristic of *Ips* mass attack (center), and galleries under the bark caused by pinyon Ips (right). Photos by Suzanne Marchetti, USDA-FS.

Figure 22. Ips-caused mortality of ponderosa pine (left), *Ips* entrance hole and small pitch tube (center), and boring dust resulting from *Ips* infestation of ponderosa pine (right) on the Black Hills NF. Photos by Kurt Allen, USDA-FS.

Figure 23. Patches of Ips caused mortality of ponderosa pine (left and center) and *Ips* creating galleries in its host tree (right) within the Nebraska NF. Photos by Kurt Allen, USDA-FS.

Western Balsam Bark Beetle

Dryocoetes confusus

Host: subalpine fir

In Colorado, pockets of mortality caused by western balsam bark beetle (WBBB) in subalpine fir mapped by aerial survey have increased from 29,000 acres in 2021 to 35,000 acres in 2022 (Fig. 24). The GMUG National Forests are seeing significant changes, especially in high elevation areas that meet sagebrush parks. The Gunnison and Crested Butte areas are showing signs of increased mortality. Ground observations indicate a large uptick in twig beetles in subalpine fir throughout the GMUG National Forests, which have turned the outermost branches red. Drought is likely the driving force causing both WBBB and twig beetles to expand throughout Colorado. While WBBB is commonly associated with trees that have been weakened by diseases such as armillaria root rot, diseases have not always been found when examining WBBB-attacked trees on the ground (Fig. 25). In spruce-depleted areas where there is less competition, subalpine fir seems to be healthier,

and this phenomenon is generally observed on the Rio Grande National Forest. Increased activity has also been observed throughout the Arapaho-Roosevelt and Routt National Forests.

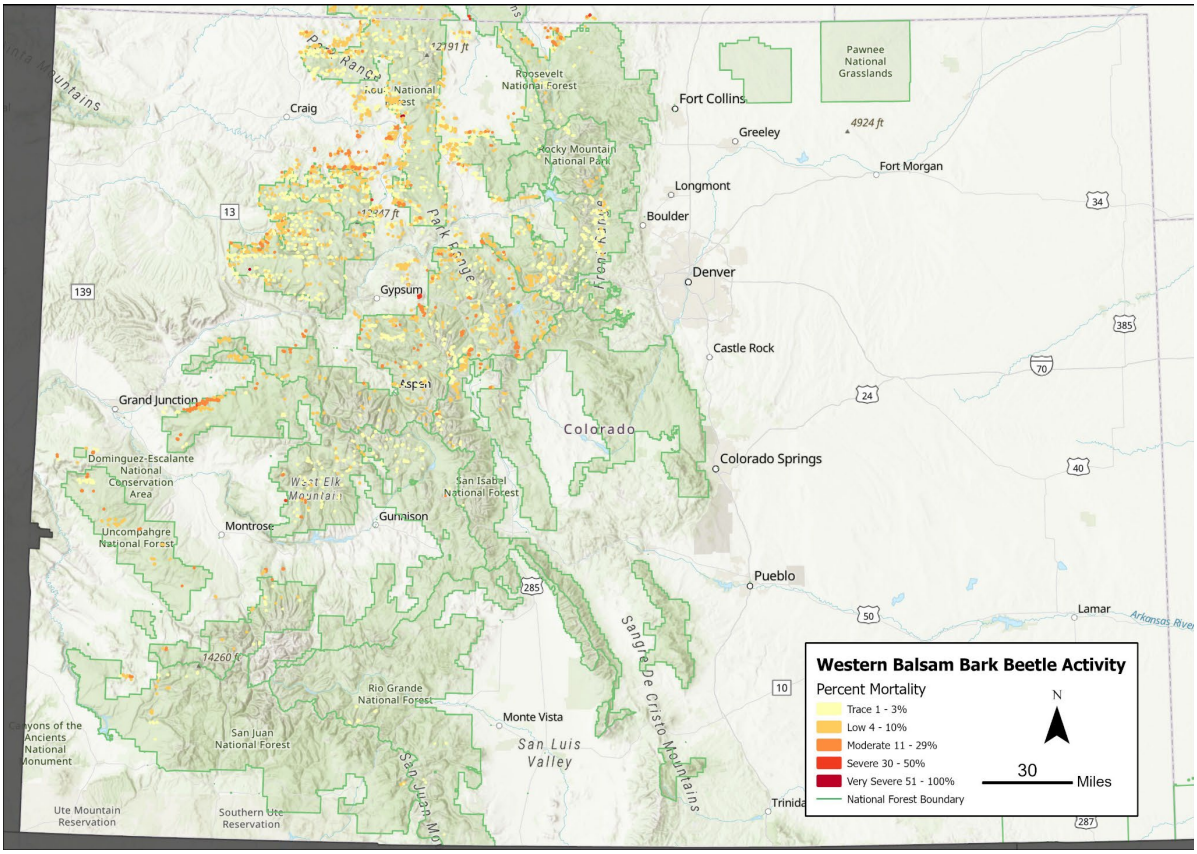

Figure 24. Trace to low-intensity western balsam bark beetle activity in subalpine fir in Colorado as observed from the 2022 aerial detection surveys. Map by Nathan Edberg, USDA-FS.

In Wyoming, aerial surveys indicated that subalpine fir mortality caused by western balsam bark beetle was light and scattered in the Absaroka, Wind River, Bighorn, and Snowy Ranges (Fig. 26). Ground surveys suggest a potential increase in western balsam bark beetle activity in the northern Bighorn Mountains.

Figure 25. Subalpine fir killed (left), and galleries carved by western balsam bark beetle (right) on the White River National Forest. Photos by Brad Lalande, USDA-FS.

