Developing a Wildfire Hazard Reduction Plan for Your Property, the Mount Helena Example

Background

Forested areas adjacent to the city of Helena are part of an ecosystem that historically supported frequent wildfires. These fires maintained a mosaic of grasslands interspersed with open park-like forests, and in some cases denser stands of trees. The development of a grazing industry across central Montana in the mid to late 1800's led to a reduction in fire occurrence due to active fire suppression and a significant decrease in fine grass fuels. Without the natural control of wildfires, and less grass competition, conifers have encroached across significant areas that historically supported rangelands. In addition, the exclusion of natural "thinning" due to fires has allowed dense thickets of conifers to develop that promote high intensity crown fires that are difficult to control and pose a real threat to urban-interface areas as well as the city of Helena. The historical frequency of fire is referred to in this scenario to indicate the historically high probability of wildfire ignition. This is not to be confused with the debate concerning restoration of historical plant communities. This plan is prepared to reduce the risk of uncontrollable high intensity crown fires while maintaining the aesthetic quality of Helena area open space.

Situation

Areas surrounding Helena have a high proportion of dense Douglas-fir and ponderosa pine forests. A significant percentage of this forest consists of small diameter trees that have little or no commercial value interspersed with stands of larger merchantable timber. The land area with such dense conifer growth is expanding as new seedlings establish along the perimeter and within these forests yearly. Dense conifer growth tends to suppress native range species resulting in sparse understory plant communities. The combination of dense forest structures located in the prevailing windward side of Helena and surrounding urban-interface zones creates an extremely high risk scenario for human life and property losses due to wildfires that exhibit extreme behavior. It is important to recognize that forests are dynamic growing entities that will require continual monitoring and manipulation. Forest management strategies will focus on two issues: 1) Treating existing forests, and 2) Managing for future desired forest conditions.

Control Measures

Forest wildfire control typically is divided into two actions: 1) Wildfire suppression, and 2) Proactive fuels management. Whereas wildfire suppression constitutes equipment, manpower, detection and access, this plan will only address access and detection. Fuels management refers to types of fuels (size and condition) and fuels distributions. Since most of the forested areas surrounding Helena consist of relatively young trees, much of the fuel loading is comprised of live trees of similar fuel condition and size. Therefore, manipulating live tree distributions and densities will be one of the highest priorities. To a lesser degree, dead fuel accumulations in the form of senescent grasses and cast off conifer branches and needles also contribute to the overall fire risk.

Plan components:

Need to know:

A. **Mapping of forest conditions**. Using standard forest inventory practices forested areas will be stratified by mapping zones with relatively uniform tree species, age calsses, size and density.
B. **Access** for fuels treatment and fire suppression.
C. **Probability of ignition sources** from lightning and human sources.
D. **Probability of crown fire behavior** and directions of spread.
E. **List of forest management practices** and their probability of reducing wildfire inertia.

Need to develop:

F. **Landscape tree removal mosaic alternatives** that decrease wildfire rate of spread.
G. **Landscape access routes** for tree removal and fire suppression.
H. **Forest maintenance plan** to provide for continual control of encroachment and stand health management.
I. **Range restoration alternatives** to ensure a healthy grass-forb-shrub community replaces trees in treated areas.

A. Mapping forest conditions

A coarse scale fire risk map (appendix A) has been developed that indicates over 80% of forested areas in the Helena Valley are at high to severe risk from wildfires. Forested areas need to be inventoried at a finer scale. A two-step process should be implemented:

1) Stands of trees of uniform structure, age and species composition can be delineated from aerial photos.
2) Delineated stands need to be inventoried for a detailed summary of species, age, volume, % understory vegetation cover, tree density and fire risk (ladder fuels, crown density, and debris accumulations).

B. Access

Access routes across Helena open space need to be determined. Both fuels treatments and fire suppression activities may require the use of all-terrain mechanized equipment. Existing travel routes for equipment should be identified on this map. Access needs should be identified based upon the following criteria:

1) All forested sites may eventually require access by all-terrain low-impact vehicles such as cut-to-length harvesters, forwarders and water tankers.
2) Access should allow for 100% approach of areas within ½ mile of open space perimeters (for rapid fire suppression response).

3) Access routes can double in use as fire breaks and should be strategically located for this purpose. (In the event of fire, less time will be available for planning access and fire breaks)
4) Permanent access routes (roads and trails) should be identified separately from potential temporary routes that may be used during stand fuels treatments and then rehabilitated.

