Fire and Vegetation in the Blue Mountains—Implications for Land Managers

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INTRODUCTION

FIRE in western forests has been common. Its influence on vegetation and soil was studied in conjunction with a comprehensive ecological evaluation of the 5 million acre (2 million hectar) Blue Mountain land mass in eastern Oregon and southeastern Washington. Both conflagration fire and natural underburning have left their mark. Plant communities dominated by lodgepole pine or western larch are the result of conflagration fire. In contrast, underburning effects on vegetation is often difficult to see. In this paper I will deal only with underburning. Evidence will be presented to document the frequency of underburning, the influence it has had on forest vegetation, interaction effect between tree cover and ground vegetation, fire influence on natural genetic selection of ground vegetation, influence underburning has apparently had on soil development, and in addition, I will briefly discuss some implications these have for land management.

Instead of dealing with underburning in broad, general terms, I would prefer to discuss in detail the interactions of fire with vegetation on a specific kind of plant community. Of 18 kinds of forest communities in the Blue Mountains, the mixed conifer/pinegrass ecosystem was chosen (Hall, 1973). Plant communities are named by the dominant tree, shrub, and herbaceous species which most clearly characterize the plant association. In this case, shrubs are absent, therefore we call it the mixed conifer/pinegrass community type. It occupies nearly 1/5 of the total acreage in the Blue Mountains. Figure 5 is a composite photograph showing a general view of the plant community dominated by ponderosa pine, a meter square sample of the ground vegetation, a soil profile view, and an overhead view of the tree crown cover. It typifies a ponderosa pine/pinegrass community essentially ungrazed by domestic livestock.

EVIDENCE OF UNDERBURNING

Underburning has been common in the Blue Mountains as shown by numerous fire scarred trees (Fig. 1). This fire scar is a storybook, a history of fire. The easiest way to open the storybook is shown in Figure 2. When cut in cross-section, a number of ripples or waves

Fig. 1. Fire scar on a ponderosa pine. Each ripple or wave on the scar represents an underburning which damaged the tree. Figure 2 is a cross section of such a fire scar.

can be seen. Each one of these waves indicates the occurrence of a fire.

The waves or ripples are formed as follows—While the tree is young, lightning strikes the ground and starts a fire in the easy-to-ignite pinegrass. Fire burns over the ground to the base of the tree igniting an accumulation of pine needles. A hot fire will scorch part of the bark on the tree resulting in death of the cambium. Eventually, the dead bark will fall away as the wound begins to heal. When this happens, the tree will usually produce pitch at the point where new bark begins to grow around the wound. Some years later lightning strikes again, burns through grass, into needles at the base of the tree and ignites the pitch. The pitch burns up the side of the tree killing bark at the edge of the wound. This bark falls away as the tree again grows around the wound. Later lightning strikes again, burns through the grass and ignites pitch killing bark.

Figure 2 is an excellent example of this situation. The date was

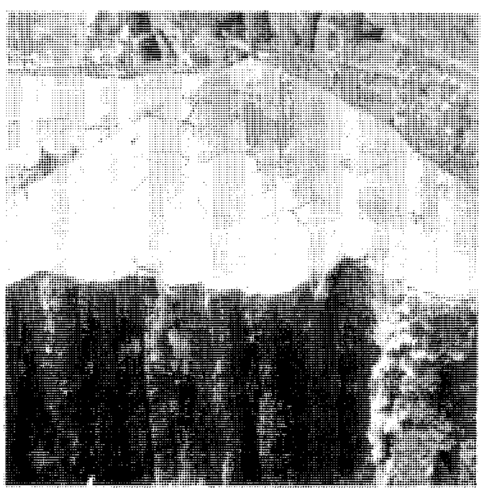


Fig. 2. Cross section of a fire scar similar to the one shown in Figure 1. Tick mark at the left indicates the tree center and the year 1763. Numbers between tick marks indicate years between marks. Each tick mark locates the annual ring of the year in which fire damaged the tree.

1763 when this ponderosa pine reached 18 inches tall (stump height). From then, the tree grew for 26 years before underburning damaged the bark and cambium forming a first fire scar. Each number on the tape between tick marks indicates the number of annual rings between fire scars. After the first fire scar, the tree was damaged at yearly intervals of: 9, 10, 13, 8, 10, 10, 5, 9, 6, 15, 9, 38, and 36 years. The fire scar occurring between 6 and 38 was 1893. Twenty years later, the United States Forest Service began fire prevention in this area. The next fire did not occur for 38 years. Since then, the tree grew for 36 years until it was cut in 1967.

