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Wildland Fire in Eastern Oregon and Washington

Abstract

Wildland fire is a major disturbance agent that shapes the forest health, productivity, and ecological diversity of eastern Oregon and Washington. Fire behavior and the effects of fire on flora, fauna, soils, air, and water are in large part driven by the availability of fuels to consume and the meteorological influences during a fire. Vegetation succession, disturbance processes, and management practices have resulted in an increase of fuels and vulnerability to extreme fire behavior and detrimental fire effects. Hazards of fire are further increased by encroachment of dwellings into forests and rangelands. Prescribed fire, selective logging, and mechanical fuel treatment are being used to reduce fire hazard, but there is disagreement as to appropriate balance and efficacy of these actions. New tools to (1) characterize fuelbeds; (2) predict mesoscale meteorology, fire behavior, fire effects, smoke production, and dispersal; and (3) demonstrate tradeoffs between prescribed fire and other fuel treatment methods are continually being improved to assist with wildland fire and prescribed fire decision making in eastern Oregon and Washington.

Basic Knowledge

The periodicity, intensity, and duration of fire across a landscape define the effects on biotic communities and resources and will naturally fluctuate with shifts in climate and changes in fuel characteristics. Many of the ecosystems associated with the forests and rangelands of eastern Oregon and Washington are known as short-interval fire adapted ecosystems. Many of the species associated with these ecosystems are fire adapted and can survive frequent, low-intensity fires.

Fire can be a precursor to other agents of disturbance such as insects (Mitchell 1990) and disease (Thies 1990). More often it is an aftereffect, fueled by the excess detritus resulting from other disturbances. Fire has an irregular frequency, intensity, and size that are directly dependent upon a source of ignition, weather, topography, fuel moisture, and fuel characteristics (i.e. type, amount, distribution, and condition) (Agee 1993, DeBano et al. 1998, Sandberg and Ottmar, 2001). This irregularity contributes to variable effects on flora (Lotan et al. 1981), fauna (McMahon and deCalesta 1990, Smith 2000), soils (Tiedemann et al. 1979, McNabb and Cromack 1990, Borchers and Perry 1990, McNabb and Swanson 1990), air (Sandberg et al. 1979, Sandberg and Dost 1990) and water (Wells et al. 1979, Beschta 1990). The variable effects contributes to a very diverse, complex, and

biologically rich forest and range landscape of the Interior Pacific Northwest (Franklin and Dyrness 1973, Agee 1990, Mutch et al. 1993, Bailey 1995, Keane et al. 1996, Jensen et al. 1997, Ottmar et al. 1998, Hessburg et al. 1999, Ottmar et al. 2001).

As humans intervene with various management policies including fire exclusion, harvesting operations, and grazing, the forest and rangeland ecosystems begin changing rapidly at several spatial scales (Baker 1993, McKenzie et al. 1996). In many cases, these management practices provide plant communities little ability to maintain their original composition and structure over time and space. Today, the forests in many of the fire-dependent ecosystems in this region are denser and more spatially uniform, have many more small trees, with fewer large trees, and have much greater quantities of fuels than did their pre-settlement counterparts (Parsons and DeBenedetti 1979, Bonnicksen and Stone 1982, Parker 1984, Mutch et al. 1993, Chang 1996, Harrod et al. 1998) (Figure 1). The floristic structure of rangelands, including the grasslands, shrublands, and woodlands of the Columbia Basin, have also been affected by a combination of fire exclusion, grazing, conversion to cropland, and invasion of exotic species such as cheatgrass that affect their fire risk, hazard, flammability, and fire return interval (Clark



Figure 1. Ponderosa pine forest in eastern Oregon with extensive spruce budworm mortality in the dense grand fir and Douglas-fir understory. The resulting large fuel loading and continuous ladder fuels have altered the fire regime increasing the risk of a high-intensity crown fire.

and Starkey 1990). Many scientists, managers, and public agree that the ecological health of eastern Oregon and Washington is declining, less resilient, and has become more susceptible to larger and more destructive wildfires, insect and disease epidemics, and climatic variations (Agee 1981, 1990, 1993, 1994; Hall 1974; Mutch et al. 1993).

