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FIRE HISTORY AND NEED FOR FUEL MANAGEMENT IN MIXED DOUGLAS-FIR FORESTS OF THE KLAMATH-SISKIYOU REGION, NORTHWEST CALIFORNIA AND SOUTHWEST OREGON, USA.

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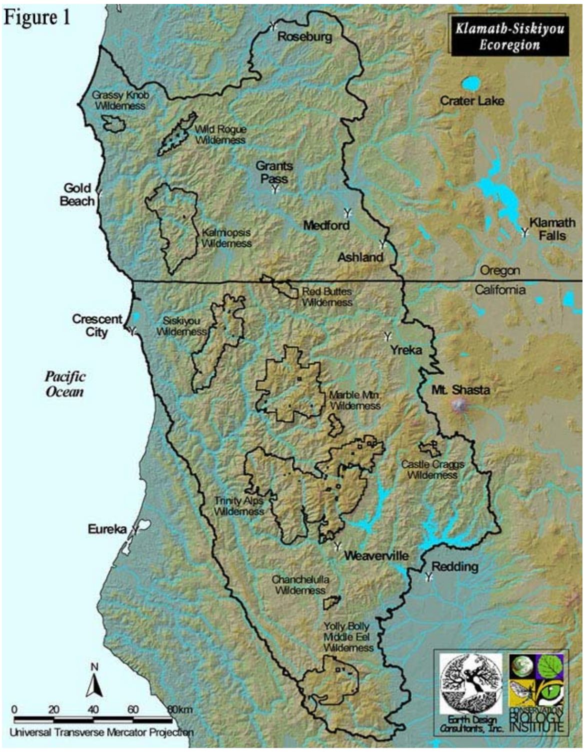
1. INTRODUCTION

Controversy exists regarding a stated need to intensively thin forest vegetation for the purpose of reducing or preventing severe wildland fires. Many believe that successful fire exclusion during the 20th century caused the density of forest trees to increase along with the risk of catastrophic fires. The Bush administration's "Healthy Forests Initiative" (HFI) (White House 2002) stakes its foundation on the widely accepted view that wildfires now burn larger areas more severely than ever before due to many decades of well-intentioned but discredited fire suppression policies. The HFI would change federal environmental laws to expedite commercial logging of mature forests with the intention of reducing hazardous fuels on federal public lands across the western United States (Gerstenzang and others 2002).[1]

Figure 1



This analysis examines whether a need exists for such thinning in mixed-conifer forests of the Klamath-Siskiyou (K-S) region of northwest California and southwest Oregon (figure 1) from the perspective of fire ecology and conservation biology. Local fire ecology studies describe development patterns of mixed-conifer forests and inform interpretation of recent fire events in the K-S region. Conservation biology recognizes ecological risk resulting from uncertainty and the decline of biological diversity, and frames recommendations for approaches to ecological restoration.

Unprecedented changes in fire behavior and effects resulting from fire exclusion and logging practices in forests dominated by ponderosa pine are widely accepted as fact (Arno and Allison-Bunnell 2002). However, there is less certainty about fire regime changes in Douglas fir (*Pseudotsuga menziesii*) forests (fig. 2), particularly in the K-S region, where climate, topography and vegetation exert widely variable influences on the duration of time between fires (frequency), the size of fires (extent), the time of year in

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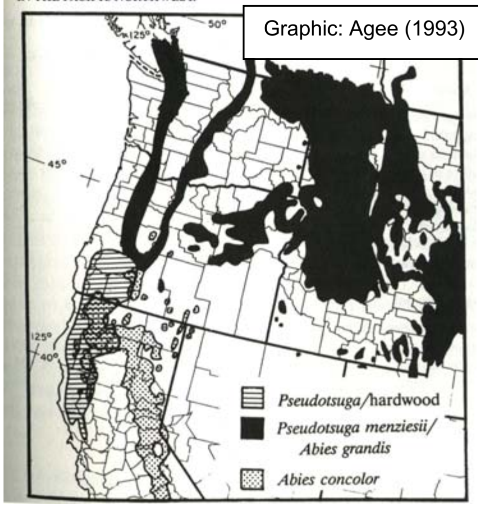
[1] The HFI proposes to weaken citizen enforcement of federal land management plans and statutes. It would exclude projects from environmental study, public comment and administrative appeals, and prevent courts from blocking projects with injunctions, as long as projects occur on lands mapped by Schmidt and others (2000) as posing a high fire danger.

which fire burns (seasonality), the heat energy output of fires (intensity), and biological effects on plants and animals (severity) (Arno 2000, Frost and Sweeny 2000). This analysis gauges the disruption of local fire ecology processes resulting from human activities, as expressed by several large wildfires events in the recent past.

This analysis focuses on mixed-conifer forests featuring Douglas fir because:

Figure 2.
MIXED-CONIFER/MIXED-EVERGREEN FORESTS IN THE PACIFIC NORTHWEST.



