Managing Risk:

The table below shows how the risk level for falling trees rises as **Time Since Death** increases on the vertical axis, and conditions become more favorable for decay on the horizontal axis. Conditions that determine how favorable an area is to decay are elevation, aspect, climate, soils, stand structure, and exposure.

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 and more experience working in this type of stand, their judgment will be fine-tuned. Additionally, **if there are moderate to strong winds present in the stand being evaluated, then the risk level will move up one to two color categories**, especially it has been more than three years since the attack.

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					
7-9yrs		**Mild Risk** (Exhibits indicators of mild decay)			
10-12yrs		**Moderate Risk** (Exhibits indicators of moderate decay)			
13-15yrs				(Exhibits indicators of extensive decay)	**High Risk**

Assessing 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.

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.

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. At this stage in the attack the tree will still be holding most of its needles but the crown will be red. There will probably be some decay in the sapwood at this point but most of the tree's structure will still be intact.

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 most 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). By the end of this stage trees are becoming much less stable. This will vary depending local site conditions.

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.

Sources and links for documents referenced in this brochure may be found at

Identifying Levels of Risk in Stands with Mountain Pine Beetle Attack

Background:

When Mountain Pine Beetles successfully attack a host tree, they introduce spores of Blue-stain fungi into the sapwood of the tree. As the fungus propagates itself throughout the sapwood it begins to cut off the tree's water and resin supply. This, along with the girdling effect from the beetles' egg galleries, cuts off the trees water and nutrient transport system and the trees die very rapidly (UBC). Once the tree dies, its moisture content falls very quickly. Studies suggest that the moisture content falls from 85-165% down to 30% or less within the first year (Lewis, Hartley). This rapid loss of moisture results in significant vertical cracks, or "checking" in the bole of the tree. Once the tree is dead it becomes more susceptible to other kinds of boring insects and decay fungi. Trees that have been killed by mountain pine beetle are usually fairly sound and stable for the first 3-5 years. However, after that period, studies have shown that the fall-rate increases dramatically (Schmit, Mata, and McCambridge). It was also observed that nearly all of the fallen trees after the initial 3-5 year period broke off at or above ground level. This suggests that decay is one of the leading contributing factors causing trees to fall (Mitchell and Preisler).

Factors affecting Tree Rate of Fall:

The first factor is the tree's **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 effected 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 much slower than trees in the bottom of a wet draw on the same slope at a lower elevation (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 a larger volume of wood to decay, and to having more decay resistant heartwood (Cluck and Smith).

Bark thickness helps control how quickly the tree loses moisture. The thick bark of ponderosa pine holds moisture in much better 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 almost always break 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.).

Stand structure has also been shown to have a significant bearing on how soon snags will begin to fall. One study showed that lodgepole pine 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 in the root collar which sped up the growth of decay fungi at the base of the tree, or both (Mitchell and Priesler).