Changes in Biodiversity

Changes in fire regimes favor certain species and associations over others, so management influences such as fire exclusion must influence the relative abundance of species, and may nearly extirpate certain plants that depend heavily on fire. The net result of fire protection in many areas has been to increase the median size and severity of fires without substantially changing fire return interval. Fuel loadings and their ability to sustain fire are reaching hazardous levels that have and will continue to lead to large, widespread, high-severity, crown fires in areas normally frequented by low-intensity ground fires (Arno 1980; Agee 1991, 1993, 1994; Mutch et al. 1993; Arno et al. 1997). This potential increase in wildland fire

activity brings an increased risk of ecosystem damage, negative economic and social impacts, and air quality degradation (Weatherspoon 1996, McIver 1998, Ottmar et al., 1998, Ottmar et al. 2001).

Prescribed Fire Versus Wildland Fire

Prescribed fire is frequently substituted for wildland fire to restore natural disturbance regimes while avoiding wildland fires' disastrous consequences (Walstad et al. 1990). However, because of changes in vegetation, as well as increased constraints resulting from human development and management objectives, the use of fire is made increasingly difficult. For example, the Clean Air Act defines smoke from prescribed fire as an anthropogenic source that could violate air quality standards, while smoke from wildland fires is considered a natural source (Sandberg et al. 1979, Mutch et al. 1993, Sandberg et al. 1999, U.S. Environmental Protection Agency 1999, Hardy et al. *In press*). Chronic human health risk from exposure to prescribed fire smoke is probably low (Sandberg and Dost 1990), but complaints about

the nuisance effects of smoke is very often the limiting factor in public acceptance of prescribed fire use.

Effects of Wildland Fire

The amount and duration of heat produced in a fire is the ultimate driving force that causes a wide range of biotic effects, environmental responses, and social/political consequences (DeBano et al. 1998). A general rule of thumb is that wildland fires that occur in areas with large accumulations of dry fuels will burn more severely than where there is less and moister fuel. Fire severity is a measure of how extensively the vegetative structure and distribution of biomass is affected by fire; in some cases a fire will destroy a desirable ecosystem structure and in other cases restore a badly out-of-balance system to a productive condition.

Although the concepts seem relatively simple, the complexity of ecosystem component interactions with the variability of fire/fuels/weather/topography and the confounding management practices of logging, chemical use, other management activities, and the encroachment of invasive species makes prediction of fire effects very difficult. General trends are what a manager can expect from most fire effects models currently in existence (Agee 1993, Reinhardt et al. 1997, Ottmar et al. *In press*). The Joint Fire Science Program is updating the synthesis of fire effects publications (rainbow series) to summarize the current state of knowledge (Joint Fire Science Program 1999). The Fire Effects Information System (FEIS) is a computerized knowledge management system that stores and retrieves current information about fire effects on plants, wildlife species, and plant communities (Fischer et al. 1996).

Fire Risk and Hazard

It is impossible to relate the recent increase in wildland fire activity to cause, but there is little doubt that risk and hazard is increasing. During the past 70 years, vegetation succession, natural disturbances (insect, disease, and blowdown), and management activities including logging, cattle grazing, and fire exclusion policies have often modified the live and dead vegetative composition and structure of forest and rangelands in the interior Pacific Northwest (Mutch et al. 1993, Keane et al. 1996, Hessburg et al. 1999, Hardy and Bunnell 1999, Ottmar et al. 2001). The change