Graphic: Agee (1993)

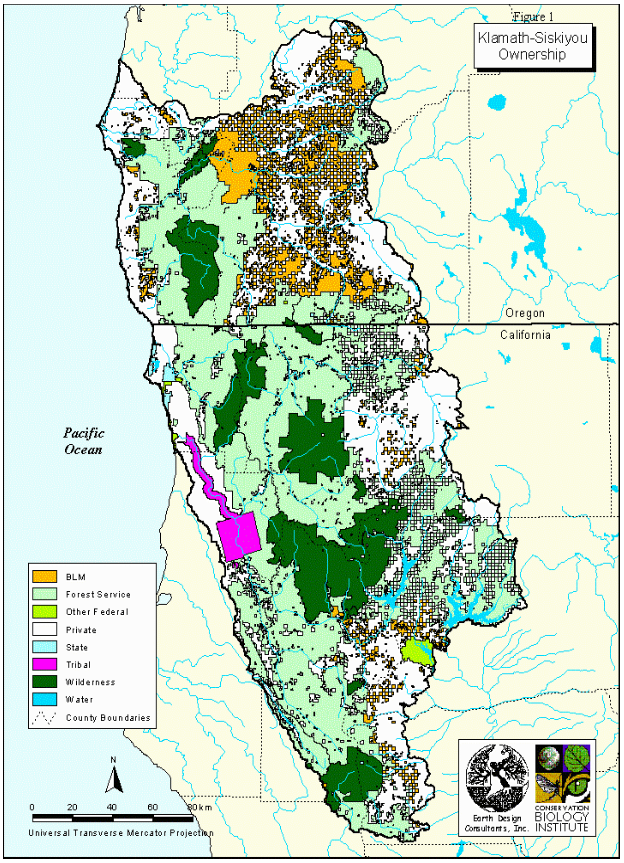
- It is the most widespread forest type in the K-S region.
- Fire is a key natural disturbance process in this forest type.
- Many federal timber sales with a purpose of reducing fire danger are proposed for this forest type.

Mixed-conifer forests dominated by Douglas fir are the most likely in the K-S region to experience accelerated logging should the HFI become law. Proposed legislation (McInnis and Walden 2003) references a coarse-scale mapping system developed by the U.S. Forest Service Fire Sciences Lab (Schmidt and others 2000) that rates nearly all lands in the K-S region as “moderately” or “significantly altered” from historic conditions and at-risk of “losing key ecosystem components” without fuel hazard mitigation. This analysis argues that the reliability of the spatial data supporting these ratings is suspect, and it notes the absence of any local-level scientific assessment demonstrating a need for intensive thinning in K-S forests. It synthesizes existing knowledge about local fire ecology processes and forest development patterns, identifies specific needs for additional research, and recommends interim criteria for prioritizing fuel management projects that could help maintain the region’s globally outstanding biological diversity.

2. GLOBAL IMPORTANCE OF KLAMATH-SISKIYOU FORESTS

Straddling the California-Oregon border, the 10-million-acre K-S region is one of the most ecologically unique regions on Earth (WWF 2003). It is transitional to the Great Basin, Oregon Coast Range, Cascades Range, Sierra Nevada, California Central Valley and the coastal region of northern California, sharing vegetative influences from each (Whittaker 1960, 1961). Thus, it features the greatest plant diversity of any geologic province in western North America (Sawyer and Keeler-Wolf 1995, Wagner 1997). Its temperate mixed-conifer forests cover steep mountainous topography and numerous environmental gradients associated with abrupt changes in bedrock geology, soils, elevation, slope, aspect and moisture (DellaSala and others 1999).

The conservation value of K-S forests is globally significant (Noss and Strittholt 1999). Over 25 percent of the region is unroaded. Roads and logging activities have fragmented three-quarters of forestlands in the K-S. It nevertheless features the largest concentration of mature and old growth forests remaining in the Pacific Northwest, mostly on public lands managed by the U.S. Forest Service and Bureau of Land Management (Strittholt and DellaSala 2001). Approximately 50 percent of regional forests occur on privately owned lands, where the most extensive conversion of native forests into young tree plantations has occurred over the last 30 years (CBI 2001). Much of this private land intermingles with land managed by federal agencies in a “checkerboard” pattern (fig. 3). Incremental degradations of relatively unmanaged forests and unroaded areas in this region, whether by unnaturally severe wildfires or by acts of people, may have disproportionately negative effects on biological diversity at continental and global scales (Noss and Strittholt 1999).