C. Ignition Locations

Wildfire ignitions statistically are 50% human caused and 50% lightening caused. An existing trails network across Helena open space is dense enough to allow for the assumption that all open space is at high risk from human caused ignition. Designated areas for smoking and other fire use should be identified across public areas based upon fuels and wildfire spread risks. Locations of past lightening strikes should also be identified from NOAA records. Forested areas with high ignition probabilities should receive priority treatment (see forest management section).

D. Crown fire probabilities

Due to the climatic characteristics of the Helena area, wildfires should be considered a constant threat. Preemptive manipulations of fuels along with early detection and aggressive suppression efforts are the most logical defense strategies. Fire behavior is largely determined by wind speed, topography, fuels, fuel moisture, and temperature. Of these, fuel concentrations and fuel types are the only manageable variables. High winds, temperature and steep topography can negate the positive effects of fuels management. Management practices to reduce fuels are therefore only effective at reducing the probability of an uncontrollable wildfire. Wildfire behavior typically can be categorized into:

1) Surface fires*
    a. High intensity: > 4ft flames and difficult to suppress.
       Energy released: 200 – 15,000 kWm^{-1}

    b. Low intensity: < 4ft flames possible to quickly suppress.
       Energy released: 100 - 800 kWm^{-1}

2) Crown fires*
    a. Running or high intensity: requires an act of nature to stop.
       Energy released: 150,000 + kWm^{-1}

    b. Patchy: possibility of containment with active aerial tanker and mechanized ground activities.
       Energy released: 8,000 – 40,000 kWm^{-1}

(* Fires releasing > 3,460 kWm^{-1} are considered uncontrollable by direct suppression efforts)

This fuels plan is designed to lower the probability of a wildfire developing into an uncontrollable high intensity forest crown fire. Within this context, two fire scenarios must be considered:

1) Ignition occurs within Helena Open Space. Prescriptive fuels treatments can significantly reduce probabilities that fires remain as surface fires and or crown fires develop only as isolated patches in areas that pose a low risk to sensitive zones (interface).

2) Ignition occurs adjacent to Helena Open Space. This requires the identification of high risk zones on adjacent forest ownerships where a wildfire could develop into a running crown fire that moves into open space zones. For example, the Helena National Forest shares a common property boundary with Helena open space and may consist of dense forest structures that represent a high risk for ignition and development into a running crown fire. To prevent such a fire from moving onto Helena open space, wider fuel breaks need to be strategically placed along property boundariesto help prevent the spread of such a fire.

Stand wildfire risk parameters:

1) Conifer seedling/sapling stage (1ft – 20 ft tall trees):
    a) Scattered seedlings/saplings interspersed with range species. Wildfires in this scenario will behave much as a range fire with scattered trees acting as isolated fuel concentrations. Few if any trees would survive a fire.
    b) Dense seedling/saplings. Conifer regeneration that is growing in a density where spacing between crowns is less than ½ the average crown diameter (for example: 10 ft diameter crown saplings that have < 5 ft between edges of crowns) pose a significant threat to facilitating a crown fire.
2) Conifer pole size class (20 – 40 ft tall trees, 5-10" diameter at 4.5 ft):
    a) Scattered. Isolated trees of this size may survive fires if lower branches are pruned up. An ideal height of 15 ft is suggested however a minimum of 6 ft should be pruned. These trees pose little threat to adding significantly to wildfire behavior.
    b) Dense. Thickets of pole sized trees can create dense canopies that trap heat from a surface fire resulting in a high energy crown fire. Spacing between edges of tree crowns should be at least ½ the average crown diameter for the risk to be reduced. In most cases this would be at least 10 feet. Alternatively, low surface fuels resulting from grass

suppression may limit surface fires unless significant dead needle accumulation has occurred.