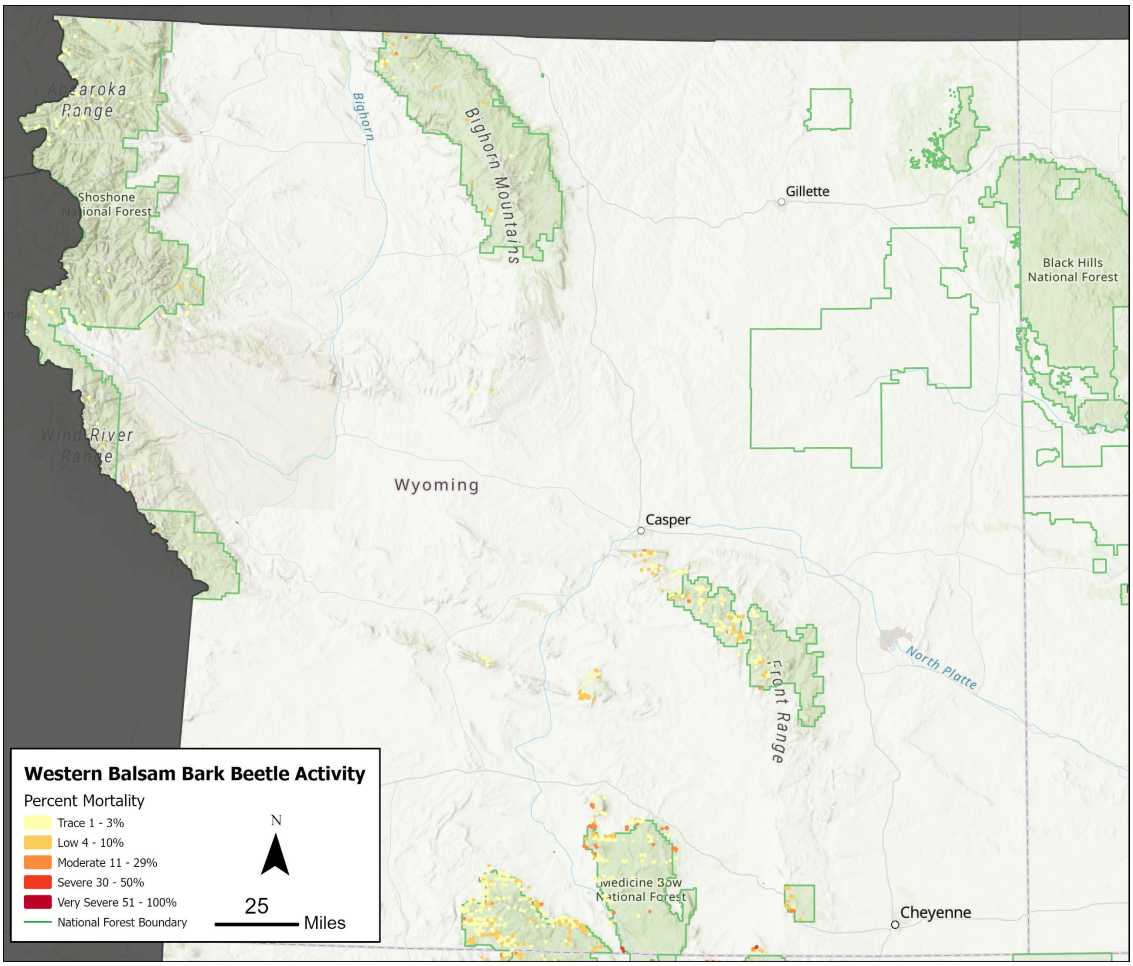

Figure 26. Trace to low-intensity western balsam bark beetle activity in subalpine fir in Wyoming as observed from the 2022 aerial detection surveys. Map by Nathan Edberg, USDA-FS.

Red Turpentine Beetle

Dendroctonus valens

Host: any pine species and occasionally Douglas-fir

Red turpentine beetle activity was observed in the Iron Springs / Iron Beetle Toe project area on the Uncompahgre National Forest via ground surveys in ponderosa pine (Fig. 27). The affected area had a prescribed burn in 2018 and fire injury likely predisposed trees to attack by this beetle. Red turpentine beetles are typically not a primary killer of healthy trees.

Figure 27. Pinned adult red turpentine beetle specimen (left) and the base of a ponderosa pine bole that has been fire-scorched and attacked by red turpentine beetles at the Iron Springs / Iron Beetle Toe project area (right). The large pitch tubes and boring dust at the base of the tree are typical of red turpentine beetle attack (right). Photos by Suzanne Marchetti, USDA-FS.

Lodgepole Pine Beetle

Dendroctonus murryannae

Host: lodgepole pine

Lodgepole pine beetle continues to be associated with limited and scattered mortality of lodgepole pine in the Bighorn National Forest (Fig. 28). This is an elusive beetle in R2 which has been found in small pockets and scattered trees in a few locations in the Bighorn National Forest over the past few years. It is not currently considered an insect of concern as it is an infrequently encountered bark beetle in the Region. Species identification was confirmed by USDA-FS Forest Health Protection National Entomologist, Bob Rabaglia in 2021.

Figure 28. Characteristic lodgepole pine beetle pitch tubes and frass (left), and an adult beetle building a gallery in lodgepole pine (right), Bighorn National Forest. Photos by Kurt Allen and Kendra Schotzko, USDA-FS.

Status of Major Defoliators

Western Spruce Budworm

Choristoneura freemani

Hosts: true firs, Douglas-fir, and spruce

Aerial surveys detected 112,000 acres of western spruce budworm activity in Colorado and 33,000 acres in Wyoming in 2022 (Figs. 29, 31).

In Wyoming, spruce budworm defoliation continues to be apparent across almost all Douglas-fir stands on the Shoshone, Bighorn, and to a lesser degree on the Medicine Bow National Forests. In many areas, heavy defoliation has been occurring for multiple years, and this has led to very unhealthy, stressed trees and tree mortality (Fig. 30). All size classes of host trees are being impacted. Light budworm defoliation has been observed in Engelmann spruce and subalpine fir in the far northwest corner of the Shoshone National Forest. Many areas with the heaviest defoliation are seeing more Douglas-fir beetle activity as the beetles take advantage of trees weakened by budworm.

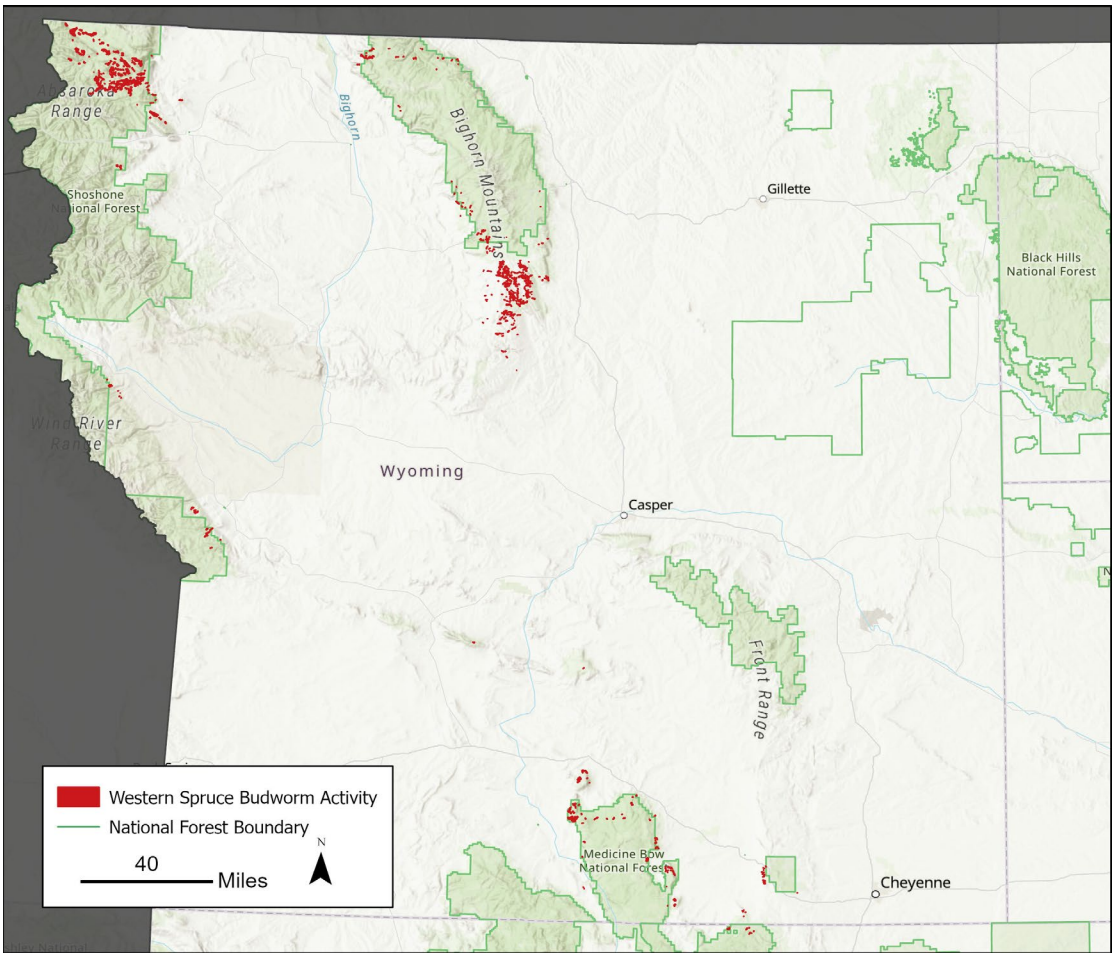

Figure 29. Western spruce budworm activity in Wyoming as observed from the 2022 aerial detection survey. Map by Nathan Edberg, USDA-FS.

Figure 30. Douglas-fir trees defoliated by western spruce budworm (top row), and the four stages of the western spruce budworm lifecycle - eggs, larvae, pupae, and adult (left to right, bottom row) on the Shoshone National Forest. Photos by Kendra Schotzko, USDA-FS.

In Colorado, spruce budworm activity remains high and continues to spread into areas with suitable hosts. Every national forest in the state has some degree of budworm disturbance (Fig 31). The south-central forests of Colorado continue to experience intense defoliation resulting in pockets of tree mortality. Repeatedly defoliated, drought-stressed trees are left susceptible to attack by Douglas-fir and other bark beetles. Ground observations in the Routt, Pike, Roosevelt, San Juan and GMUG National Forests recorded heavy budworm damage in spruce/fir stands in 2022.