3. HISTORICAL ROLE OF FIRE IN KLAMATH-SISKIYOU FORESTS

Fire is the primary natural disturbance agent in K-S forests, influencing vegetation structure, species composition, soil properties, nutrient cycling, hydrology and other ecosystem processes (Agee 1993). Most native plants and animals evolved with fire and many are adapted to, if not dependent on, fire’s periodic occurrence (Martin 1997). Ecologists have suggested that the region’s outstanding biological diversity is due in part to its natural disturbance regimes and to fire in particular (Martin and Sapsis 1992). Variability of fire regimes in time and space creates diverse complexes of species and habitats (Brown 2000). It follows that conservation of ecological integrity depends on the extent to which managers allow fire to play its essential role in the ecosystem (Frost and Sweeny 2000). Moreover, to be effective over the long-term, ecosystem management on federal lands must account for historic patterns of fire frequency, size, timing, intensity and severity in the design of appropriate restoration strategies (Baker 1994). If land managers are to increase fire management activities, understanding the historic role of fire, its natural range of frequency and effects, and how these have changed due to human activities is essential to success (Hardy and Arno 1996).

3.1 *Variability of fire occurrence and severity*

Mixed-conifer forests of Douglas fir, white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), ponderosa pine (*P. ponderosa*) and incense cedar (*Calocedrus decurrens*) blanket the middle elevations of the Klamath

Mountains and frequently intermix with forests consisting primarily of Douglas fir and hardwood species (Frost and Sweeny 2000) (figs. 2, 4). The fire regimes of mixed-conifer and Douglas fir/hardwood forests are among the most variable in the Pacific Northwest, "prevent[ing] credible generalizations about fire and its ecological effects" (Agee 1993). Historic and contemporary fires have included severe stand-replacing conflagrations, mixed severity fires, and low severity "underburns," often within the same fire perimeter (Frost and Sweeny 2000). As flames encounter different fuel conditions, topographic positions and weather, the intensity of fire and its effects on vegetation fluctuate in complex patterns. The result is a patchy mosaic of multi-aged stands across the landscape, with each patch exhibiting different tree densities, ages and species (Taylor and Skinner 1998, Willis and Stuart 1994).

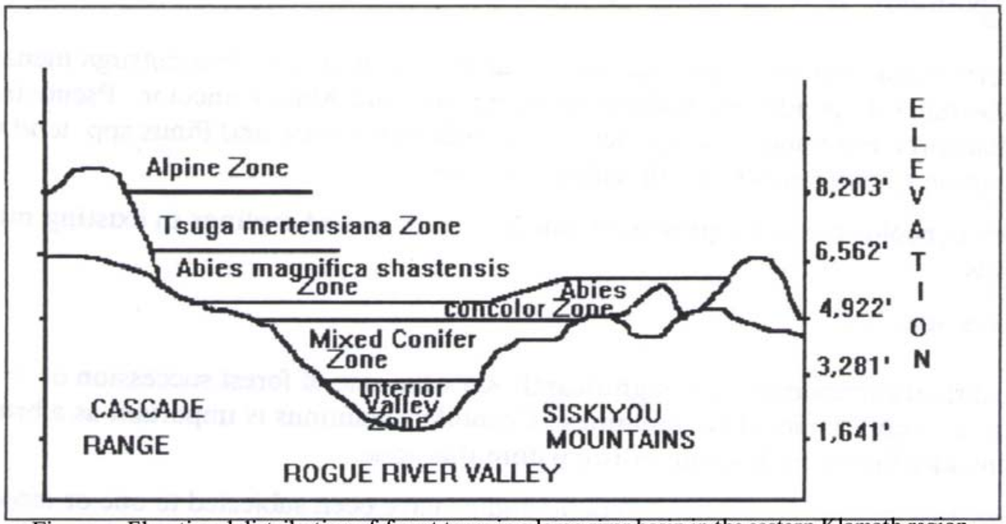


Figure . Elevational distribution of forest types in a large river basin in the eastern Klamath region.

Time between fires (frequency) in mixed-conifer forests varies widely across the K-S, with documented return intervals ranging from 3 to 116 years. In the Salmon River watershed, Willis and Stuart (1994) describe a mean frequency of 10 to 17 years, but with extreme variability (3 to 71 years) since 1740. In the Thompson Creek watershed, Taylor and Skinner (1998) calculated median return intervals of 12 to19 years in four distinct plant associations. Again, fire frequencies spanned significant ranges of time, from 4 to 87 years in stands consisting of white fir and Douglas fir, and from 5.5 to 116 years in pure stands of Douglas fir.

Slope aspect, elevation and soil moisture greatly influence vegetative composition and fire frequency (fig. 5). For example, Taylor and Skinner (1998) describe four forest types located between 1950' and 4800' above sea level. Those forests feature:

- Pure stands of Douglas fir.
- Douglas fir, sugar pine and ponderosa pine at lower elevations on south and west aspects.