3) Mature size class (40+ feet tall, > 10" DBH):
    a) Scattered. Trees that have a minimum distance of 30 feet between the edges of their tree crowns may be considered scattered. This typically results in 40 to 50 trees per acre for a maximum density. Stands of this character are considered relatively fire resistant, especially if their lower limbs are missing from the soil to a height of 15 feet. Occasional dead needle buildup at the bases of tree can allow long duration fires to occur that can kill trees, however, crown fires are rare in these types of stands.
    b) Dense. Mature trees with touching crowns or less than the ½ crown spacing rule are susceptible to crown fires if surface fuels are high enough. Often dense stands have self pruned their branches and a low intensity surface fire has little opportunity to climb into tree crowns. These stands are most at risk from a crown fire that moves into them or patches of high surface fuel accumulations that allows enough heat build-up to cause the canopy to ignite.
4) Mixed: A mixture of seedling, sapling, pole and mature sized trees:
    a) Scattered. Typically this type of configuration consists of a mature tree surrounded by pole sized trees which is further surrounded by seedling and saplings. When these occur as isolated clumps or patches, a fire will most likely consume the entire patch and then drop to the ground again. Stands with mixed size classes represent the greatest risk as a continuous fuel ladder exists from surface grasses to seedling to saplings to poles to mature trees. Individual trees should have at least 10 ft between crown edges though 30 ft would be more ideal before this type of stand would be considered relatively crown fire resistant.
    b) Dense. This configuration would simply be a series of patches as described in 4a. with the patches merged into one continuous forest of differing sizes of trees. This is the most conducive conifer structure for promoting high intensity crown fires. Stands such as this can be converted into scattered mature stands as described in 3a. with complete removal of the smaller size classes.

E. Forest Management Practices.

Trees, both living and dead present a wildfire fuel hazard. During periods of drought conifers produce ample quantities of wax, terpene, and phenolic compounds that are extremely flammable. Although any coniferous tree represents a fire hazard, large-scale crown fire risks can be reduced by eliminating fuel configurations that are continuous in character. To this end, a variety of harvesting practices need to be implemented. They are listed with specific reference to the Helena Open Space requirements.

1) Patch cutting. An alternative term to what has been referenced as "clear-cutting", patch cutting refers to the removal of every conifer within a designated area essentially clearing it of all trees. The term "Patch" cutting is used because the boundary of such a cutting unit is often irregular in shape and is designed to simulate the irregular patchy mortality that a wildfire creates. Patch cut boundaries are determined using topographic features such as ridges and valleys, naturally occurring tree size and age differences, and human aesthetic desires. A patch cut may vary in size from 1/10 acre to 40+ acres, contain island clumps of trees or individual trees that are spaced at variable distances and to a degree create a "Swiss cheese" effect across a landscape with a continuous cover of conifers. Patches are typically large enough to limit the shading from edge trees and thereby support diverse range plants that require full sunlight. For fuel break purposes the opening needs to be large enough to limit the possibility of a fire from jumping across the patch. Areas where the probability of a running crown fire is high would require a series of smaller openings (1/4 to 5 acres) followed by a larger opening (5+ acres). The purpose is to rob the approaching fire of energy before it hits the last fire and more significant opening. Large crown fires have jumped mile-wide natural fire breaks such as the Salmon and Missouri River Canyons. Guidelines for implementing a patch cut are as follows:

    a) Boundary of the patch cut should create a complex polygon that fits into the landscape. Typically this should mimic the pattern created by a naturally occurring wildfire. See appendix B.
    b) Stumps should be cut as close to the ground as possible.
    c) Retention trees should be left in clumps if smaller diameter trees are left or if trees are tall with small crowns confined to the very tops of trees (trees with profiles such as # 3, 4, 6 & 7 on page 10). Isolated mature trees may be left if they are of large enough diameter and crown configuration to withstand the stress of increased wind and temperature extremes (trees with profiles such as 1, 2, & 5 on page 10).
    d) Soil disturbance should be minimized during the tree removal process.
    e) Woody residual debris should be treated by chipping, burning or removal from the site. Small (< 10 ft diameter and height) burn piles or broadcast burning would be considered optimal in an effort to keep nutrients on site and minimize site impacts.
    f) Size should vary from ¼ acre to as large as the landscape dictates. In some instances, removal of all trees from a specific slope may be needed to restore range conditions.