This stump shows a fire scar being produced at an average of once every 10 years prior to the start of protection of forest lands from wildfire in 1914. The 10 year average is a maximum time between underburnings. Lightning could have ignited pinegrass and burned up to the tree without causing a fire scar if pitch or needles were not present. We have evidence here that fire burned *at least* once every 10 years. I feel that underburning has been a normal part of the environment in the Blue Mountains (Hansen, 1942). In 1973, 220 fires were started by lightning in the Blue Mountains; an average of one fire for each 23,000 acres each year (Anon., 1973).

UNDERBURNING EFFECT ON TREES

Recurrent underburning in the pine dominated mixed conifer/pinegrass plant community maintained a very open stocking of trees by periodic thinning. Groups of young ponderosa pine under significant competition could not grow fast enough in diameter or height to escape the fires. This means that ponderosa pine stands did not develop according to the classical concept of "normal stand development" (Meyer, 1961). Normal stand development suggests that thousands of seedlings become established, some seedlings grow faster than others, become dominant, suppress their neighbors, and finally eliminate the suppressed trees from the stand. With fire control, hundreds and sometimes thousands of young ponderosa have become established per acre (Fig. 3). These young trees have not grown according to normal stand development theory, instead they have almost universally become stagnated. We have found little

Fig. 3. Stagnated ponderosa pine photographed in 1964. Stocking density is 2000 stems per acre. The board is one meter tall and marked in 1 dm increments; width of board at top is 2 dm (8 inches). Dominant trees are 60 years old while smaller trees are 40 years old. Tree behind meter board is 9.5 inches diameter and is growing at 0.05 inches dbh per year. Stand was thinned to 110 trees per acre in December, 1964.

evidence in the Blue Mountains to indicate that ponderosa pine can, within a 50 to 100-year timespan, break out of stagnation. Instead trees persist and grow in diameter at 50 to 70 rings per inch and in height at 4 to 6 inches per year to at least age 80.

Height and diameter growth of trees which developed with recurrent underburning is entirely different. Increment cores show diameter growth (BH) of three to five rings per inch at the center of a tree. Rate of diameter growth gradually slowed as stand density increased. This suggests that initial stocking density of most natural pine stands was quite low. Low stocking density is further supported by presence of large dead limbs close to the ground. Many old growth ponderosa pine still retain limbs 2 to 4 inches in diameter in the lower third of the bole which could only develop under open stocking.

The relationship between underburning and tree stocking has important land management implications. First, stocking level control is *mandatory* for managing ponderosa pine (Fig. 4). Overly dense young stands must be pre-commercially thinned so trees can grow to commercial size. Once of commercial size, periodic thinning is desirable to prevent stand stagnation and reduced growth. A second concern deals with estimating allowable cut volumes. Some methods accept "fully stocked stands" as contributing a full share to harvestable volume. Small diameter stagnated stands of pre-commercial size will not furnish future scheduled harvestable volume.

A typical stand is 40 years old, 8 feet tall, 2 inches dbh and growing at 50 rings per inch (0.4 inches diameter growth in 10 years). A land manager dealing with ponderosa pine in the Blue Mountains is not fat and happy with "well stocked stands." Instead, he has an economic liability on his hands requiring stand treatment prior to realizing an economically saleable product. The manager should be more satisfied with "understocked stands" which will grow rapidly to a suitable diameter. Control of underburning has created a serious land management problem.

Fig. 4. Same stand as Figure 3 as it appeared 10 years later (1974). Thinning was required to break stagnation. Tree at meter board is 12.7 inches diameter and is now growing at 0.35 inches dbh per year.

Underburning has affected trees in another way. Fire has selectively killed white fir and Douglas-fir while favoring ponderosa pine due to highly different bark conditions between these species. Pine develops fire resistant bark containing a 1/8 to 1/4 inch thick dead outer layer at about 2 inches diameter. Fir bark remains green and photosynthetically alive up to 4 inches diameter at the ground level. This bark is so sensitive to heat that fire burning quickly through pinegrass is able to kill the bark and destroy the tree. In fact, white fir bark is so sensitive to heat that understory trees released by overstory removal often suffer sunscald due to temperatures created by direct sunlight. With the demonstrated success of wildfire suppression, ponderosa pine is being replaced by white fir and Douglas-fir. By eliminating underburning, we have changed the environment to such an extent that a new "primary" succession is taking place. The ponderosa pine/pinegrass community is changing to a fir/pinegrass—heartleaf arnica plant community (Weaver, 1961; West, 1969). Compare Figure 5 with Figure 6. Figure 5 depicts ponderosa pine/pinegrass fire dependent plant community. Figure 6 depicts white fir and Douglas-fir with occasional ponderosa pine after 120 years without underburning. This is the reason we call this plant community "mixed conifer/pinegrass" rather than ponderosa pine/pinegrass. Our data indicate that cubic volume productivity of wood is about 20 percent greater when the site is dominated by firs than when it is dominated by ponderosa pine.