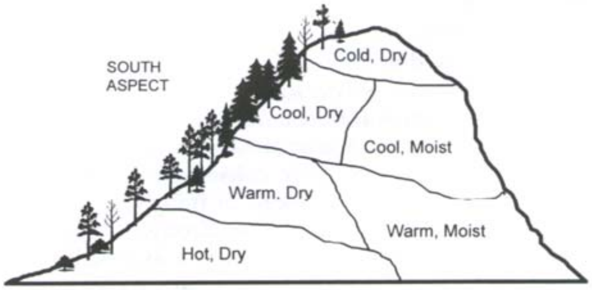


Figure 4. The temperature-moisture gradient influences the vegetation that occurs across the landscape.

- Douglas fir, white fir and sugar pine at higher elevations on south and west aspects.
- White fir and Douglas fir at higher elevations, and on north and east aspects.

Douglas fir generally decreases in abundance as elevation increases. At lower elevations, an understory of hardwood trees including tanoak (*Lithocarpus densiflorus*), Pacific madrone (*Arbutus menziesii*), bigleaf maple (*Acer macrophyllum*) and black oak (*Quercus velutina*) occurs beneath a canopy of Douglas fir, sugar pine and ponderosa pine. Those communities historically burned more frequently than at higher elevations, where hardwoods are less abundant and white fir and Douglas fir dominate the forest canopy. Other local studies support this finding of shorter periods between fires at lower elevations, on more exposed sites, and in drier forest types (Atzet 1996, Frost and Sweeny 2000).

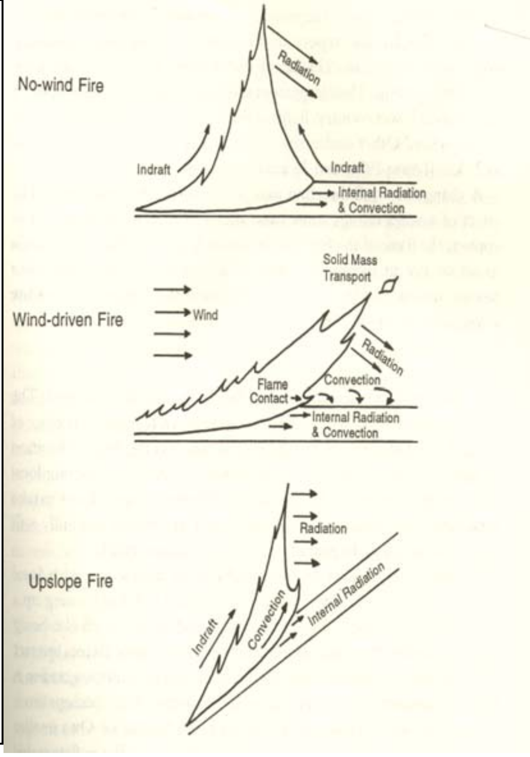


Figure 6. Slope and wind bring flames nearer to unburned fuels, pre-heating fuels and enhancing heat energy output. Graphic: Whelan (1995).

"Large portions" of historic fires burned at low and moderate severity in these mixed-conifer forests (Agee 1993), but high severity fires also were important to the ecosystem (Frost and Sweeny 2000). High severity fire effects typically account for 10 to 20 percent of the total area burned in any recorded fire event (Atzet 1996, Frost and Sweeny 2000). Slope position on steep terrain significantly affects the distribution of high severity fire. Convection currents drive radiant heat upward and bring flames nearer to adjacent unburned vegetation, thus pre-heating fuels and enhancing the intensity of heat energy production and release (fig. 6). Taylor and Skinner (1998) report that of the area burned at mid-slope positions on the west side of Thompson Ridge between 1850 and 1950, more than 20 percent burned at high severity, and over 70 percent of upper slope positions burned at high severity.

3.2 *Forest development patterns*

The wide variability of time between fires and burn severity patterns creates many potential development pathways for K-S mixed-conifer and Douglas fir/hardwood forests that often converge at maturity with an open overstory and more continuous understory of hardwoods (Thornburgh 1982). Frost and Sweeny (2000) describe four scenarios that span the range of fire interactions with stand development in Douglas fir/hardwood forests:

- In the absence of fire, importance of hardwoods increases but long-lived Douglas fir remains co-dominant. Species composition may remain somewhat stable over many decades.

- Low intensity fires thin small Douglas fir trees and create canopy gaps that allow for regeneration. Fire top-kills hardwoods but they resprout from their roots. Successive fires of low intensity at intervals spanning decades result in stands with multiple age classes and fine-grained patchiness.

- After a fire of moderate intensity, hardwood sprouts may co-dominate a site and scattered large Douglas fir trees may produce many seedlings. The hardwoods grow more quickly at first, but eventually Douglas fir overtops them.

- After a more severe fire, few young Douglas fir trees survive. Hardwoods may dominate the stand for decades until fir invades from adjacent stands.

Young Douglas fir trees easily succumb to fire, but become highly resistant with increasing age and bark thickness (Agee 1993). Mild fires often kill thin-barked hardwood species, but the hardwoods aggressively resprout from their root crowns (fig. 7). Their early post-fire sprouting ability gives hardwoods a competitive advantage on burned sites (Frost and Sweeny 2000).

