Forest Health Protection
Pacific Southwest Region

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To: District Ranger, Mt. Hough Ranger District, Plumas National Forest

Subject: Potential bark beetle activity within the Moonlight and Antelope Complex Fires (NE07-08)

At the request of Ryan Tompkins, Silviculturist, Mt. Hough Ranger District, I visited the 2007 Moonlight and Antelope Complex fires on November 29, 2007 to evaluate fire-injured trees and assess the potential for increased bark beetle activity within and adjacent to the burned areas. I examined trees in areas north of Antelope Lake and west of Wildcat Ridge in the Moonlight Fire and areas south and east of Antelope Lake in the Antelope Complex Fire. These fires encompassed extremely large areas of which only a small percentage was observed during this visit. Additional areas within the Antelope Complex were previously visited on July 27, 2007 with district personnel from the Beckwourth and Mt. Hough Ranger Districts.

Figure 1. Moonlight Fire, Plumas National Forest, November 29, 2007

Background

The Moonlight Fire started on September 3, 2007 (Figure 1) and burned 64,997 acres of mixed conifer in the transition zone between the westside mixed conifer and eastside pine forest types. The conifer species, and their approximate composition, found within the burn consist of 13% ponderosa pine (*Pinus ponderosa*) and Jeffrey pine (*Pinus jeffreyi*), 15% incense cedar (*Libocedrus decurrens*), 10% Douglas fir (*Psuedotsuga menziesii*), 2% sugar pine (*Pinus lambertiana*), < 1% lodgepole pine (*Pinus*

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contorta), and 60% red fir (*Abies magnifica*) and white fir (*Abies concolor*). The Antelope Complex started on July 5, 2007 and burned 22,902 acres of mixed conifer in the transition zone with the same species composition and in eastside pine stands consisting primarily of Jeffrey and ponderosa pine. For both fires, approximately two-thirds of the acreage burned at a high intensity killing nearly all vegetation. These two fires are in close proximity to each other with their respective perimeters nearly joining at Antelope Lake, approximately 10 miles south of Susanville, CA. Salvage operations are planned for approximately 14,000 acres in the Moonlight Fire and 2,600 acres in the Antelope Complex. The proposed roadside hazard removal will utilize Forest Health Protection marking guidelines for fire-injured trees while salvage away from roads will be limited to dead trees (no green needles present).

Observations

Field observations of the Moonlight Fire and Antelope Complex Fire consisted of visiting representative stands from the Vegetation Severity Map, which depicts the percent basal area (BA) mortality based on remotely sensed crown scorch and consumption data. Depicted areas include stands with 0% mortality up to 100% mortality.

Low Vegetation Severity (0-25% BA mortality)

These areas burned mostly as surface fires with minimal crown scorching. However, cambium sampling revealed a wide range of injury from near complete girdling at the root collar to very little injury. The range of cambium injuries found in individual sampled trees was similar regardless of tree diameter. An exception to this appeared to be in the mid-sized ponderosa and Jeffrey pine (~12-20" DBH) where the extent of observed cambium injury was not as great.

Moderate Vegetation Severity (25-50% BA mortality)

These areas also burned mostly as surface fires but with greater amounts of crown scorch, including complete crown scorching and consumption of individual trees and groups of trees. These stands contained higher levels of cambium injury on average than the low severity areas with many trees sustaining heat killing of cambial tissue higher on the bole.

High Vegetation Severity (>50% BA mortality)

These areas burned at very high intensities, mostly as crown fires, with very little tree survival. Very few trees in these areas have any remaining green foliage and most experienced nearly complete crown consumption. These trees also have very high levels of cambium injury extending high on the bole.

Insect Activity

No current bark (*Dendroctonus spp*.) or woodboring beetle (Family: Cerambycidae and Buprestidae) activity was observed in fire-injured trees within the Moonlight Fire.

Flatheaded woodboring beetles (Family: Buprestidae) were observed in several trees in the Antelope Complex. These beetles were in various stages of development from small larvae

mining in the cambial layer to larger larvae boring into the sapwood. Bluestain fungi (*Ophiostoma spp.*) were associated with most of these attacks. Woodpecker activity is apparent on many trees.

Some of the sampled trees in the Antelope complex that were completely crown scorched, and had no signs of live crown (shedding of scorched needles or the presence of green at the base of scorched needles), still had moist cambium that had not been attacked by bark or woodboring beetles.