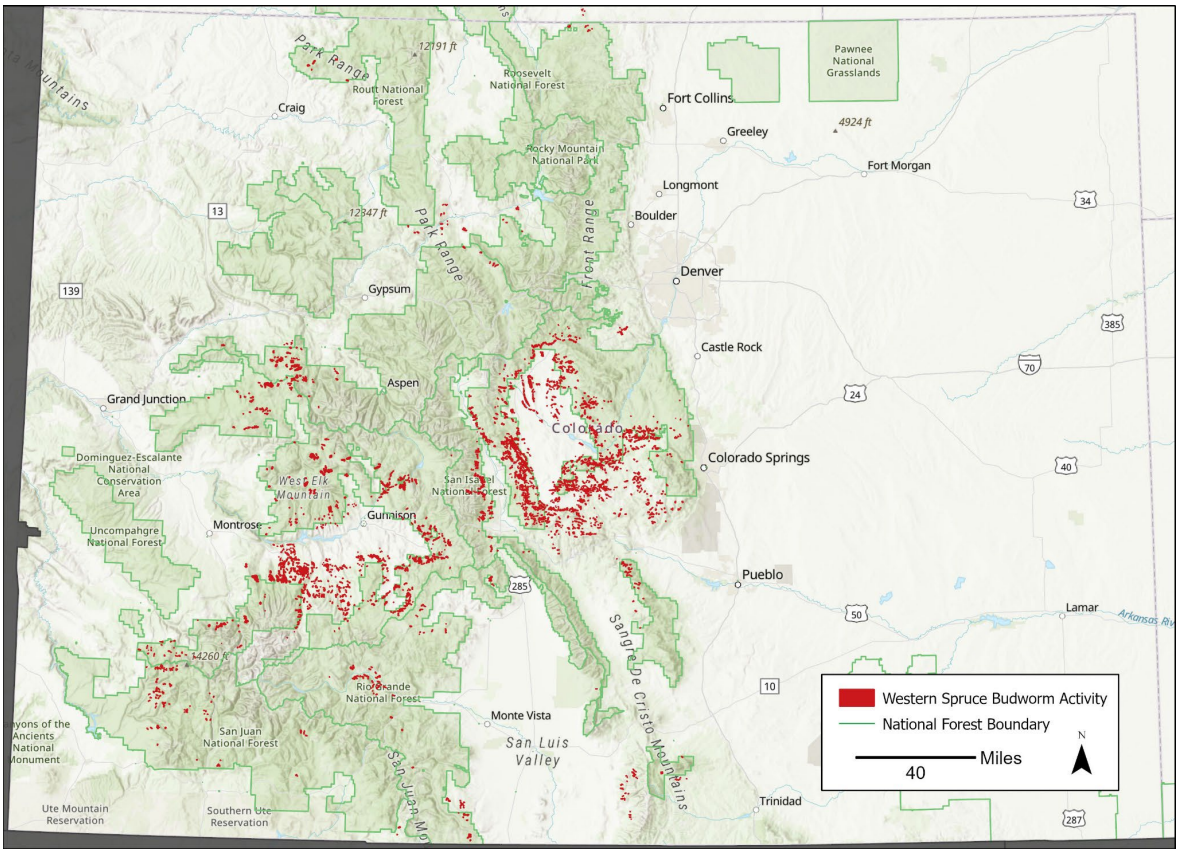

Figure 31. Western spruce budworm activity in Colorado as observed from the 2022 aerial detection survey. Map by Nathan Edberg, USDA-FS.

Aspen Defoliating Insects

Aspen defoliation/foliar damage caused by a number of defoliators and other biotic and abiotic agents was observed on 30,000 acres in 2022, primarily in Colorado (Fig. 32). The most notable insect defoliation was caused by large aspen tortrix and western tent caterpillar. Ground-checking the causal agent is difficult in many areas. However, ground observations did detect increased activity on Kenosha Pass in the Pike National Forest. The GMUG and Rio Grande National Forests have experienced higher levels of defoliation in the last few years, but this year was less notable. Aspen leaf diseases and abiotic defoliators are discussed in the “Status of Major Diseases” chapter. All of these produce similar aerial signatures and must be ground-checked to verify the specific damage-causing agents in a particular stand. Aspen typically survives defoliation events, as they can refoliate by mid-summer, however, repeated defoliation over several years can result in mortality.

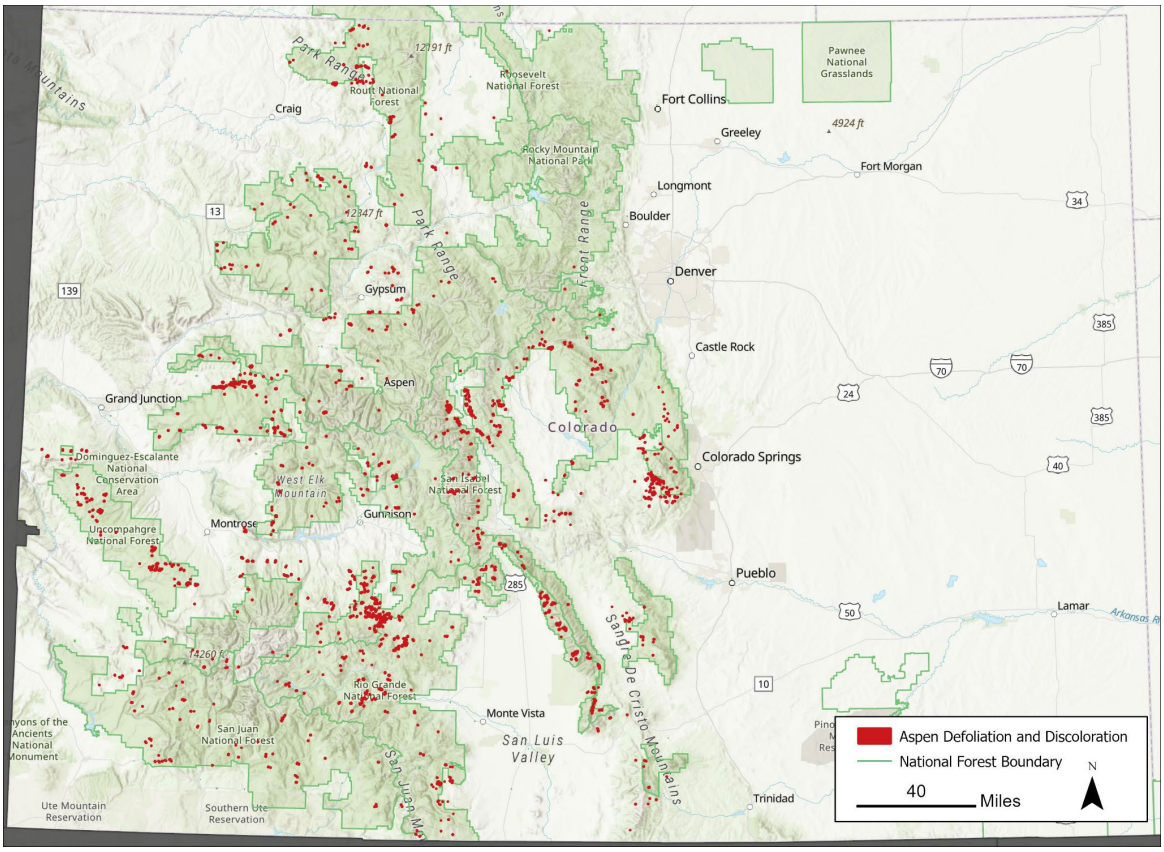

Figure 32. Aspen defoliation and discoloration in Colorado as observed from the 2022 aerial detection survey. Map by Nathan Edberg, USDA-FS.