Multiple studies characterize Douglas fir establishment after fire as frequent but patchy at a landscape scale. The combination of factors needed for Douglas fir regeneration is actually quite rare at a very local, site scale. Its shade intolerance and need for mineral soil and/or burned seedbeds (Arno 2000) may account for episodic regeneration patterns among Douglas fir forests with variable age classes and structures. In the Salmon River watershed, moderately severe fires on about a 140-year return interval create growing space for Douglas fir stand initiation (Willis and Stuart 1994). Such long periods between moderately severe fires could account for the mosaic distribution of even-aged groups of Douglas fir trees across the landscape.

Figure 7. Tanoak sprouts from burned root crown in the Biscuit Fire, Siskiyou National Forest, OR. Photo: U.S. Forest Service.

The development of forest stands exhibiting structurally diverse, late-successional conditions largely depends on the occurrence of relatively frequent and mixed-severity fires (Taylor and Skinner 1998). Variations of disturbance patterns in time and space are important to diversity in vegetative succession. This variability is likely a critical aspect of long-term ecosystem dynamics and function, and an important factor contributing to the K-S region’s outstanding biological diversity (Brown 2000, Martin and Sapsis 1992). Moreover, the wide variation in fire regime attributes likely is equally or more important than mean or median values in creating the vegetation mosaics that exist across the landscape (Frost and Sweeny 2000, Taylor and Skinner 1998).

3.3 *Differences from surrounding regions*

Taylor and Skinner (1998) argue for a place-based understanding of fire effects on forest development patterns because disturbance regimes vary geographically, and this variation contributes to regional differences in forest structure. In the Cascades Range of western Oregon, for example, large stands (>100,000 ha) of even-age Douglas fir are thought to develop from large, infrequent, severe fires that kill most trees, followed by long fire-free periods that typically exceed 100 years (Agee 1993, Morrison and Swanson 1990). In contrast, fires occur much more frequently and generally with lesser severity in the warmer, drier Douglas fir forests of the K-S region, where average time between fires often is less than 20 years (Taylor and Skinner 1998, Willis and Stuart 1994).

Differences in climate, understory vegetation, time between fires, and overall landscape patterns between Cascadian and K-S Douglas fir forests led Willis and Stuart (1994) to associate the latter with mixed-conifer forests in the Sierra Nevada region, where historic fires have been described as frequent and low or moderate in severity (Skinner and Chang 1996). K-S and Sierra Nevada forests evolved in a similar Mediterranean climate with hot, dry summers and cool, wet winters. Moreover, forests in both regions host plant species that evolved with relatively frequent fires (Frost and Sweeny 2000).

However, others caution against likening disturbance dynamics across geographic regions, even among seemingly similar forest types. Beaty and Taylor (2001) studied an area of the Lassen National Forest (LNF) in the southern Cascades, in between the K-S and Sierra Nevada regions, where they monitored spatial and temporal variation of fire regimes on a mixed-conifer forest landscape. Fire regime parameters varied spatially with species composition, elevation, slope aspect, and soil moisture (fig. 5). Frequent fires of low and moderate severity primarily influenced forest development patterns, but high severity fires also occurred and were very important to structural diversity at stand and landscape scales. Greater proportions of high severity burns occurred at upslope positions and on ridges due to upward fire movement and pre-heating effects on vegetation (fig. 6). The largest extent of severe fires occurred during or after periods of prolonged drought.

An implication is that a chaotic, non-equilibrium disturbance dynamics may better describe mixed-conifer forest development patterns than a traditional equilibrium view of succession that depicts forest development as time-dependent because of the period between fires needed for sufficient fuel to accumulate and carry the next fire (i.e., fuel-dependent) (Beaty and Taylor 2001). An additional implication is that significant geographical differences exist among mixed-conifer forests along the Pacific slope of North America. Unlike vegetation in the south Cascades and Sierra Nevada, where plant associations typically occupy distinct altitudinal zones across relatively gentle topography, varied K-S forest types often intermix at fine scales (Frost and Sweeny 2000, Taylor and Skinner 1998). This extreme variability makes it difficult to isolate the fire regime of a particular forest patch, as it may be equally or more influenced by the spread of fire from adjacent vegetation (Frost and Sweeny 2000). Therefore, extrapolation of fire history information from other regions to K-S forests is not appropriate.

4. FIRE REGIME CHANGES RESULTING FROM HUMAN ACTIVITIES

4.1 *Indigenous burning patterns changed with European settlement*

Indigenous peoples of the Klamath region had highly developed traditions of intentional burning to maintain open stands of oaks, aid in the collection of insects, fungi and acorns, clear areas for travel, and to improve habitat for preferred plants and game animals (LaLande and Pullen 1999). Indigenous people ignited fires more often at lower elevations and less frequently as elevation increased (McKinley and Frank 1995), although oral history suggests that anthropogenic fires regularly burned up to 6,000 feet above sea level (Martinez 2003). Lightning ignitions dominated the fire regimes of mid-elevation forests (Frost and Sweeny 2000), although some mid-elevation forests probably ignited relatively frequently as anthropogenic fires spread out of the lowlands (Martin and Sapsis 1992).