Realizing that underburning has tended to favor ponderosa pine and discourage white fir is significant information for the land manager. He has the opportunity of growing at least three different tree species on this site instead of just ponderosa pine. He has an opportunity of increased fiber production by converting pine to fir. But he should note that fir regeneration only occurs under a shelterwood often of ponderosa pine, whereas ponderosa can regenerate in full sunlight. This means that silviculture for maintaining ponderosa pine is different from that for encouraging Douglas-fir or white fir.

Lack of underburning has apparently retarded growth of ponderosa pine trees. On several sites we compared height and diameter growth between ponderosa pine and white or Douglas-fir in full

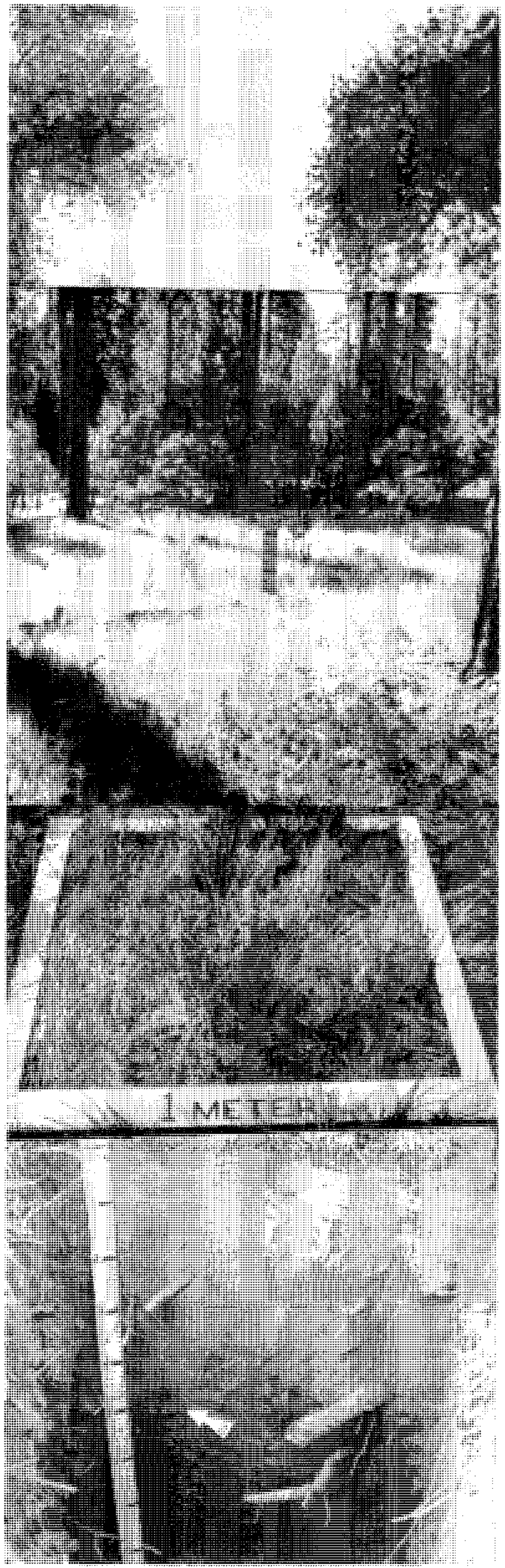
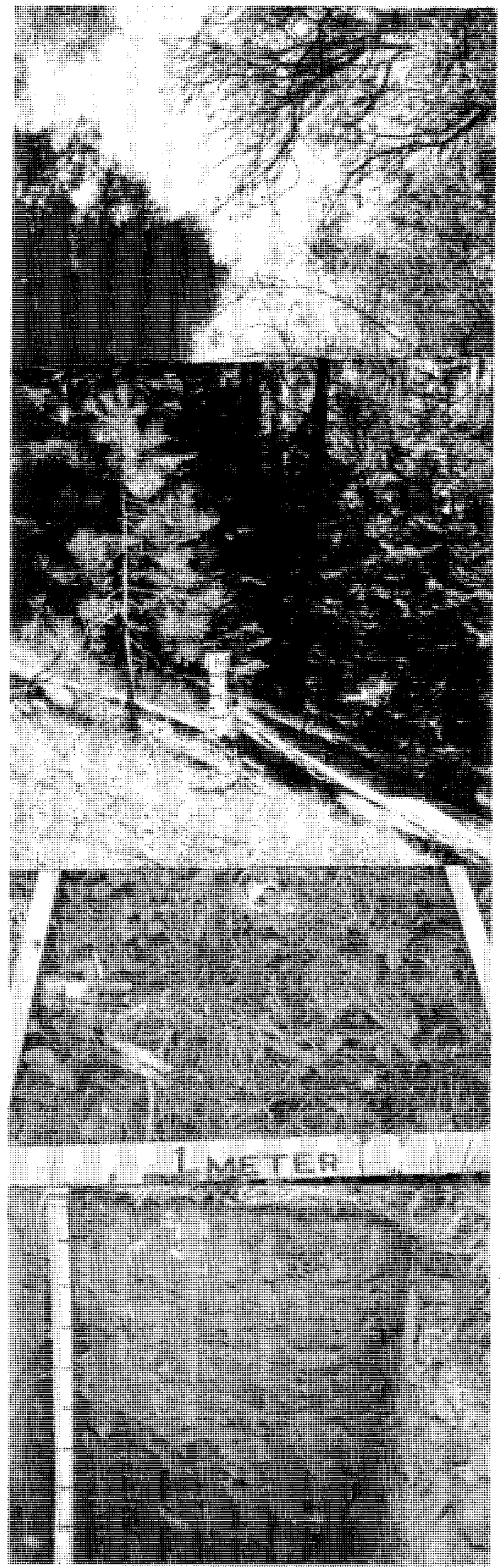