Large Aspen Tortrix

Choristoneura conflictana

Host: aspen

Large aspen tortrix activity (Fig. 33) was widespread throughout aspen stands in Colorado in 2022, although no tree mortality was observed. The heaviest defoliation occurred in early summer with notable damage occurring on the Pike and San Isabel National Forests. The distribution appeared to be intermixed with other defoliating insects, especially the twoleaf tier moth where whole stands of defoliated aspen were observed (Fig. 34). A synergistic relationship may exist between these two native insects, however this dynamic is poorly understood and requires further study. Annual weather events likely contribute to the size and extent of outbreaks in our region.

Figure 33. Defoliated aspen stand (left), and pupa in aspen leaf rolled by large aspen tortrix (right) near Kenosha Pass. Photos by Rebecca Stokes USDA-FS.

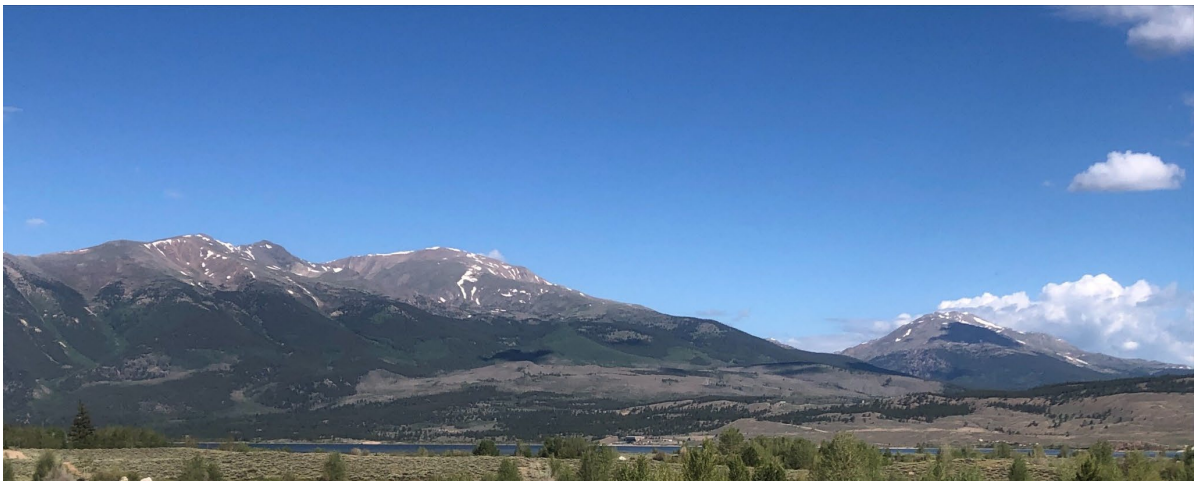

Figure 34. Large area of aspen defoliation caused by a combination of large aspen tortrix and aspen twoleaf tier moth in the Sawatch Range. Photo by Alex Rudney USDA-FS.

Western Tent Caterpillar

Malacosoma spp.

Host: aspen, chokecherry and several other broadleaved tree and shrub species

Known for the formation of silken shelters or tents in deciduous trees (Fig. 35), western tent caterpillars were commonly encountered throughout the region in 2022. Four species of tent caterpillars occcur in Colorado. Heavy defoliation was observed on gambel oak, mountain mahogany, aspen and cottonwood trees in southwestern CO in early summer.

Figure 35. Western tent caterpillars in their tents on chokecherry in Gunnison National Forest. Photos by Amy Lockner, USDA-FS.

Aspen Twoleaf Tier Moth
Enargia decolor
Host: aspen, cottonwood

Aspen twoleaf tier moth activity was observed in aspen stands in the Gunnison National Forest and in the Sawatch Range. The light brown adult moths were also frequently collected in spongy moth traps. Translucent grey/green larvae feed inside webbing-bound leaves between May and mid-July (Fig. 36). As they mature, they begin feeding on the edges and outer surfaces of the leaves. Semi-mature and mature larvae construct their feeding and living shelter by tying the flat surfaces of two leaves together, a distinguishing characteristic of this small moth. Infested crowns appear very thin and ragged with many leaves being completely consumed. Close inspection is often required to differentiate the leaf damage cause by this insect from that of the large aspen tortrix. Outbreaks of this species are usually short-lived as a large number of parasites can cause the collapse of the infestation.

Figure 36. Aspen twoleaf tier moth larvae found characteristically sandwiched between two aspen leaves (left) and an adult moth (right). Photos by Griffin Payne, Colorado State Forest Service and Amy Lockner, USDA-FS.

American Aspen Beetle

Gonioctena americana

Host: aspen

Heavy defoliation from the larvae of American aspen leaf beetles was reported on Kenosha Pass and South Park in Park County, Colorado. American aspen leaf beetles are 5-6 mm long and overwinter as adults in leaf litter on the forest floor. Females deposit live larvae in groups of about 12 on the underside of the leaf in June and larvae feed for about three weeks (Fig. 37).

Figure 37. American aspen beetle larvae in Park County, CO in 2022. Photo: Dan West, Colorado State Forest Service.

Pine Looper

Phaeoura mexicanaria
Host: ponderosa pine

Pine loopers defoliated about 4,000 acres of ponderosa pine in the Hell Canyon Ranger District of the Black Hills National Forest in 2022. Looper-caused defoliation was observed in mid-August 2022 northeast of Pringle, South Dakota (Figs 38-39). This species is native to the Black Hills and can be found throughout the West. Pine looper defoliates all ages and crown levels of ponderosa pine. No other host tree species have been identified. Pine looper usually persists in low numbers without causing noticeable damage. Large infestations of pine looper are an uncommon but natural occurrence.

Pine looper larvae mimic different parts of their pine hosts as they mature. Early instar larvae resemble pine needles or fine twigs (Fig. 40). Later instar pine loopers more closely resemble pine twigs and small branches, and come in various colors that camouflage well with twigs and branches. Color variations observed include black and dark brown, dark brown and red, orange and brown, orange and cream, and grey/black with reduced tubercles (Fig. 41). They feed on both new and old foliage from July through August. Young larvae partially consume needles, resulting in curled brown foliage, while older larvae consume needles down to the fascicle sheath (Fig. 42). Pine loopers spend the winter as pupae in the duff (Fig. 43) and begin emerging as adult moths in mid-June. Large infestations of pine looper are not only uncommon but also very short-lived. Parasites, predators, and diseases (Fig. 44) are abundant during infestations. These natural enemies drive the collapse of infestations after one or two years.