Indigenous burning virtually disappeared from the Klamath region within just a few years of European settlement due to settlers' aggressive displacement tactics (Beckham 1996). Fires ignited by settlers (especially miners) in the last half of the 19th century differed dramatically from those set by indigenous people in terms of seasonality, extent, and intensity (McKinley and Frank 1995). Livestock grazing also altered fire occurrence and behavior by reducing fine fuels that previously allowed frequent surface fires to spread, and by exposing mineral soil, thereby giving conifers such as Douglas fir a competitive advantage over perennial grasses and other herbaceous plants adapted to frequent, low-severity fires (Belsky and Blumenthal 1997).

4.2 *Fire suppression has increased average fire size*

Despite national policy, fire suppression did not become effective in the remote Klamath Mountains until after World War II, when fire fighting became mechanized and drew support from an expanded network of roads and surplus military aircraft (Frost and Sweeny 2000, McKinley and Frank 1995). In contrast, Sierra Nevada forests experienced sharp declines in fire frequency near the turn of the 20th century due to persistent efforts by European settlers to exclude natural fires from the landscape (Skinner and Chang 1996). While certain aspects of Klamath fire regimes may have changed by the mid-20th century, wildland fire nevertheless played an active role throughout its historic range at least until 1950 (Frost and Sweeny 2000, McKinley and Frank 1995, Odion and others in press).

Fires generally have been less frequent in Klamath mixed-conifer forests during the suppression period (Atzet and Martin 1991, Frost and Sweeny 2000, Taylor and Skinner 1998, Willis and Stuart 1994). Large fires that ignite during extreme weather now account for the vast majority of acres burned, whereas in the past more small- and moderate-sized fires burned across a wider range of weather and fuel conditions (Frost and Sweeny 2000, Stephens 1998, Taylor and Skinner 1998). Contemporary fires of any significant size now ignite simultaneously with others and together overwhelm suppression resources (Odion and others in press, USDA 1994). As a result, fire sizes are increasingly homogenous. This may negatively affect biodiversity. A restricted range of suitable burning conditions and longer average time between fires may disadvantage fire-adapted biota with short life cycles relative to the time between fires (Martin and Sapsis 1992).

4.3 *Timber management has altered landscape flammability*

At a landscape scale, selective logging has removed many of the large, fire-resistant trees that survived numerous fires (Arno 2000). Clearcutting accelerated after the 1950s and has since converted tens of thousands of acres of mature and old growth forests into young, even-aged tree plantations (fig. 8) (Noss and Strittholt 1999). Plantations are more susceptible to severe fire effects than unmanaged older forests (DellaSala and others 1995, Ingalsbee 1997, Odion and others in press). The increased susceptibility of plantations to severe fire is due to:

- Structural characteristics including high stocking densities and uniform canopies that support heat energy output by fire (Sapsis and Brandow 1997).
- Warmer, windier and drier microclimates than unmanaged, closed canopy forests (Countryman 1955, van Wagtendonk 1996).
- Accumulations of fine logging "slash" on the ground that rarely get cleaned up (USDA 1994, Weatherspoon and Skinner 1995).

Figure 8. Even-aged tree plantation established after clearcut logging. Photo: E. Frost.

The number and distribution of plantations resulting from industrial timber management likely has altered fire behavior and effects at both stand and landscape scales (Frost and Sweeny 2000). Perry (1995) suggests that the existence of highly combustible even-age tree patches on a forest landscape creates the potential for "a self-reinforcing cycle of catastrophic fires." In addition, most plantations occur next to roads that spread invasive and exotic plants (DellaSala and Frost 2001), and roads increase the risk of human-caused ignitions during hot, dry conditions (USDA 2000).

4.4 *Recent wildfires express fire regime conditions*

Many factors including fire history, the pattern and intensity of past logging, and topography complicate characterizations of change in K-S mixed-conifer forests. A finer-scale analysis is required to determine the actual condition of forests in specific watersheds. Such analysis should make use of data gained from site-specific study instead of using data extrapolated from other regions or forest types.