2) Thinning. This practice is designed to change the character of a forested stand from dense to more open. Several types of thinning are utilized due to multiple possible stand configurations (combinations of tree size classes) and multiple possible residual stand objectives. For most situations where wildfire hazard reduction is the objective, a residual stand of trees that has ample space between individual tree crowns is desired. An average of 30 to 40 mature

conifers per acre will be the target density for the most fire resistant configuration.

a) Thinning from below. This practice leaves the largest trees with respect to stem diameter and percent crown area. The intent is to create an open forest of mature trees by removing all other trees. This practice requires the presence of mature trees capable of surviving increased wind and temperature fluctuations. This type of thinning is ideal for stands with mature healthy ponderosa pine or Douglas-fir.
b) Free thinning. A practice that is used to select against specific tree species or tree characteristics. Trees of all age classes with good crowns and potential for growth and longevity are left. Trees with characteristics that would limit longevity of growth are removed. Often results in a patchy structured forest (which in some cases is highly desirable for its "natural " appearance"). In the case of Mt. Helena, certain areas would be ideally suited for this type of thinning – specifically areas that have a combination of Douglas-fir and ponderosa pine where pine would be the favored species.
c) Mechanical thinning. So named for its development in plantations where trees are evening spaced. The objective of this technique is to leave trees spaced at a uniform distance from each other such as 15 x 15 ft or 20 x 20 ft. This type of thinning would be applicable to seedling and sapling sized stands where some residual trees are desired but a majority must be removed to reduce fuel loading. An ideal spacing of 30 feet between trees would be desirable for Mt. Helena situations.

3) Combined patch cutting and thinning. For the objectives of Helena Open Space, the majority of the tree removals should be a combination of harvesting practices to create a patchy environment of differing tree sizes and configurations. Dense patches should be left for wildlife purposes as well as aesthetics, however these patches that are a high crown-fire risk should be isolated by thinnings and patch cuts. It is extremely important that denser mature stands are not directly next to stands that are intermediate in size so as to create a fuel ladder. There should be a distinct discontinuity in fuel structures between stands of trees to keep a fire in one stands from jumping "up" into the adjoining stand. Observations of fire behavior indicate the fires will not jump "down" from crowns into shorter fuels very readily.

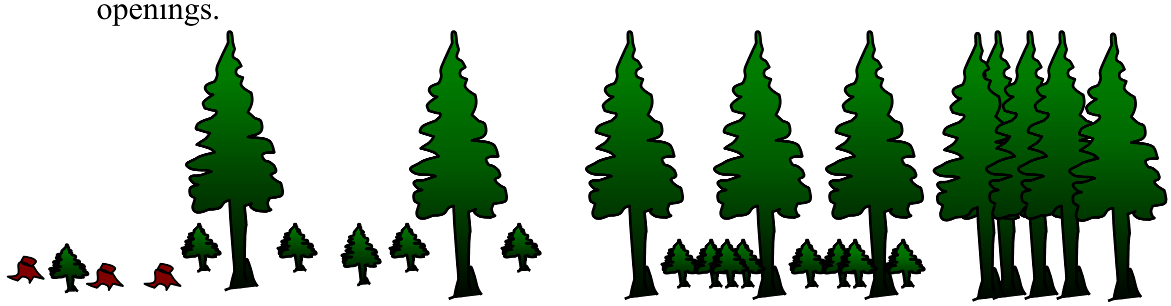
4) Stewardship cutting. Areas with large components of "non-merchantable" trees are expensive to treat. On average thinning or removing dense patches of seedlings and saplings costs between $200 and $300 per acre. To offset this cost, stewardship contracting as emerged as a feasible alternative. The objective of stewardship contracts is to use the harvest of merchantable timber to pay for the thinning of non-merchantable trees. Helena Open Space has a matrix of mature confers and immature trees. Thinning from below in stands of mature trees would reduce the risk of these stands from being consumed and contributing towards a high intensity running crown fire. The value of the

trees to be removed would be used to pay for manipulations in non-merchantable stands. Likewise, the creation and rehabilitation of trails and roads would be part of the contract.

5) Longevity. All forests are dynamic entities. As younger trees grow taller, mature trees become overmature and senescent, and thinned stands become dense enough to recreate a fuel hazard. Any forest plan should include and plan for the periodic maintenance of forest conditions. Considering the productivity of Helena area forests, a cycle of 20 years per acre may be required. This may mean that a small portion of the total are of the Helena Open Space is treated every year. A simplistic calculation would be total area/20 = areas to be treated annually by some form of stewardship contract. Another component that should be considered is to control future conifer encroachment. Preliminary analysis of experimental goat grazing shows great promise for reducing conifer seedlings establishment. Conifers seedlings, especially Douglas-fir may be very effectively lethally browsed. On average, a 3-year grazing cycle is recommended for this type of control.

