Identifying Levels of Risk in Stands with Mountain Pine Beetle Attack

Introduction:

Mountain Pine Beetles are attacking and killing millions of acres of forest in the Northern Rockies. Huge stands of timber are being converted to snag patches every year. As time goes on, these beetle-killed snags will continue to weaken and eventually fall. This presents a significant safety risk to Government employees when working in the woods.

Trees that have been killed by mountain pine beetle are usually fairly sound and stable for the first 3-5 years. After that period studies have shown that the fall-rate increases dramatically (Schmit, Mata, and McCambridge). After the initial 3-5 year period observations found that nearly all of the attacked trees broke off at or above ground level. This suggests that decay is the leading contributing factor causing beetle-killed trees to fall (Mitchell and Preisler).

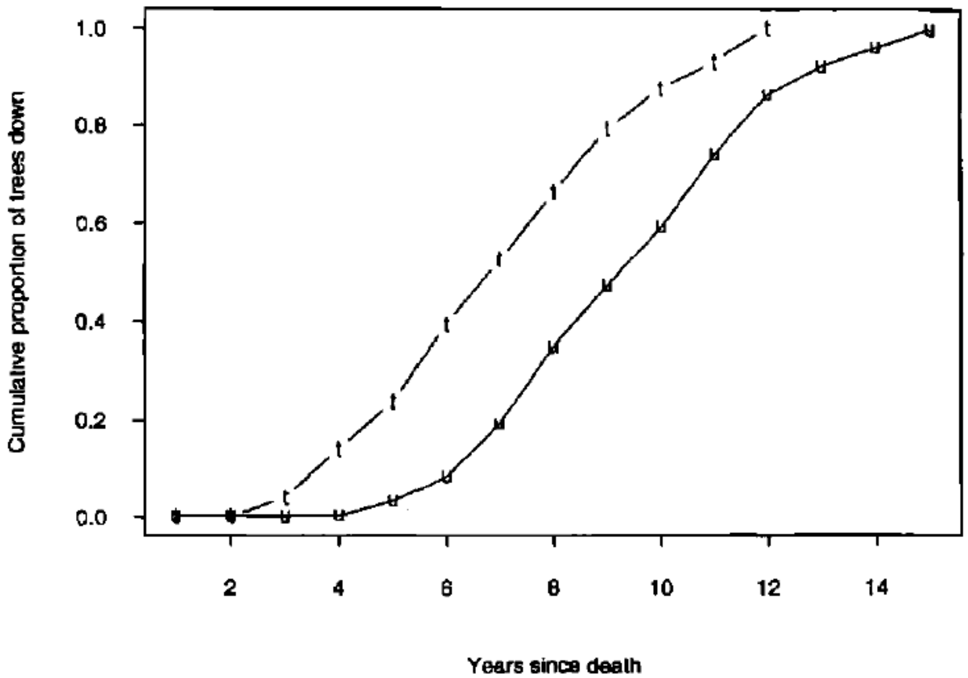
As Forest Service employees, we must learn how to identify the extent of decay in beetle-killed stands and the risk associated with different levels of decay.

Factors affecting Tree Decay and Rate of Fall:

- **Time since death:** Exact number of years since a tree was attacked and died may be difficult to determine just by looking at it but you can get a rough idea by its outside appearance.
    - Trees under first year of attack will still be green to yellow.
    - First two years after attack trees canopies will be red and will still be holding most of their needles.
    - Three years after the attack and beyond, trees will appear grey and will lose more and more of their canopies from this point on. Observing a tree in the grey phase should be a clue that it may be decaying and unstable. Many studies have shown that the half-life (time it takes for half of the snags in a stand to fall) of beetle-killed trees lies somewhere between 6 and 9 years (Lewis and Hartley; Farris and Zach).
- **Climate** is the other primary factor, along with time, that determines the speed and extent of fungal decay spread through the structural fibers of the tree. Decay spreads more easily in warmer, moister conditions. Decay growth may be slowed or stopped completely if conditions become too cold or dry. The **microclimate** that the affected trees are in will also have a major effect on the rate of decay. Trees on high elevation exposed ridges with dry soils will decay slower than trees in the bottom of a wet draw on the same slope at a lower elevation (Mitchell and Preisler).