Discussion

Insect Activity in Fire-Injured Trees

The current lack of bark and woodboring beetle activity within the Moonlight Fire is not surprising due to the late season timing of the fire. Most bark and woodboring beetle activity peaks during the summer months tapers off by late summer and early fall. While there were undoubtedly some trees attacked by various bark and woodboring beetles this fall, most insect activity will begin during the spring of 2008. Initial activity will most likely include red turpentine beetles (*Dendroctonus valens*) and engraver beetles (*Ips spp.*) attacking pines and a few species of woodboring beetles attacking both pines and firs. As the season progresses, ambrosia beetles (such as *Trypodendron spp.*), other bark beetles (*Dendroctonus spp., Scolytus spp. and Phloeosinus spp.*) and additional woodboring beetles will likely attack suitable fire-injured host trees of all species (Figure 2). The amount of insect activity and the resulting tree mortality depends on many factors such as the timing of the fire, the level of fire injury, the level of insect activity in the area prior to the fire, stand characteristics and precipitation. Staining and decay fungi in individual trees will be associated with nearly all bark and woodboring beetle attacks.

Figure 2. Bark Beetle Attacks and Woodpecker Feeding on Fire-Injured Pine

The Antelope Complex was an early season fire but late enough in the year to miss the peak flight for red turpentine beetle (which occurs in late May) and the first peak flight for some other bark beetle species such as the western pine beetle (*Dendroctonus brevicomis*), which occurs from late May through June, Jeffrey pine beetle (*Dendroctonus jeffreyi*) and the mountain pine beetle (*Dendroctonus ponderosae*), both which generally occur from June through July. The timing of the fire occurred at the beginning of the peak flight period for the fir engraver beetle (*Scolytus ventralis*), which is most active in July and August. Although not observed during this visit, it is very likely that many fire-injured trees of all species were attack this past summer by bark beetles and will begin to fade by next spring and summer.

Fire damaged trees can be placed into three categories: 1) those killed outright or so severely injured by the fire that they will soon die, 2) those that are uninjured or lightly injured and should survive, and 3) those in between, the moderately injured trees. Bark beetles will attack trees in all three categories but successful brood production will only occur in trees with moist cambium. Trees in category one typically do not have enough moist cambium after the fire or if they do, it will become either resin soaked or dry out before beetles can complete their development. Furthermore, the higher the severity of injury a tree receives during the fire the less likely bark beetles will attack it. Trees in category two provide the highest level of suitable cambium for bark beetles but typically are not injured to the extent that their defenses are compromised. These trees still have the ability to pitch out beetles as they attack or more often are avoided by bark beetles altogether. The highest level of bark beetle attacks are likely to occur on trees in category three, the moderately injured trees. These trees will have moderate to high levels of crown scorch and cambium injury that compromise their defense systems and put them at a higher probability of mortality based on injury alone. These trees can also provide ideal habitat for bark beetles, especially if cambium injuries are concentrated on the lower bole or at the root collar. Woodboring beetles are likely to attack and successfully reproduce in both moderate and severely injured trees but since these types of beetles typically attack only dead and dying trees, they are not a threat to healthy trees within or adjacent to the burned areas.

Over the past three years elevated levels of red turpentine beetle activity have been noted in several areas in northeastern California. All cases have been associated with wildfires, prescribed fires or thinning activities. To date, these attacks have not caused elevated levels of mortality. In the prescribed fires and wildfires, post-fire mortality has been observed but was caused by fire-related injuries (primarily cambium kill) as opposed to red turpentine beetle attacks, with the exception of some mortality observed in small diameter pines.

Figure 3. Ponderosa pine mortality 3-years post-fire, 2004 Power Fire, Eldorado National Forest

Additional tree mortality within both of these wildfires should be expected over the next three to five years (Figure 3). Mortality will likely occur from fire injuries alone, in the case of severely injured trees, or from a combination of fire injuries and bark beetle attacks, in the case of moderately injured trees. The highest mortality levels are expected to occur in the moderate and high vegetation severity areas with scattered mortality in the low vegetation severity areas (refer to Vegetation Severity maps). Bark beetle activity is not likely to result in a population buildup that will subsequently spread into uninjured or lightly injured trees or spread into adjacent unburned stands. Based on past observations by Forest Health Protection (FHP) personnel of fires in the Sierra Nevada, the build up of bark beetles within burned areas has not resulted in increased attacks in adjacent unburned stands. A possible exception to this

has been observed in Jeffrey pine in the 2002 McNally Fire (Sequoia National Forest) where Jeffrey pine beetles that had attacked moderately fire-injured trees emerged to attack adjacent trees that appeared to be only lightly injured. However, the extent of injuries to the cambium and root systems of these trees is unknown and could have been moderate to severe.