6) Tree selection. A brief illustration of trees dimensions that are proven to survive best following stand manipulations is as follows:

Forest management practices of the past typically focused on the ecosystems where large stand replacement fires shaped the forests. The practice of clearcutting, seed tree and shelterwood cuts, all of which are referred to as "evenaged" management practices, are well suited for simulating stand replacement or crown fires. Which of these practices was used depended largely on the species mixture and individual tree characteristics in a stand. Where individual trees of desirable species have stem and crown dimensions that suggest their ability to withstand the shock of a more open environment, a seed tree or shelterwood cut is recommended. Stands that are dominated by sick or suppressed trees may benefit greatest from a series of clearcuts. Tree species that require full sunlight (shade intolerant) such as ponderosa pine, lodgepole pine and aspen will benefit from larger openings. Species that prefer intermediate shade (shade tolerant) such as Douglas-fir and subalpine fir will benefit from smaller openings.

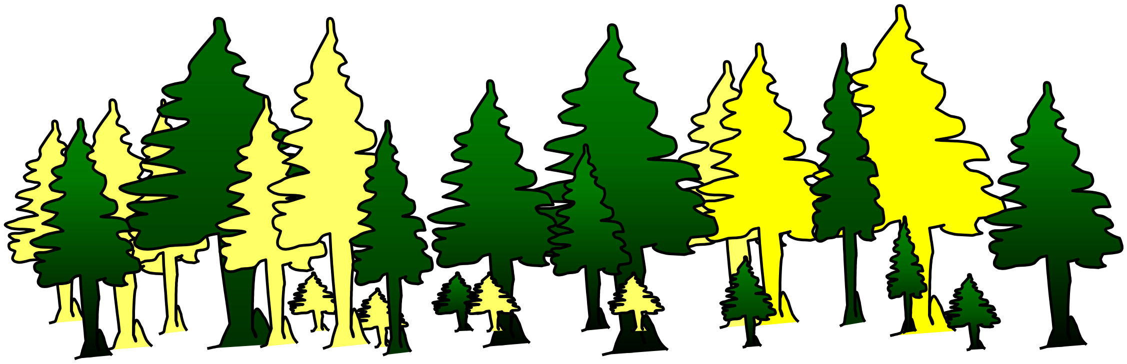


Clearcut **Seed tree *(shade intolerant)*** **Shelterwood *(shade tolerant)***

Sites that typically had mixed severity fires provide for the greatest options in forest management practices. Simulating those types of disturbance often calls for patches of trees to be treated differently although large scale evenaged treatments also work. Often the stand of trees itself will indicate what naturally would have occurred. For example, an area that has dense standing trees with large amounts of down woody debris would have led to a crown fire, burning all trees in that area and creating a large clearing. Stands that have a random spacing of dense and open grown trees would have burned in clumps creating small opening while leaving the more open spaced trees intact. Areas that are composed of large well spaced trees would have supported a fire that stayed on the ground with an occassional tree burning up. Mosaics such as these provide multistructural forests and are often the most productive wildlife habitats. Harvesting patterns can vary from several acre openings to individual tree selection. It is important to recognize that many different treatments can be used within the same stand of trees.

Single tree selection and group selection (*light color are cut trees*)

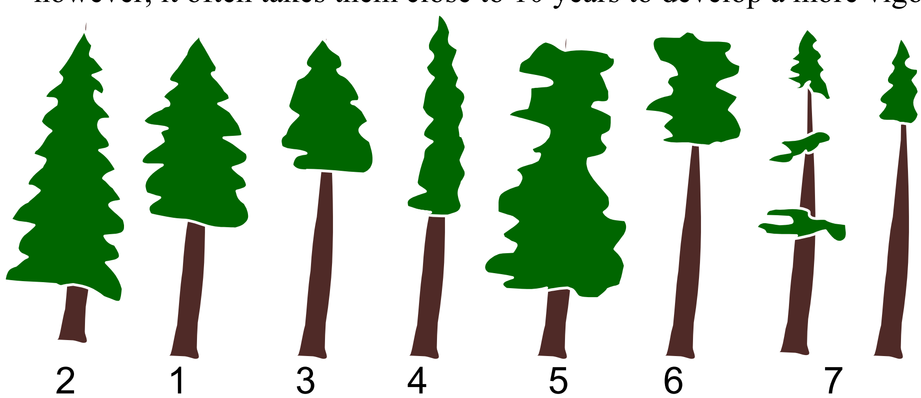
Drier ponderosa pine and Douglas-fir sites usually supported frequent fires that kept most of the stands in an open savanah- like composition. Quite often these areas are also used extensively by deer and elk for winter range because of the lush bunchgrass understory that was promoted by frequent fires. In the absence of fire prolific tree regeneration can occur resulting in dense stagnant stands of small diameter pine and fir trees. These stands not only represent a significant fire danger, but lose their bunchgrass understory to shading resulting in loss of winter range. Overgrazing of such sites will accelerate the development of dense tree regeneration. Land managers are often challenged in their efforts to restore such situations because there are currently poor markets for small diameter tree stems making these sites expensive to manage. Thinning combined with with light grazing (to reduce the fire hazard from cured grasses) is a good management alternative for these sites. Unevenaged management is also a good option on these sites.