Fig. 65. Plant community type called mixed conifer/pinegrass which is currently dominated by ponderosa pine. Crown cover averages 50 percent; pine has been maintained by periodic underburning; grass production is 600 to 800 pounds per acre; soils are brown forest derived from volcanic ash deposited upon a residual soil. Arrows indicate charcoal (burned roots).

Fig. 6. Mixed conifer/pinegrass plant community type dominated by white fir and Douglas-fir. Crown cover averages 80 to 100 percent with some residual overstory of ponderosa pine; firs completely dominate tree reproduction because underburning has been excluded, ponderosa is dead and dying (note down ponderosa by meter board); grass has greatly decreased with increasing fir cover, now averaging only 50 to 75 pounds per acre; soils are brown forest with no evidence of podzolic formation.



sunlight under low stocking conditions. On one site, ponderosa was 41 years old, 2 inches diameter, and 8 feet tall. Within 10 feet of this tree in equally full sunlight was a white fir 20 years old, 3 inches diameter, and 18 feet tall. Pine grew 6 inches in height last year and the fir grew 20 inches in height. Pine averaged 40 rings per inch diameter growth and fir averaged 13 rings per inch. Old growth ponderosa pine on this site, which developed with periodic underburning, showed 3 to 5 rings per inch diameter growth at the tree center and 5 to 7 rings per inch at 3 inches dbh. Something seems to inhibit growth of ponderosa pine while not adversely affecting white fir or Douglas-fir.

I suspect a selective inhibitory substance exists in ponderosa pine litter that is destroyed with periodic underburning. Without fire, this substance is free to build up in the soil and reduce pine growth. Measurements on underburned stands have suggested increased diameter growth of pine compared to unburned controlled plots. A somewhat analogous situation has been found in France with Norway spruce (Duchaufour and Rousseau, 1959). Under dry summers and buildup of tree litter, manganese reaches concentrations that prevent regeneration of spruce. It does not prevent regeneration of beech and maple. Consequently, the land manager in France must grow alternate rotations of spruce and hardwoods or destroy the toxic manganese in litter by scarification. In this country, pine litter has been shown to influence root growth of various grasses and forbs (Jameson, 1968; McConnell and Smith, 1971).