- **Stand structure** has also been shown to have a significant bearing on how quickly snags will begin to fall. One study showed that trees in thinned stands began falling 3 years after attack and trees in unthinned stands began falling 5 years after attack. It was thought that this was due either to the thinned stands being more exposed to wind, or the additional light transmission in the thinned stands warming the soil at the root collar which sped up the growth of root decay fungi, or both (Mitchell and Preisler).
- **Wind** is probably the biggest mechanism actually causing the fall of snags. A study done on stands of beetle-killed Ponderosa snags in Colorado showed that 90% of the snags or greater fell in the same direction, in line with prevailing winds (Schmit, Mata, and McCambridge). This suggests that most of the trees came down when winds were present.
- **Tree diameter** also has a bearing on how long a snag will stand. Larger diameter pines have been shown to stand longer than smaller diameter pines. This is due in part to having more wood to decay, and to larger trees having more decay resistant heartwood (Cluck and Smith).
- **Bark thickness** helps control how quickly the tree loses moisture. The thick bark of ponderosa pine retains more moisture than the thin bark of lodgepole pine. This allows decay fungi to propagate much further up the bowl on ponderosa (Bull, E.). This means that while a ponderosa snag may have extensive rot 2/3 of the way up the bole, under the same environmental conditions, the rot in a lodgepole snag may be confined to within a few feet of the ground. Because of this, lodgepole pine almost always breaks at ground level while Ponderosa have more of a tendency to break off incrementally down the bole (Everett et.al.).
- The **Sapwood/Heartwood ratio** of trees also effects how quickly they decay. Heartwood is much more resinous than sapwood and is filled with extractives(waste products of photosynthesis). There are many species of decay fungi that can decompose sapwood, but very few of these can decompose heartwood, and even for the ones that can it takes much longer (Lowell et.al.).

The following table is from a study by Mitchell and Preisler (1998) showing the fall rates of lodgepole pine in thinned stands (t) and unthinned stands (u) in Oregon. This table shows how the fall rate picks up significantly after the first 3-5 years after attack and then slows down once 80-90% of the trees in the stand have fallen. It also shows the effect that stand structure has on when the first trees begin to falling.



Managing Risk:

There are many clues you can use to help assess the level of risk in beetle-killed stands. Understanding the different stages of decay and their causes, along with the visual indicators that accompany each stage of decay will help you determine the level of risk for operating around a particular tree or stand of timber.

Chronology of decay:

- **Early decay (0-2 years after attack)**- Bark beetles enter the inner bark of trees and excavate galleries to lay eggs. When the larva's hatch, they feed on the cambium of the tree creating their own galleries. If the galleries cover too much of the cambium layer of the tree, nutrient flow from the foliage to the roots is impeded. The adult beetles introduce blue-stain fungi as well as some decay fungi into the sapwood of the tree (Farris et. al., 2002). As the blue-stain fungi spreads through the sapwood of the tree it cuts off the tree's water conducting capabilities. This, along with the galleries from the bark beetle larva, effectively girdles the tree and causes death within weeks of the attack. As the tree weakens, it attracts many other "secondary" insects including boring beetles, which may carry fungi with them or create a vector for fungal spores to enter their galleries(Farris et. al., 2002).
    - o **Indicators of early decay-** Signs of early stages of attack include pitch-tubes on the bowl of trees and frass(boring dust) at the base of trees. A yellowing crown

is also an indicator of a successful beetle attack. Trees at this stage are much lower in moisture content than adjacent healthy trees, but should still be structurally stable.

Pitch tubes on the bole of a lodgepole pine attacked by mountain pine beetle

- **Mild decay (1-4) years since attack-** Bark beetles have killed the tree and their brood continue to tunnel through the cambium which helps to loosen the bark. Many other kinds of wood boring beetles are also moving through the sapwood and even the heartwood, making it easier for decay fungi to inhabit different layers of the tree (Lowell et. al.). The thick bark of ponderosa pine holds moisture in the tree allowing sap rot fungi to spread from the disease vectors created by the insects. Lodgepole Pine dry out much faster than Ponderosa due to their thin bark. Once their moisture content goes below the 20% range, decay from fungi is impeded. This means that in dry sites, most of the decay in lodgepole will be confined to the ground level(Lowell et. al.).
    - **Indicators of mild decay-** Woodpecker foraging and nesting is closely tied to insect infestation and tree decomposition stage(Farris et. al. 2002). Look for signs of wood pecker flaking of the outer bark. These areas are easily identified by the lighter colored bark that is revealed underneath the darker outer bark. Also look for “drill holes” which show that boring beetles have infested beyond the inner bark and into the sapwood. These drill holes may expedite the decay process by opening up more area of the sapwood to the spores of decay fungi. The action of drilling also helps to loosen the bark of the tree. Because lodgepole dries so quickly it may not be utilized by secondary beetles as much as ponderosa, therefore the signs of woodpecker foraging may not be as evident and you may have to look for other indicators to determine stage of decay. The

first two years after the attack the tree will still be holding most of its needles but the crown will be red. After two years the crown will become grey and lose most of the needles. There will probably be some decay in the sapwood at this point but most of the tree's structure will still be intact.

The flaking of the outer bark of trees is evidence of woodpeckers searching for bark beetles just under the bark.