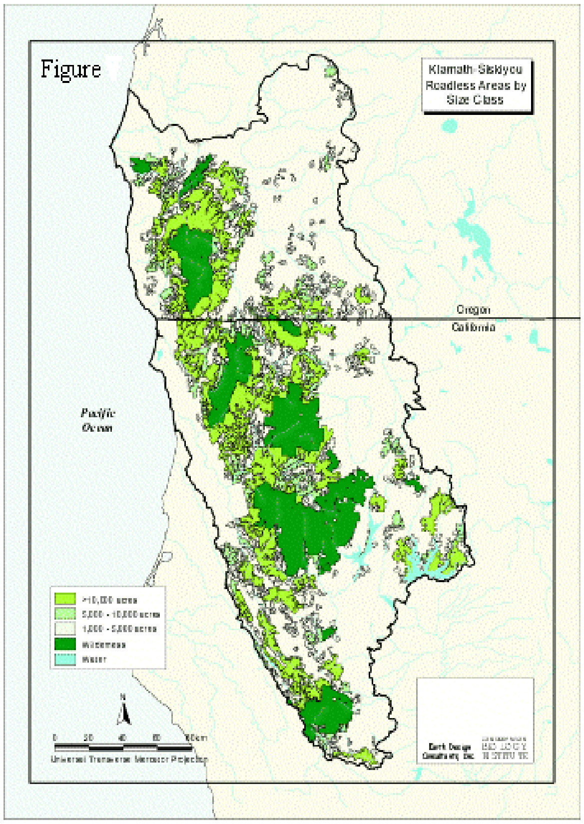
Nevertheless, observations of contemporary fire events permit some cautious inferences. Even with decreased fire frequency during the suppression era, large fire events over the past two decades have displayed severity patterns similar to those of historical fires. These wildfires covered large (>20,000 ha) areas and exhibited heterogeneous burn patterns and effects comparable to what researchers have described of historic fires:

- 2002 Biscuit fire in the Siskiyou NF (USDA 2002).
- 1999 Megram fire in the Six Rivers NF (USDA 1999).
- 1994 Dillon fire in the Klamath NF (USDA 1996).
- 1987 Silver fire complex in the Siskiyou NF (USDA 1989).
- 1987 Klamath fire complex in the Klamath NF (USDA 1994).

Taylor and Skinner (1998) conclude that the relatively short period of effective fire suppression in the Klamath Mountains (~55 years) and the variety of burning conditions that existed in the 1994 Dillon fire "likely combined to produce severity patterns … similar to those of historical fires." The Forest Service found that the Dillon Late-Successional Reserve met standards as functioning late-successional forest habitat after the fire (USDA 1996). This suggests that wildfire use for resource benefits is compatible with conservation of habitat for threatened and endangered species, and may be appropriate in portions of the K-S region that remain within their historic ranges of fire disturbance variability (Taylor and Skinner 1998).

A study of the 1987 Klamath fire complex affirms the consistency of contemporary fires with historic severity patterns and the unique susceptibility of plantations to unusually severe fire. Odion and others (in press) found that young (<20 year-old) tree plantations experienced "much higher severity fire" than closed canopy forests. More than 50 percent of all high severity fire in the Klamath complex occurred in plantations, even though tree farms only comprised 17 percent of the burned landscape. In contrast, closed canopy, mature forests mostly experienced low and moderate severity effects – up to 13 percent high severity.

Most of the older, closed canopy forests in the 1987 Klamath complex had not burned since before 1911, when land managers first began recording fires. Long absence of fire therefore is not a reliable predictor of high burn severity in unmanaged forests. Indeed, fuel properties in such forests "are resilient to long fire-free periods, suggesting that available fine fuels reach an equilibrium (or decrease where shrublands are replaced by forest over time) rather than continuing to accumulate, otherwise long-unburned areas would tend to burn at higher severity" (Odion and others in press). This suggests that extreme weather is more likely than fuel build-up to generate high severity fire effects. Topography also can be an important "bottom-up driver" of fire intensity (fig. 6) (Heyerdahl and others 2001). These findings support conclusions by Beaty and Taylor (2001) and Bessie and Johnson (1995) that weather and topography are more important influences on fire behavior than fuel accumulation.



Wildfires in the Klamath region may be larger on average than historically because fires that ignite during extreme weather now account for the vast majority of acres burned. In the past, small and moderate-sized fires burned across a wider range of weather and fuel conditions (Stephens 1998, Taylor and Skinner 1998). Contemporary fires of any significant size ignite simultaneously, and together they overwhelm suppression resources (USDA 1994).

However, contemporary fires are not necessarily more severe than ever before due to fire exclusion. Industrial timber management likely has had greater direct, indirect and cumulative effects on fire severity patterns than fire exclusion due to the creation of dense networks of young tree plantations and roads. In contrast, areas without roads (fig. 9) generally displayed a higher proportion of low and moderate severity fire effects in the Klamath complex consistent with historical patterns (Odion and others in press). The region's relatively abundant roadless country is not easily accessible to fire suppression resources. Therefore, a policy of fire suppression does not equate to effective fire exclusion in these areas (DellaSala and Frost 2001).