UNDERBURNING EFFECTS ON GROUND VEGETATION

Underburning has had both a direct and indirect effect on ground vegetation. An indirect effect is depicted by comparing Figures 5 and 6. Fire-dependent ponderosa pine/pinegrass produces 600 to 800 pounds of forage per acre in pinegrass and elk sedge under 50 percent tree crown cover. As pine is replaced by fir, tree crown cover increases significantly. Figure 6 shows sapling and pole fir under a partial overstory of ponderosa pine with a total crown cover of about 80 percent. This crown cover drastically reduces ground vegetation as shown in the meter square of Figure 6. Here, grass production is only 50 to 75 pounds per acre and heartleaf arnica becomes apparent. Clearly, control of underburning has not only caused an increase in fir and a change in the forest community but also has caused a dramatic shift in ground vegetation.

This shift in ground vegetation has significant management impacts. In 1940, 64,000 animal units grazed in the Blue Mountains. By 1970, 10,000 animal units were lost because of increasing fir cover. An animal unit is one cow and her calf or five to seven sheep. This is a 16 percent reduction in livestock carrying capacity. It represents not only a significant financial impact on those ranchers dependent upon use of National Forest grazing land but it also significantly reduces red meat for the consumer. In 1940, the Blue Mountains supplied 64,000 people with their 1-year supply of beef (114 pounds per person per year). By 1970, only 54,000 people were supplied. Even though population of the United States increased, the ability to produce red meat was eliminated for 10,000 people.

Changing ground vegetation due to tree cover poses a problem in evaluating condition of the rangeland and trend in dominance of forage plants (Dyksterhuis, 1949; Ellison, 1951). In "typical" rangeland evaluation, good condition is equated with climax vegetation dominance. If livestock are forced to overgraze the range, they will tend to kill the most palatable forage plants causing a downward trend in their dominance. The range is then considered to be in fair or poor condition. This very same situation is occurring *without* livestock influence in the mixed conifer/pinegrass plant community. Pinegrass and elk sedge, the most palatable plants, decrease with increasing tree cover. Interpretation of range trend must separate changes in ground vegetation caused by tree cover from those caused by livestock impacts. Interpretation of trend is our best means of appraising current livestock management—we strive for no downward trend in good range condition or upward trend in fair or poor condition. In addition, condition of the rangeland must be related to tree cover instead of climax ground vegetation dominance. The climax condition suggested by Figure 6 is not a suitable benchmark for estimating how much pinegrass and elk sedge should occur under a 50 percent crown cover of pine (Fig. 5). Range condition guides must relate tree cover to composition, density and productivity of ground vegetation.

Big game animals, deer and rocky mountain elk, suffer the same reduction in forage as livestock. In addition, variety of palatable plants is significantly reduced. In the ponderosa pine/pinegrass fire community, five to eight plants contribute significantly to deer and elk forage. In the dense fir/arnica-pinegrass community, only three plants significantly contribute forage.

Underburning has had a direct effect on ground vegetation. Recall that ponderosa pine was scarred by natural wildfire an average of once every 10 years. In order to be scarred, the fire had to be carried by ground vegetation. Thus pinegrass, elk sedge, balsam wooleyweed, vetch, arnica, strawberry, and all other ground vegetation plants in this community developed genetically under a regime of 100 percent utilization every few years. Those plants best able to compete and colonize the site became dominant. Nature selected these plants genetically in the same way that we breed and select pasture or hay grasses. Various species and varieties are mowed at 2 or 3-inch stubble heights to evaluate their performance under use. Those which perform best are selected to produce pasture or hay. Periodic burning has endowed pinegrass and elk sedge with the ability to withstand managed utilization by livestock. They can persist and increase under natural range conditions with 25 to 50 percent utilization every year.

Some plants often found in this plant community, like the shrub ceanothus, need fire for continued survival. Ceanothus seeds require heat treatment by surface or conflagration fire to trigger germination (Hickey and Leege, 1970). With fire control, many stands of ceanothus have not regenerated. This shrub is desirable because it provides cover and essential early spring, late fall and winter forage for game animals and it adds nitrogen to the soil. The current means of maintaining ceanothus is by logging and use of fire for residue reduction.

Other shrubs, such as bitterbrush, are killed by fire (Weaver, 1957). They generally do not have the capability of sprouting following burning and their seeds are not stimulated by heat treatment. In this case, underburning has a detrimental effect on game animals by eliminating a key winter forage species. Ironically, elimination of bitterbrush or sagebrush within the forest zone seems to be advantageous for livestock because it tends to increase grass production.