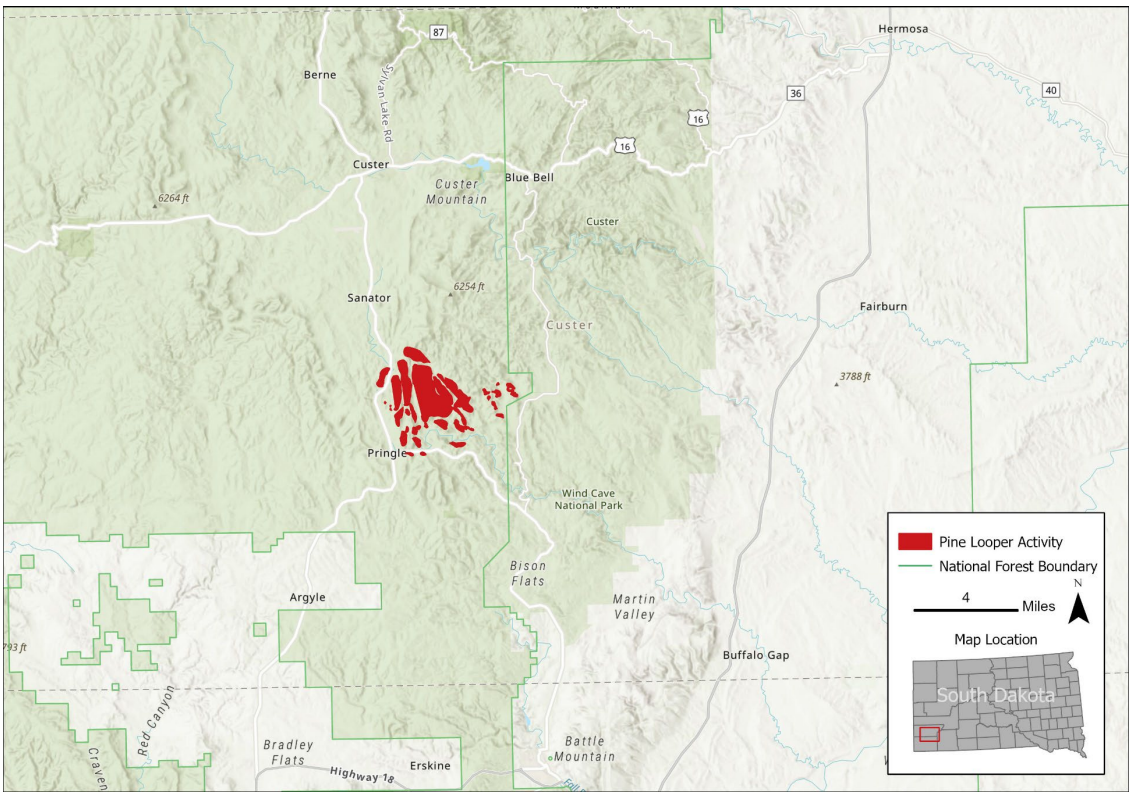

Figure 38. Area affected by pine looper defoliation on the Black Hills National Forest as observed by the 2022 aerial detection survey. Map by Nathan Edberg, USDA-FS.

Figure 39. Defoliation of ponderosa pine by pine looper caterpillars in the Black Hills National Forest in 2022. Photos by Kendra Schotzko, USDA-FS.

Figure 40. Early instar pine looper, Black Hills National Forest, 2022. Photos by Kendra Schotzko, USDA-FS.

Figure 41. Diversity of late instar pine looper color and morphology observed in the Black Hills National Forest in 2022. Photos by Kendra Schotzko, USDA-FS.

Figure 42. Damage and complete consumption of ponderosa pine foliage by pine looper in the Black Hills National Forest 2022. Photos by Kendra Schotzko, USDA-FS.

Figure 43. Pine looper pupae collected for observation (left), buried in the duff of a ponderosa pine stand in the Black Hills National Forest (center), and evidence of animal foraging in the Black Hills National Forest. Photos by Kendra Schotzko, USDA-FS.

Figure 44. Dead pine looper in the Black Hills National Forest aggregated at the base of a ponderosa pine tree (left) and hanging from ponderosa pine branches (center and right). Photos by Kendra Schotzko, USDA-FS.

Status of Major Diseases

Dwarf Mistletoes

Arceuthobium spp.

Hosts: pines and Douglas-fir

Dwarf mistletoes (Fig. 45) are parasitic plants that are among the most widespread and damaging forest pathogens in the region. Five *Arceuthobium* species occur in the Rocky Mountain Region, each with a specific set of susceptible hosts. Dwarf mistletoe infections cause branch deformities such as swelling and “witches’ brooms”, stunted growth, thinning crowns, and premature mortality. Stress induced by severe infection often leads to bark beetle or root disease-related mortality. Fire regimes play a direct role in the incidence and severity of dwarf mistletoes. Fire exclusion leads to extensive spread.

Figure 45. Limber pine dwarf mistletoe (*Arceuthobium cyanocarpum*) on Rocky Mountain bristlecone pine (left) and a heavily infected Rocky Mountain bristlecone pine with large witches' brooms on Bureau of Land Management land in South Park, Colorado (right). Photos by Liz Hahnenberger, USDI-BLM.

Dwarf mistletoes are ubiquitous in the region, but extremely large wildfires over the past decade have reduced inoculum levels in some areas, particularly in lodgepole pine forests of northern Colorado and southern Wyoming. Silvicultural treatments to reduce impacts are being conducted in many parts of the region including the Bighorn, Medicine Bow-Routt, and Shoshone National Forests. Continued management of dwarf mistletoes, in conjunction with bark beetle management, will increase the health of future forests.

A dwarf mistletoe management guide is available for the region (*Dwarf Mistletoes: Ecology and Management in the Rocky Mountain Region*). Please see the Rocky Mountain Region, Forest Health Protection website.

Root Diseases

Root diseases are persisting and occur within all tree species in R2. Recent extreme storms and weather patterns have exposed pockets of extensive damage caused by these pathogenic fungi. As a result, *Armillaria* spp. (the most damaging root disease pathogens in mixed conifer forest types), *Onnia tomentosa* (spruce-fir and pines), *Ganoderma applanatum* (aspen and various hardwood species, especially in eastern R2), *Heterobasidion* spp. (white fir in Colorado and pine in central Nebraska), and *Phaeolus schweinitzii* (Douglas-fir) were all found within R2 in 2022. Extreme wind events resulted in patches of blowdown with further investigation revealing extensive infection from numerous root diseases. Root diseases are difficult to identify without fruiting bodies, difficult to manage as they persist in the soil for decades as saprophytes, and symptoms are often obscure. For some districts, increased precipitation in the spring and summer months of 2022 gave rise to a significant amount of fruiting bodies of some root disease pathogens. Additionally, management is more complex in stands where two multiple root diseases occur simultaneously.

Armillaria Root Disease
Armillaria spp., primarily *A. solidipes* (*A. ostoyae*), *A sinapina,* and *A. gallica*
Hosts: all tree species in the Region are susceptible

Armillaria spp. are the most common root pathogens and occurs on all conifer and hardwood tree species in the region. *Armillaria solidipes* is found mostly in conifers, *A. gallica* is found mostly in hardwoods, and *A. sinapina* is found in both conifers and hardwoods. Signs of the pathogen include mycelial fans under the bark and melanized root-like rhizomorphs (Fig. 46), zone lines in wood, and occasionally clustered honey-mushrooms at the base of trees in late summer to late fall. Infected hosts may have crown dieback and thinning, basal resinosis, and extensive decay of the tree's roots and butt.

Infected trees may show similar symptoms of dieback to stresses caused by abiotic factors, therefore identifying the signs of the disease is key to positive identification. Following high wind events and post-management, tree failures resulting from the lack of healthy root systems revealed extensive Armillaria root disease infections in southern Colorado. In 2022, no formal surveys were conducted for Armillaria root disease, however, there are projects in development for 2023.

Figure 46. Rhizomorphs formed within internal decay of white fir stump (left). Extensive decay and mycelial fans in the failed root system (center). Down subalpine fir, with dieback and thinning crown, following failure caused by Armillaria root disease (right). Photos by Brad Lalande, USDA-FS.

Tomentosus Root Rot
Onnia tomentosa
Hosts: Spruce-fir (Engelmann and white spruce, subalpine fir) and lodgepole pine

Tomentosus root rot is a white pocket rot that occurs in the roots and base of susceptible trees. The pathogen produces small, leathery or velvety annual fruiting bodies that range from yellow-brown to dark brown (Fig. 47) during August and September. Spread occurs primarily via root-to-root contact or by spore infection of root wounds. With all the moisture, fruiting bodies were highly abundant in southern Colorado in 2022, indicating that the pathogen is abundant. Due to the timing of fruiting bodies, their small size, and their distance from the main stem (they occur mostly on roots near the soil surface), they are easily missed during assessments of developed recreation sites. This can result in whole tree failures due to extensive root decay.

In 2022, a multiregional (Regions 1, 2, 4) group conducted tomentosus root rot surveys in Montana and Wyoming, in coordination with Dr. Jane Stewart's lab at Colorado State

University. The study will expand into Colorado and Utah to determine root disease pathogens associated with individual tree species and to establish a rapid genetic assay to identify presence in susceptible trees. The multiregional group sampled symptomatic and healthy tree species at campgrounds throughout Montana and in Yellowstone National Park, by collecting core samples at the base of trees, root samples, and fruiting bodies (when present). Additional collections were conducted in southern Colorado in collaboration with the Gunnison Service Center.

Figure 47. Tomentosus root rot fruiting body with velvety, light brown upper surface (left) and white pocket rot in infected roots (right). Photos by Brad Lalande, USDA-FS.