5. IMPLICATIONS FOR FUEL MANAGEMENT

Extreme variation in climate, topography and vegetation of the K-S region compared to other regions preclude credible generalizations about fire history and effects in local mixed conifer forests dominated by Douglas fir. Research specific to this region does not support the contention that fire regimes are significantly changed from the historic range of variability as a result of fire exclusion. Indeed, strong evidence suggests that contemporary fires display severity patterns consistent with historic fire disturbances. The relatively short duration of effective fire suppression in some areas (50 to 60 years) coupled with wide natural variation in fire return intervals (3 to 116 years) argue against application of the "unnatural fuel buildup" hypothesis to K-S forests.

The idea that unnatural fuel accumulation has resulted from fire exclusion may apply to certain ponderosa pine forests of the Intermountain West, where low intensity surface fires historically maintained open forests which have now become prone to crown fires because of changes in fuel loading and arrangement in the absence of fire (Covington 2000, Hann et al. 1997). However, this view of ecological change is subject to uncertainty because fire history methods lack modern calibration and are subject to sampling biases that rarely are taken into account (Baker and Ehle 2002). There is little or no evidence to support its application to other ecosystems (Anderson et al. 1999), including K-S forests. Nevertheless, federal land managers widely and unscientifically apply it (USDA 1998a, 1998b, 1998c, 1998d, USDI 2003, 2002a, 2002b, 1999). Ecologists have demanded convincing evidence of unprecedented conditions before land managers embark on evolutionarily unprecedented treatments such as intensive mechanical thinning to reduce fuel loads (Gutsell et al. 2001).

The need for intensive thinning to reduce fuel loading on K-S forest landscapes requires rigorous scientific assessment. A widely used system for describing fire regimes and condition classes indicates that most of the K-S region is “moderately” or “significantly altered” from historic conditions and at-risk of “losing key ecosystem components” without fuel hazard mitigation (Schmidt and others 2000), and this system is cited in legislation that would greatly accelerate intensive thinning in K-S forests. However, the “Fuelman” spatial data system’s reliability beyond providing a basis for prioritizing allocation of resources to local areas for further assessment is suspect. It represents only the percentage of forested area and tree canopy cover, rather than actual forest structure or ground fuel loading, which is a prerequisite for predicting the likelihood of an active crown fire (DeBano and others 1998). Thus, it does not provide a defensible basis on which to prioritize and design site-specific projects. Attempts to base local fuel management planning on this system could result in misplaced projects and considerable waste of public resources (Morton 2003).

Such an assessment, at a minimum, should determine 1) areas where fire regimes have departed from the historic range of variability and where fire effects could be ecologically detrimental, 2) the most effective ways to mitigate fire effects where remedial action may be needed, and 3) ways to protect the region’s unique biological diversity from unnecessary degradation. Systematic inventories of plant associations, fire history, forest structure and fuel loading are needed at a local scale to prioritize areas for fuel management. In addition, the following principles that emerge from existing knowledge about fire disturbance dynamics and forest development patterns in the K-S region should inform local risk assessment and project planning:

Unmanaged forests tend toward wildfire resilience

A key feature of most unlogged mixed-conifer forests in the K-S region is the prevalence of very large (>20 inches in diameter), older trees that have survived numerous fires (Arno 2000, Frost and Sweeny 2000, Willis and Stuart 1994). The structural diversity of unlogged mature forests in the form of high closed canopies and large down trees tend to inhibit hot fires (Agee and others 2000, DellaSala and Frost 2001). Shade provided by a closed forest canopy shields the ground surface from direct solar radiation, reduces ground temperature and increases the relative moisture of ground fuel (Countryman 1955). Large down trees slow the horizontal movement of wind and thus, fire spread, and they store huge amounts of water that can take heat energy out of fire (Amaranthus and others 1989). As noted above, unmanaged older forests are not immune from high severity, stand-replacing fires. Indeed, some measure of high severity fire disturbance is an important influence on the biological diversity of K-S forests.

Young tree plantations are prone to severe fire effects

Wildfires often spread rapidly in young, even-age tree plantations due to contact with densely spaced fine fuels positioned low to the ground (DellaSala and others 1995, Sapsis and Brandow 1997). Small trees in structurally homogenous stands have been anecdotally reported by fire fighters to vaporize when burned by wildfire (Ingalsbee 1997). Young plantations are far more vulnerable to intense fire behavior and severe fire effects than unmanaged, closed canopy forests that retain higher levels of structural diversity, shading and moisture (Agee 1996, Odion and others in press, Weatherspoon and Skinner 1995).

Roads indicate fire risk

People ignite more than 90 percent of all wildfires on federal public lands, which can be attributed to the operation of motorized vehicles, logging equipment, smoking, arson, campfires and debris burning (NIFC 2000). Logging roads provide unregulated access to the majority of forestlands in the K-S region (CBI 2001). Roads are a cumulative ignition source on the landscape, as road access increases risks from arson and accidental fires (DellaSala and others 1995).

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