The attack behavior of the Jeffrey pine beetle, which attacks Jeffrey pine, and it close relative, the mountain pine beetle, when it attacks lodgepole pine, presents a special situation where additional mortality to uninjured or lightly injured trees in close proximity to infested fire-injured trees is possible within the Moonlight and Antelope Complex Fires. These beetles typically attack individual trees or small groups of trees, reproduce and then emerge to attack adjacent trees. This generally results in an expanding group kill with older dead trees in the middle surrounded by recently dead trees and freshly attacked trees the farthest from the center. Population increases, measured by the number of successfully attacked trees, have been observed by FHP personnel over the past couple of years for both of these bark beetle species throughout California with most of the Jeffrey pine beetle activity occurring in the central and southern portions of the Sierra Nevada range and most of the mountain pine beetle activity occurring in the Cascades and Warner Mountains.

In the Moonlight and Antelope Complex Fires, lodgepole pine occurs in very low numbers and is mostly confined to the perimeter of meadow complexes and along riparian corridors and Jeffrey pine is most abundant in the northern and eastern portions of both fires in mixed conifer stands but makes up a small percentage (probably less than 10%) of the forested areas. In the eastside pine areas of the Antelope Complex, Jeffrey pine is mixed primarily with ponderosa pine and occurs at a much higher percentage in these stands.

The preceding information regarding bark beetle activity, the subsequent mortality of fire-injured trees, and the potential for bark beetle populations to build up within burned areas and spread to adjacent stands, are based on past observations of fires in different areas, of different sizes and during different climate cycles. It should be noted that stand conditions are very susceptible to bark beetle activity within and adjacent to the burned areas. These stands are characterized by extremely high stand densities that, in many cases, are well above recommended stocking thresholds for minimizing bark beetle caused mortality. In addition, the precipitation year from July 1, 2006 to June 30 2007 was one of the driest on record, with less than 50% of normal rainfall. This year the area has only received approximately 55% of normal to date. Although limited bark beetle activity and associated tree mortality was observed in the area prior to the fires, current stand conditions and deficit precipitation levels point to a high probability of elevated bark beetle activity and tree mortality in all areas, regardless of whether or not they burned.

Effectiveness of Salvage Logging in Preventing Insect Activity

Salvage logging typically does not have a significant effect on lowering bark beetle caused tree mortality as it tends to focus on the dead and dying trees and does little to reduce overstocking, which is the underlying cause of tree stress and the resulting bark beetle reproductive success. In order for a tree removal project to have any chance of reducing bark beetle caused tree mortality it would have to reduce stocking levels enough to increase the health and vigor of residual trees. Fire salvage that focuses on removal of dead and severely injured trees will not reduce the potential for the build up of bark beetle populations. Furthermore, fire salvage that also includes the removal of moderately fire-injured trees is

not likely to have an impact on the future mortality of uninjured, lightly injured or adjacent unburned trees as these trees are not typically attacked by bark beetles post-fire. However, if salvage logging results in stocking levels that are 80% or less of "normal" for the site, the susceptibility to future bark beetle caused tree mortality will be reduced. As previously described, a special situation may exist for Jeffrey pine and lodgepole pine based on Jeffrey and mountain pine beetle attack behaviors. Removing the moderately injured Jeffrey and lodgepole pine may prevent additional mortality to uninjured and lightly injured adjacent trees. To have any chance of success, these initial tree removals would need to be followed up by close monitoring of residual trees in order to detect and promptly remove all green bark beetle infested trees prior to beetle emergence.

Utilizing the Healthy Forest Restoration Act for Fire Salvage

The current forest, insect and disease conditions within both the Moonlight and Antelope Complex fires do not meet the necessary criteria under the Healthy Forest Restoration Act (HFRA). No current insect or disease epidemic exists within or adjacent to the project area (based on the 2007 aerial mortality surveys and a field evaluation by FHP staff on November 29, 2007). The HFRA specifically states that a hazardous condition alone, for example, high stand density or in this case, an abundance of fire-injured trees, does not qualify unless there is a current insect or disease epidemic. Special conditions such as windthrow, blowdown or ice-damage are exempt from the current epidemic requirement. Fire-injured trees are not included under these special conditions.