Rusts and Cankers

Comandra Blister Rust

Cronartium comandrae

Hosts: lodgepole and ponderosa pine
Alternate hosts: bastard toadflax and northern comandra

This fungal rust disease is one of the most damaging diseases of lodgepole pine and occasionally damages ponderosa pine in the region as well. The disease causes timber volume loss. Symptoms include extensive cankering that often results in spiked tops (top-kill), flagging (branch death), and tree mortality (Fig. 48). Infected seedlings and saplings are often rapidly killed.

In the Region, it is mainly a problem of lodgepole pine in Wyoming and northern Colorado. The disease enters its host through needles and spreads down branches. In recent years, many twig and branch cankers have been observed. It was frequently observed in the Bighorn and Shoshone National Forest wilderness areas in 2022. Because it can take a few years for the disease to spread to stems and girdle trees, future top-kill and mortality should be expected.

Figure 48. Comandra blister rust killing a large tree (left), a close-up of the same tree showing the perennial concentric canker ridges (middle), and a sporulating canker on a lower branch (right). Photos by Jim Blodgett, USDA Forest Service.

White Pine Blister Rust

Cronartium ribicola

Hosts: limber, whitebark, and Rocky Mountain bristlecone pine
Alternate hosts: currants and gooseberries (*Ribes* spp.), and species of *Pedicularis* and *Castilleja*

White pine blister rust (WPBR), caused by the exotic, invasive fungus *Cronartium ribicola*, continues to spread and intensify in R2. Favorable weather conditions over the past decade have allowed for continued expansion of the disease into previously unimpacted sites. New outbreaks have been reported in Boulder, Larimer, Alamosa, Huerfano, Costilla, and Saguache counties in Colorado and Albany and Carbon counties in Wyoming. Branch flagging, top kill, and mortality of some seedlings and saplings is occurring. In areas where the disease is well-established, such as the Medicine Bow, Bighorn, Shoshone, and Black Hills National Forests, WPBR is killing and damaging trees in almost all stands.

The combined impacts of WPBR, bark beetles, and climate change threaten white pines. Limber pine is listed as a “species of local concern” on the Black Hills National Forest, “species of management concern” in Rocky Mountain National Park, and “Bureau of Land Management (BLM) sensitive species” in Wyoming. In December 2022, US Fish and Wildlife Service listed whitebark pine, which occurs on the Shoshone National Forest and Wind River Indian Reservation in R2, as threatened under the Endangered Species Act. The Species Status Assessment Report concluded that the primary stressor affecting the

conservation status of whitebark pine is WPBR. Protections for whitebark pine will be increased and conservation strategies will be promoted.

R2-FHP is collaborating on a study with Colorado State University, Rocky Mountain Research Station, and the National Park Service to gain a better understanding of rust phenology and the meteorological drivers of spore production in our more arid environments. Abundant spore production was observed on wax currant (*Ribes cereum*) and giant red paintbrush (*Castilleja miniata)*, species typically considered insignificant hosts, during the particularly wet late summer and early fall of 2022 on the Arapaho-Roosevelt NF (Fig. 49), and on the more typical *Ribes* hosts on the Bighorn and Shoshone NFs in 2022. This may suggest a future spike in pine infection and indicate that wax currant and paintbrush may play a larger role in the disease cycle in the Rocky Mountain Region compared to other parts of the west. Forest Health Protection in the Rocky Mountain Region is partnering with Colorado State University, Rocky Mountain Research Station, the National Forest System, the National Park Service as well as other USDA-FS Regions to develop, promote, and implement proactive management strategies to protect, conserve, and restore these important species.

Figure 49. White pine blister rust was confirmed on giant red paintbrush (left) and wax currant (right) on the Arapaho-Roosevelt NF in 2022. Photos by Kelly Burns, USDA-FS.

Broom Rusts of Spruce and Fir
Chrysomyxa arctostaphyli
Hosts: Colorado blue, Engelmann, and white spruce
Alternate hosts: bearberry or kinnikinnick, manzanitas are occasional alternate hosts
Melampsorella caryophyllacearum
Hosts: subalpine and white fir
Alternate hosts: chickweeds

These fungal rust diseases are common in Colorado and Wyoming (Fig. 50). Initial infection results in chlorotic (pale) needles. Later, bright orange aecia develop on needles. Over several years the pathogen causes dense proliferation of branches (witches' brooms). These rust diseases cause dead tops and branches, growth loss, and tree mortality. Decay fungi often enter trees through dead tissue at the infection site, resulting in stem and branch breakage. This is a common problem in developed recreation sites in the region. These diseases were often found sporulating in 2022 in Colorado, South Dakota, and Wyoming. This could indicate that 2022 is a mass infection year (wave years) with favorable conditions for sporulation.

Figure 50. Broom rust in a stem that killed a large tree (left), fir broom rust on a branch (upper-right), and a close-up of sporulating broom rust (lower-right). Photos by Jim Blodgett, USDA Forest Service.

Western Gall Rust
Peridermium harknessii
Hosts: lodgepole and ponderosa pine

This pine-to-pine rust of stems and branches does not require an alternate host. The disease occurs in lodgepole and ponderosa pine throughout the region. Stem cankers ("hip-cankers," Fig. 51), often have a target-like appearance, greatly reduce merchantable volume, and often result in stem breakage. Stem breakage can result from the direct distortion of the wood, or more often because of decay fungi that can enter trees through the dead bark caused by this disease.

Figure 51. Western gall rust causing extensive deformation of lodgepole pine stems. Photos by Jim Blodgett, USDA Forest Service.

Diplodia Shoot Blight and Canker Disease
Diplodia sapinea
Hosts: pines and other conifers

This fungal disease is most damaging to ponderosa pine in the region. It causes shoot blights and cankers and affects trees of all ages and sizes (Fig. 52). Damage can be severe ranging from dead needles to tree mortality. Diplodia is now established in Wyoming and is a reoccurring disease problem in Kansas, Nebraska, and South Dakota. This is one of the few diseases frequently identified during Aerial Detection Survey (ADS), but only heavy infections have a strong enough aerial signature to detect remotely.

Figure 52. Diplodia shoot blight and canker disease in mature ponderosa pine trees (left and middle) and seedlings (right). Photos by Jim Blodgett, USDA Forest Service.

Lophodermella Needle Cast

Lophodermella concolor and *L. montivaga*

Host: lodgepole pine

Needle casts are one of the few diseases that can be detected via ADS. In the peak of discoloration in the early to mid-2010s, Lophodermella needle casts were found throughout much of Colorado. Recent climatic trends to warmer, drier environments suppressed these pathogens. In 2021 and 2022 seasonal monsoonal conditions, typically occurring in late spring to early summer, occurred in southern Colorado. The weather exacerbated current populations of *Lophodermella* causing isolated outbreaks, although little to no acres were mapped during 2022 ADS flights. As the infections were isolated to smaller areas, this is not likely a cause for concern, unless monsoonal conditions continue in future years.

These diseases cause defoliation or early casting of needles. Typically, the pathogen infects current year's needles either causing discoloration in early spring (*L. concolor*) or late summer to fall (*L. montivaga*). The resulting branches exhibit characteristic tufts with new needles being uninfected, while previous year's needles are brown or cast (Fig. 53). Typical symptoms include green needles occurring in last years and current needles, with all other needles either brown or defoliated. In southern Colorado, west of Marshall Pass, a landscape level infection occurred in 2022. All tree size classes were affected, while understory trees incurred more damage than overstory trees.

Figure 53. Tufted appearance of casting needles caused by Lophodermella needle cast (left). Needles with *Lophodermella montivaga* infection with browning/cast needles in previous year's needles (center). Symptoms of branch/tip dieback associated with Lophodermella needle cast (right). Photos by Brad Lalande (left) and Kelly Burns (center and right), USDA-FS.