Thinning and unevenaged management (*light color indicates cut trees*)

Tree selection criteria for vigorous high value trees

The criteria used for determining which individual trees to cut or leave are usually based upon their crown characteristics. Since the green needles are the food producing part of the tree, the more needles a tree has, the better the growth rates will be. In general, if less than a third of the entire tree height supports green needles, the tree is a poor choice as a leave tree. Optimal tree crowns occupy between 60 and 40 % of the tree height. Greater than 60% crown area results in a healthy tree, however one that also requires more water, nutrients and space relative to the amount of stem wood it produces. Less than 30% crown results in a tree that is top heavy and subject to wind breakage, slow growing, and often reflects a poor root system that may be inadequate to supply the tree with enough water during dry periods. Trees of lesser quality may eventually recover if left, however, it often takes them close to 10 years to develop a more vigorous crown.



1) Best form **2)** Still good -knotty wood **3)** Will recover though risk of wind breakage **4)** Over crowded, may sun scald, may recover **5)** An older # 2, good wildlife, may live another century
6) Overmature, low vigor, high risk **7)** Diseased, low vigor, raptor nest trees

Tree selection for wildlife

Wildlife requires food sources and hiding cover. Tree structural and species diversity are the most common desired components for wildlife. Tree selection criteria should favor size and crown diversity. A spindly tree with a small crown may be favored by an owl or eagle whereas a dense bushy shrub is preferred by nesting warblers. Large snags, vigorous trees, odd shaped trees all contribute to wildlife habitat. For diversity, clumps of dense, evenaged trees can also be left in a mosaic with savannah-like openings. Wildlife species are especially sensitive to changes in their historical forest enviroment. It is important to match the patch size of the management areas to the patch size that fire historically created.

Insect and disease criteria

Most insects and diseases prefer specific tree species. Observing which tree species is suffering in a stand of trees will often indicate which species to select more heavily against. It is easy to overreact, however. Some degree of tree mortality is normal and necessary as insects are an important food source for a variety of wildlife species. Maintaining a healthy population of insect predators is the best way to keep pests in balance. Selecting for a diversity of tree species will keep any one insect or disease from devastating an entire stand of trees.

The wildfire issue

Although it is extremely important for humans to consider the historical ecology of a forest ecosystem when we contemplate alternative management scenarios, it is of equal importance to consider the risks associated with wildfire. Wildfire does not respect property boundaries and has little concern for human residences other than the fact that a house is a fuel to be consumed. When considering managing your forest, several facts about wildfire need to be taken very seriously. First, there is no such thing as a "fireproof" forest. Second, we need to take into consideration wildfire behavior during normal years when weather patterns are fairly typical, and we need to take into consideration wildfire behavior during "extreme" years when drought, wind and lightning are much more prevalent than normal.

Forest wildfires typically erupt into dangerous events when they encounter three types of fuel conditions. The first is an accumulation of "fine" fuels - dead debris ranging from cured grasses to dead tree branches less than 4 inches in diameter. Since these types of fuels ignite very easily, a lightening strike or spark will easily start and spread. The second situation is a continuous layer of fuel across the landscape. This allows fires to "run" across the landscape creating enough energy to preheat and ignite larger fuels. The third condition is unique to forests and consists of a dense conifer overstory. Heat from a fire on the ground will get trapped by the dense canopy until the needles get hot enough to ignite into a "crown" fire. If a continuous dense forest canopy exists across the landscape, condition two will be met and a running crown fire will result, often creating flames over 300-ft tall. It is often impossible or undesireable to create forest conditions that remove all fine fuels or dense forest canopies. However, by manipulating the distribution of these conditions across the landscape it is possible to create "fuel breaks" that will slow a fire down and allow control measures to be used effectively.

A visual model of the Mt. Helena and wildfire risk scenarios