Economic Losses and Potential Hazards Caused by Staining and Decay Fungi

Figure 4. Woodboring Beetle Mining and Bluestained Sapwood

Significant degrade and value losses are highly likely if fire-injured trees are not removed promptly. Nearly all of the beetles previously discussed carry spores of staining and/or decay fungi that immediately begin to invade sapwood (Figure 4). Bluestain, although not a source of structural degrade, can dramatically reduce the economic value of pine species. Bluestain spreads rapidly into the sapwood and by the end of one year can typically be found in nearly all dead and dying pines. An FHP monitoring study (Eglitis 2006) of 84 fire-killed ponderosa pines in central Oregon found bluestain in 100% of the first 16.5 foot bole sections and in 58% of the second 16.5 foot sections of sampled trees one year post-fire. At the end of two years, 92% of sampled trees had bluestain throughout the entire bole. The occurrence of bluestain within the Moonlight Fire is not likely to increase until beetles attack trees next spring and early summer. Trees that were attacked by beetles late this fall most likely have bluestain, but growth and spread within the sapwood should be minimal during the winter months. Decay fungi that are introduced typically do not cause significant degrade until after the first year post-fire, with smaller diameter trees decaying faster than large diameter trees.

Sapwood decay can create significant tree hazards in addition to a reduction in economic

value. This is particularly true for fire injured white fir, as green trees that develop extensive sapwood decay over the next few years could present hazardous working conditions for field crews. FHP monitoring of fire-injured trees has revealed the failure of 8" to 24" dbh red and white fir, with green crowns, in as little as three years (Report: SPR-07-05). The rate of failure increased dramatically after the fourth year post-fire, especially in conjunction with high winds or heavy snows.

During the 1999 Bucks Fire on the Plumas National Forest the crowns of many true firs were light to moderately scorched. These same trees suffered moderate to severe cambium injury and in some cases near complete girdling. Following the fire, frass and/or boring dust from wood boring and ambrosia beetles were evident on many of the tree boles, which is often indicative of internal injury. Bark sloughing over the last couple of years from the injured areas of the bole and root collar has revealed extensive decay of the sapwood; however, most of these trees have maintained green crowns. During the fourth year post-fire, a few trees within the burn that had green crowns and extensive bole decay failed. In the fall of 2004, after an early storm brought heavy snow and wind, many more trees failed that had these same decay characteristics. This has also been observed in a few fir trees in the 2001 Star Fire (Tahoe National Forest) and the 2000 Storrie Fire (Lassen National Forest).

Conclusion

Bark and woodboring beetle activity in fire-injured trees is expected to increase within the Moonlight and Antelope Complex Fires. However, based on past FHP observations of fires in the Sierra Nevada, the build up of bark beetles within these burned areas is not likely to result in increased attacks in uninjured, lightly injured or adjacent unburned trees. As previously discussed, additional tree mortality should be expected over the next 3 to 5 years due to fire injuries and bark and woodboring beetle activity within the burn, mainly associated with moderately fire-injured trees.

The proposed action of removing only dead trees (no green needles present) will have no effect on bark beetles and limited effect on woodboring beetle populations. In addition, as previously discussed, removing fire-injured trees is not likely to have an impact on future mortality of uninjured, lightly injured, or adjacent unburned trees as these types of trees have typically survived in other Sierra Nevada fires regardless of salvage efforts. Overstocked stand conditions and below normal precipitation will have a greater influence on bark beetle activity and tree mortality than the presence of fire-injured trees.

The current forest conditions within both the Moonlight and Antelope Complex fires do not meet the necessary criteria under the Health Forest Restoration Act (HFRA). FHP aerial surveys and a recent site visit did not reveal an outbreak situation for any insect or disease within or adjacent to these project areas. Furthermore, fire-injured trees are not included as a special condition, such as blowdown or windthrow, under HFRA.

Significant degrade and value losses are highly likely if fire-injured trees are not removed promptly. Decay and staining fungi are expected to be present in nearly all bark and woodboring beetle attacked trees by next spring and summer and in additional trees as they succumb to fire-injuries over the next few years. Beetle activity and the presence of bluestain are already evident within the Antelope Complex and will be evident in most severely fire-injured and fire-killed trees in the Moonlight Fire by the end of next summer.

Sapwood decay will become significant during the second year post-fire causing significant degrade and additional economic value loss.

If you have any questions regarding this report and/or need additional information please contact me at 530-252-6431 or at dcluck@fs.fed.us.

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