Common Aspen Diseases

Mature aspen stands continue to deteriorate due to a multidecadal drought, and primary and secondary biotic agents in Colorado. In 2022, only 370 acres of aspen discoloration were observed within the region by ADS as many stands reached their tipping point due to abiotic and biotic factors. Although most of the region is currently affected by drought, seasonal monsoonal conditions have increased moisture during the late spring and summer of 2022 in Colorado. These conditions are typically conducive for spread and intensification of foliar pathogens. A few scattered stands in South Dakota and Wyoming did have severe Marssonina leaf blight, but overall, foliar diseases were less prevalent than in 2021.

The health of aspen stands throughout the region varies depending on location. Deterioration typically occurs in low elevation, south facing stands, as trees become stressed and succumb to secondary agents. Ground surveys in southern Colorado identified (in order of frequency) aspen trunk rot (*Phellinus tremulae*), cytospora canker (*Cytospora* spp.), sooty bark canker (*Encoelia pruinosa*), and black canker (*Ceratocystis populicola*) were the most abundant diseases associated with declining and dead stands (Fig. 54). These agents vary in importance throughout the region with sooty bark canker causing the most mortality, then cytospora canker, aspen trunk rot, *Ganoderma*, *Armillaria,* and black canker. Sooty bark canker was found mainly on standing dead trees, while the other agents were found in both healthy and declining trees. *Diplodia tumefaciens* was locally abundant in aspen stands of the Colorado Front Range. Fortunately, regeneration is highly abundant in recently treated stands, or where fires have occurred. Over 5,000 trees per hectare of aspen regeneration found, on average, in the 2022 ground surveys.

Figure 54. The three most common diseases found on aspen in Region 2. Fruiting body of *Phellinus tremulae* causing extensive decay on aspen, with pleasing fungus beetles feeding (left). Abundant tendrils exuding from pycnidia (fruiting bodies) of cytospora canker (center). Concentric curved lines indicative of sooty bark canker (right). Photos by Brad Lalande, USDA-FS.

Abiotic Damage

Downed Trees from Avalanches and Wind

Depending on the tree species and the size of trees broken or uprooted, avalanches or windthrow can create habitat for damaging beetles. Spruce beetle, Douglas-fir beetle, and western balsam bark beetle are all attracted to downed trees and could potentially build up populations in their respective hosts, Engelmann spruce, Douglas-fir, or subalpine fir. Beetle populations built up in downed trees can move to adjacent standing host trees. Mountain pine beetle is not attracted to downed trees, so the risk of bark beetle outbreaks is less where downed trees occur in lodgepole or ponderosa pine stands. The risk from bark beetles increases with the increasing size of host trees toppled and increasing abundance of standing host trees in adjacent stands. Other beetles such as engraver beetles also attack downed trees and can compete with potentially more serious bark beetles for space beneath the bark. In areas where avalanches are frequent, trees tend to be smaller and present less risk. Weather conditions, stand age, and composition all influence the potential for bark beetles to move into downed trees and eventually adjacent trees.

Relatively little damage caused by avalanches and wind was observed in 2022, a notable exception was in the Culebra mountains south of Cuchara Pass where 1,600 acres of primarily spruce and fir were windthrown in the winter/spring of 2021-22 (Fig. 55).

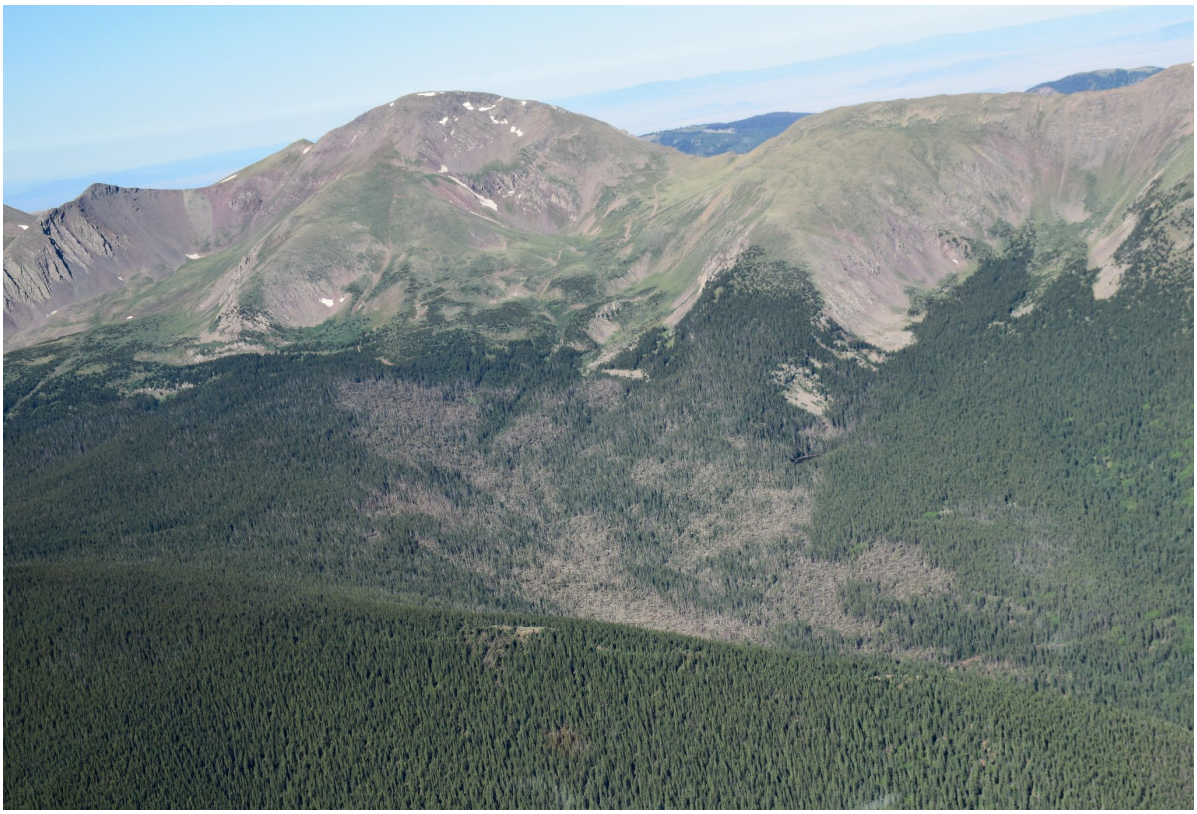

Figure 55. A large area of windthrown lodgepole, spruce and fir trees on the east side of the Culebra mountains, San Isabel National Forest, Colorado. Photo by Justin Backsen, USDA-FS.

FHP Programs and Information for Managing Invasive Species

The most notable invasive forest pest of our native trees in the region is the Eurasian disease white pine blister rust, which is expanding its range in five-needle pines.

Many more invasive tree insect and disease pests affect non-native trees in our urban and planted landscapes. Some are devastating urban tree pests such as emerald ash borer, walnut twig beetle, and Dutch elm disease. On our National Forest System lands, invasive plants are a serious threat to our rangelands and native plant communities. State and Private Forestry-FHP does not fund invasive plant treatments on National Forest System lands.

Invasive Plant Grants to States

FHP provides limited grant funding to state agencies for assistance with the local management of invasive plants on state and private forest lands to reduce the spread of priority weeds on all forest lands. By maintaining some flexibility in the program, states can put these dollars where they can make a project or program successful. Even small grants to the local weed management boards can make a big difference. Each state handles the funds differently to support treatments and leverage state and county funding for weed programs. Our state agency partners for the invasives plants program are the Colorado Department of Agriculture, Wyoming Department of Agriculture, South Dakota Department of Agriculture-Resources, Conservation and Forestry Division, Nebraska Forest Service, and Kansas Forest Service.

Other Entomology and Pathology Activities

FHP Trainings

R2 FHP staff provides annual training opportunities to resource managers on Forest Insect and Disease Identification and Management (FID) and Hazard Tree Management (HTM). In 2022, a hybrid training model was used for both courses in which participants attended a virtual classroom followed by an in-person field session to reduce exposure to COVID-19. In 2022, HTM field sessions were conducted on the Arapaho-Roosevelt, Pike-San Isabel, and San Juan National Forests and FID courses were conducted on the Arapaho-Roosevelt, Bighorn, Black Hills (2), GMUG, Medicine Bow-Routt, Nebraska, Pike-San Isabel, and Shoshone National Forests. The virtual portions of the training sessions were conducted live via Microsoft Teams, and attendance was at an all-time high and included a diverse group of agency representatives and stakeholders (USDA-FS, NPS, BLM, State, universities, and private companies). For more information regarding regional trainings please visit our regional training website.