UNDERBURNING AND SOIL

We have seen that underburning was common in the Blue Mountains. It affects tree vegetation which in turn affects ground vegetation. Fire has itself affected ground vegetation. By deduction, it would seem that soils have developed under periodic ground fire in this plant community. The soil photo of Figure 5 has two arrows indicating burned tree roots. For years, these soils caused consternation to soil scientists trying to classify them according to European or eastern United States nomenclature. The mixed conifer/pinegrass plant community occurs in a northern type of environment characterized by snow cover during the winter (Montane Forest Formation) (Lutz and Chandler, 1946; Oosting, 1958). In Europe and eastern United States, pine and fir stands characterized by winter snow cover invariably grew on a podzol, or podzolic soil. A podzol has a very dark A-1 horizon 1 to 3 inches thick, a white A-2 horizon 3 to 6 inches thick, and below that a B horizon of brown to dark brown. Note in both Figures 5 and 6 that neither soil is a podzol or podzolic. These have been referred to by Canadians as gray wooded or brown forest soils (Spilsbury, et al., 1963). They occur in the west under forest/grass plant communities that have been periodically underburned. Ground fires consumed the litter necessary for podzol development. Abundant grass roots have carried a brown to moderately dark brown color well down into the soil profile. Brown forest soils developed under periodic burning and are capable of withstanding periodic burning. In fact, if our supposition is correct that ponderosa pine litter inhibits ponderosa pine growth, it would seem desirable to consider periodic burning to remove tree litter from the surface of the soil.

UNDERBURNING AND FIRE HAZARD

Fire hazard is directly correlated with changes in tree cover and ground vegetation. Note in Figure 5 that fuel for wildfires is confined largely to grass with an open tree canopy permitting heat to dissipate easily. Figure 6 depicts something different. Grass has been replaced by pieces of wood inside the meter square plot, a down tree is partly decayed next to the meter board, and the tree canopy has nearly closed. When lightning strikes in a stand depicted by Figure 6, the fire does not move quickly through light, flashy fuel but tends to burn slower and hotter in tree needles, twigs and old trees. This heavier fuel produces more heat and the closed crown canopy does not permit heat to escape. The result is volatilization of flammable oils in tree needles which suddenly ignite in an explosion to create a catastrophic crown fire. This phenomenon was precisely the cause of conflagration fire in the Mitchell Creek area during those terrible Wenatchee, Washington, fires of 1970. Mitchell Creek is a mixed conifer/pinegrass plant community type. It was totally consumed by conflagration fire.

SUMMARY

Interpretation of underburning in mixed conifer/pinegrass community types of the Blue Mountains in eastern Oregon suggests that: surface fires occurred at an average of at least once every 10 years; ponderosa pine is being replaced by white fir or Douglas-fir; ponderosa pine stands did not develop according to the "normal stand development" concept; pine stands require control of stocking density to avoid stagnation; range grasses decrease with increasing tree cover as pine is replaced by fir regardless of livestock use thereby complicating interpretation of range trend; pinegrass is capable of sustaining livestock use because of its development under periodic 100 percent utilization by fire; some plants, particularly shrubs, are dependent upon fire for their survival whereas other shrubs are killed by fire; soils in these plant communities have developed under periodic fire and should be considered "brown forest" instead of "podzolic" due largely to this fire influence and its encouragement of grass vegetation; and fire hazard is changing from light, flashy fuels under an open tree canopy to heavy fuels.

Control of underburning in the mixed conifer-pinegrass community has created an increased fire hazard in a *known fire environment.* We have changed from a fire resistant plant community to a fire susceptible plant community. We may not have a choice about burning-only a choice of how to burn; prescribed fire or wildfire.

SPECIES LIST

Plants			
Arnica	*Arnica cordifolia*	Maple	*Acer sp.*
Balsam woolyweed	*Hieracium scouleri*	Mixed conifer	*Pinus ponderosa, Pseudotsuga menziesii, Abies grandis*
Beech	*Fagus sylvatica*	Norway spruce	*Picea excelsa*
Bitterbrush	*Purshia tridentata*	Pinegrass	*Calamagrostis rubescens*
Ceanothus	*Ceanothus sp.*	Ponderosa pine	*Pinus ponderosa*
Douglas-fir	*Pseudotsuga menziesii*	Sagebrush	*Artemisia tridentata*
Elk sedge	*Carex geyeri*	Strawberry	*Frageria species*
Firs	*Abies grandis* and *Pseudotsuga menziesii*	Vetch	*Vicia americana*
Heartleaf arnica	*Arnica cordifolia*	Western larch	*Larix occidentalis*
Lodgepole pine	Pinus contorta	White fir	*Abies grandis*
Animals			
Deer	*Odocoileus hemionus*	Rocky Mountain Elk	*Cervus canddensis*

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