As more secondary boring beetles begin infesting trees deeper into the wood, drill holes from foraging woodpeckers begin to appear.

- **Moderate decay (3-6 years since attack)-** Decay fungi have infected many areas of the sapwood through boreholes, drill holes, and cracks in the bowl. Between 3 and 5 years most of the sapwood still holding enough moisture to support decay fungi will be broken down by the pathogen. In drier areas this decay may be confined to the ground level. Decay may even begin in the heartwood depending on what fungi are infecting the tree.
    - **Indicators of moderate decay-** At this stage, the crowns of the tree will have lost most of their foliage and will appear gray. At year 3 the tree will be holding most of the small “branchlets” in the canopy, but many of these will be lost by year 5(Lowell et. al.). Conks(the fruiting bodies of decay fungi) will also begin appearing on the bowl of the tree revealing areas of decay within the sapwood. Around 4 to 5 years the bark of the tree may start to loosen but will still be covering more than 90% of the bowl. Around 5 years, woodpecker nest cavities may begin to appear in the upper bowls of larger snags(mostly Ponderosa). Studies show that most species of woodpeckers require an extensive amount of decay to excavate a nest cavity(Farris et. al. 2002). By the end of this stage trees are becoming much less stable. This will vary depending local site conditions. This is especially important in ponderosa pine because the loss of structural integrity may reach much further up the bole of the tree. Between 3 and 5 years the fall rates for beetle-killed snags rises significantly each year.
- **Extensive decay (6-8+ years since attack)-** Beyond 6-8 years the decay fungi will have worked completely through the sapwood and will begin working through the heartwood. Decay rates through the heartwood will depend on several factors. These factors include species of fungi, and amount and density of heartwood(Lowell et.al.). Smaller trees with less heartwood will be totally compromised before larger trees.
    - **Indicators of extensive decay-** At this stage there will be many clues of extensive decay. All of the smaller branchlets will be gone and many larger branches will begin to fall. Large chunks of bark will begin to slough off of the tree. In lodgepole, bark sloughing will begin at the basal log(Lowell et.al.). Nest cavities will be very common place especially in the larger Ponderosa Pine at this point. Cavities may appear in Lodgepole if environmental conditions have allowed wood to decay further up the bowl. Conks will also be very common at this time, possibly several different species on the same tree. The higher up the tree conks are visible the higher the decay has progressed. This is the final stage of decay. Trees in this stage should be considered very unstable. Fall rates for an attacked stand are usually highest between 6 and 10 years. Some larger trees may stand for many more years but most stands will have lost 90% of their standing dead by 12-14 years(Lewis and Hartley).

Ponderosa snag with broken top, sloughing bark, and woodpecker cavities**.**

The following table shows how the risk level for falling trees rises as **Time Since Death** increases on the vertical axis, and environmental conditions become more favorable for decay on the horizontal axis.

It should be noted that this table is not a hard and fast rule. There are too many variables that play into site conditions that promote or inhibit the propagation of decay to reduce everything into a simple table. Every stand should be evaluated individually and judgment should be used to determine how favorable conditions are at each site. As employees gain more experience working in this type of stand, their judgment can become fine-tuned.

<u>If there are moderate to strong winds present in the stand being evaluated, then the risk level will move up 1 to 2 color categories, especially if it has been more than three years since the attack.</u>

Risk Matrix for Falling Snags in Beetle-Killed Stands

Stand’s susceptibility to decay growth

Time since Death	Least susceptible	Mild	Moderate	More	Most susceptible
0-3yrs	**Low Risk** (Exhibits indicators of early decay)				
4-6yrs			**Mild Risk**		
7-9yrs			(Exhibits indicators of Mild Decay)		
10-12yrs		**Moderate** (Exhibits of moderate	**Risk** Indicators Decay)		**High Risk**
13-15yrs					(Exhibits indicators of extensive decay)

-**Low Risk**- most of the structural properties of the wood are still intact. Decay has not had enough time to spread or environmental factors have limited the growth of decay.

-**Mild Risk**- decay fungi has begun decomposing the sapwood, starting from the beetle’s galleries and moving inward. Tree still has over 50% of its sapwood intact.

-**Moderate Risk**- decay has moved through most or all of the sapwood in any area with enough moisture to support decay. Decay fungi capable of decomposing heartwood have begun working on the last remaining structural parts of the tree. Boring beetle galleries may also have done significant damage to the internal structure of the tree.

-**High Risk**-decay fungi have moved through all structural parts of the tree in at least one point on the bole.

Even after the current beetle epidemic subsides, the hazards created will affect our operations in the forest for decades to come. As forest service employees we must continually improve our ability to identify different levels of risk and adjust our tactics to meet our operational and safety goals.