Hazard Tree Management Program

Various new and updated Hazard Tree Management products were recently completed. Those include a new *Tree Failure e-Form* and associated *Tree Failure Form Guide*. Revisions were made to the *Hazard Tree Evaluation Survey123 and ArcGIS Online Guide* and *Trimble Hazard Tree Evaluation Guide*. All Hazard Tree Management Training PowerPoints were updated, as were the Region's Hazard Tree Web pages. FHP provided virtual talks, on-site hazard tree survey training and assistance with hazard tree management in 2022. More information is available on the Region 2 FHP Hazard Tree Management Website.

Hazard Tree Management Success Story

During a pre-season inspection of Springdale Campground on the Pike's Peak Ranger District, Pike-San Isabel National Forest, USDA-FS employees identified several recent tree failures that they suspected were caused by root disease (Fig. 56). Springdale Campground is operated and maintained by Rocky Mountain Recreation (RMR) and consists of 13 campsites, some of which are within mature spruce-fir forests. With the okay of the District Ranger, FHP conducted a site visit with Ranger District and RMR employees to diagnose the problem and assess the extent of the situation. Armillaria root disease was confirmed in several live trees, but impacts appeared to be concentrated in a small portion of the campground with a more northern exposure. In spring 2022, ten RMR employees successfully completed the FHP HTM training. Once trained, RMR conducted a more thorough survey of the campground; their findings supported our initial assessment. The concessionaire closed the affected area of the campground pending mitigation. However, the majority of the campground remained open (Fig. 56). We appreciate the hard work by RMR and the District to ensure the health and safety of all who recreate on USDA-Forest Service lands.

Figure 56. An Engelmann spruce that failed with extensive root decay caused by Armillaria root disease (left). A small portion of the campground was closed pending mitigation (right). Photos by Kelly Burns, USDA-FS.

Special Forest Health Protection Projects

Evaluation Monitoring (EM)

Sentinel walnuts: monitoring decline and change in western Kansas walnuts for early detection of thousand cankers disease. EM-IW-20-01. Ryan Armbrust and Jim Kruse.

Special Technology Development Program (STDP)

Developing tools for early detection an monitoring of high elevation pine rusts STDP-R2 2022-01. Kelly Burns and Jane Stuart

Biocontrol of Invasive Forest Pests (BCIFP)

Enhancing Canada thistle biocontrol: development of accurate and cost-effective tools to identify Canada thistle rust in plant tissue and soil. BCIFP-R2-20-01. Andrew Norton.

Performance curves to optimize mass rearing and field release of introduction biological control for Russian knapweed. BCIFP-R2-20-02. Paul Ode.

Publications

2022 Biological Evaluations and Service Trips

Gunnison Service Center

GSC-22-01, Lalande, B., Lockner, A., Schotzko, K., S. Marchetti. 2021. Evaluation of Quaking Aspen 10-year Management Plan on the White River National Forest. Service Trip Report.

GSC-22-02, Lalande, B., Lockner, A., Schotzko, K., S. Marchetti. 2021. Proposed Aspen Management Strategies and Forest Health Aspen Insect and Disease Monitoring Plan on the White River National Forest. Service Trip Report.

GSC-22-03, Lalande, B., Lockner, A., Marchetti, S., J. Nelson. 2022. Forest Health Site Visits on the Rio Grande National Forest, Divide and Saguache Ranger Districts. Service Trip Report.

GSC-22-04, Marchetti, S., Lockner, B., Lalande, B., J. Nelson. 2022. Mountain Pine Beetle Activity in Lodgepole Pine: Update on the Wilder-Gunnison Highlands, and Gunnison National Forest Outbreak. Service Trip Report.

GSC-22-05, Lalande, B., Lockner, A., S. Marchetti. 2022. Forest Health Tour of the San Isabel National Forest (Salida and San Carlos Ranger Districts). Service Trip Report.

GSC-22-06, Lockner, A., Lalande, B., Marchetti, S., K. Schotzko. 2022. Forest Health Assessment of Colorado National Monument. Service Trip Report.
GSC-22-07, Lockner, A., Lalande, B., Marchetti, S., J. Nelson. 2022. Project Site Visits and Concerns on the San Juan National Forest. Service Trip Report.
GSC-22-08, Lalande, B., Lockner, A., Marchetti, S., J. Nelson. 2022. Remeasurements of the Gunnison and Uncompahgre National Forests Sudden Aspen Decline Plots: Comparison Between 2020/2021 and 2013. Service Trip Report.
GSC-22-09, Marchetti, S., Lockner, A., J. Nelson. 2022. Spruce Beetle Trapping in the Cottonwood Canyons of the San Isabel National Forest. Service Trip Report.

Lakewood Service Center

LSC-22-01, Evaluation of Declining Aspen Stands in Steamboat Springs, HPBE RD, RNF – Burns, Kruse, Lalande, Stokes
LSC-22-02, Site Assessment of Aspen Ski Area – Stokes
LSC-22-03, Fox Park Dwarf Mistletoe Projects – Burns
LSC-22-04, Tie City Campground Hazard Tree Assessment, Laramie Ranger District, Medicine Bow National Forest – Burns
LSC-22-05, Douglas RD PIPO – Burns
LSC-22-06, EDRR Plots in RMNP – Burns
LSC-22-07, Forest Health Assessment of Fort Riley – Stokes
LSC-22-08, Forest Health Assessment of Fort Leavenworth – Stokes

Rapid City Service Center

RCSC-22-01, Bark Beetle Activity on the Black Hills National Forest – Allen, Schotzko
RCSC-22-02, Pine Engraver Beetle Activity on the Nebraska National Forest – Allen, Schotzko
RCSC-22-03, Observations on Dendroctonus murrayanae in lodgepole pine on the Bighorn National Forest – Allen, Schotzko
RCSC-22-04, Spruce Beetle Assessment, Bighorn National Forest – Allen, Schotzko
RCSC-22-05, Forest Insect and Disease Conditions in the East Winds Project Area – Allen, Schotzko
RCSC-22-06, Black Hills National Forest Log Deck Inspection: Cameron POL Decks, Mystic Ranger District - Schotzko
RCSC-22-07, Western Spruce Budworm Activity in the Tensleep Canyon Area, Bighorn National Forest – Allen, Schotzko, Blodgett
RCSC-22-08, Defoliation by Western Spruce Budworm in the Shoshone National Forest, Wyoming – Allen, Schotzko
RCSC-22-09, Western Spruce Budworm Activity in the Sinks Canyon Area, Shoshone National Forest – Allen, Schotzko
RCSC-22-10, Limber Pine Planting in the Black Hills National Forest (2021 Update) – Blodgett
RCSC-22-11, Summary: Pine Looper in the Black Hills National Forest – Schotzko

Other Reports and Peer-Reviewed Publications

Bentz, B. J., Hansen, E. M., Davenport, M., & Soderberg, D. (2022). Complexities in predicting mountain pine beetle and spruce beetle response to climate change. In *Bark Beetle Management, Ecology, and Climate Change* (pp. 31-54). Academic Press.

Blodgett, J. T. and Mayer, C. 2022. Research and Management of High-Elevation Five-Needle Pines in Western North America. Foundation, Whitebark Pine Ecosystem, "Full Issue" (2022). Research and Management of High-Elevation Five-Needle Pines in Western North America. 20.

Schoettle, A.W., Burns, K.S., McKinney, S.T., Krakowski, J., Waring, K.M., Tomback, D.F., Davenport, M. (2022) Integrating forest health condition and species adaptive capacities to infer future trajectories of the high elevation five-needle pines. In *Forest Ecology and Management, 521,* 120389.

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