has resulted in increased fuel loads that have directly increased the vulnerability of the landscapes to extreme fire behavior with resultant detrimental ecosystem and social/political effects. Invasive species have increased the flammability of the rangeland grass and shrub types, and continued human settlement into the forests and rangelands has led to an increased risk of property destruction from wildland fire (Bradley 1984, Seely and Gilpin 1997, Alcock 1997). Furthermore, the risk of fire in the near future decades can be expected to increase dramatically owing to global warming (JISAO/SMA Climate Impacts Group 1999, Dale et al. 2000, Flannigan et al. 2000). Increased smoke generated by wildland fire can severely affect the health of human beings, especially the young and old. In addition, firefighters battling the blazes will be subjected to increased hazardous conditions with prolonged exposure to fatigue, stress, smoke, and poor nutrition potentially leading to increased incidence of upper respiratory and other illnesses (Sharkey 1997, 1999; USEPA 1999; Reinhardt and Ottmar 2000a, 2000b).

Management Strategies

Management practices such as cutting, thinning, mechanical treatment, or the use of prescribed fire are being applied to reduce or break up the integrity of the fuelbed and move the landscape in the direction of historical structures and disturbance regimes (USDI and USDA 1995, Reinhardt and Ryan 1998). Consequently, several studies and projects are under way to quantify the ecological, economic, and social consequences of alternative restorative treatments to reduce wildland fire threat (Joint Fire Science Program 1998, Weatherspoon 1999). Improved risk assessment methodology to evaluate fire risk and hazard is needed to improve the analysis of management options (Andrews and Williams 1998).

Effects of Fire Management

Widespread use of restorative management practices are needed to return ecosystems to a more desirable state. (Amo 1996, Mutch and Cook 1996). Prescribed fire, selective logging, and mechanical fuel treatment are several of the most common methods that are being implemented to reduce excessive fuel accumulations and break up fuel continuity, moving forests and rangelands into

structures and disturbance regimes that are less susceptible to large, catastrophic wildland fire. However, the appropriate balance among proactive management treatments (cuttings, mechanical fuel treatments, and prescribed fire) and wildland fire are still unknown (SNEP 1996, van Wagendonk 1996, Weatherspoon, 1996, Stephens 1998). Treatment applicability and effectiveness vary widely, depending on vegetation type, access, topography, and economic feasibility. All treatment options have potential drawbacks and must be employed with careful professional judgment and full awareness of possible tradeoffs with other resources. Whether fuel treatments will actually reduce fire frequency, severity, and occurrence is still unknown and further field-oriented research and extensive monitoring is needed.

Decision-Support Tools

The frequent occurrence of fires throughout modern history has led to an extensive body of knowledge and models to forecast and predict (1) fuel characteristics and loads, (2) fuel consumption, (3) fire effects, (4) weather, (5) potential risk of wildland fire, (6) fire behavior, and (7) social/political and economic consequences. This information is available in a variety of tools to support manager decisions with regards to wildland fire.

Successful operation of fire risk, fire behavior, and fire effects models require accurate fuel characterization to estimate the amount of biomass consumed. At present, direct field measurement techniques (Brown 1974, U.S. Department of Interior 1992, Means et al. 1994) have been developed although they are very time consuming and costly to implement (Sandberg et al. 1988). A compilation of single and stereo photographs with accompanying vegetation characteristics data have been developed that will provide a means for quantifying and describing existing fuel properties (Maxwell and Ward 1976, Maxwell and Ward 1980, Fischer 1981, Ottmar et al. 1998, Ottmar et al. 2000). These collections of photographs and fuels data are called a photo series and have been shown to reduce inventory time by 95% with minimal loss of accuracy and precision in managed forests of Washington and Oregon. (Sandberg et al. 1988). These series however, are not complete for many fuel types in this region. New research efforts are under way to add to the series currently available (Joint Fire Science Program

1999). A new national fuels characterization system (Sandberg and Ottmar, 2001) is being developed to improve current fuel assignments across both large and small scales for land managers and carbon modelers and will be completed by 2003. Finally, the Fire and Fuels Extension (FFE) (Beukema et al. 1999) incorporates models of fuel dynamics, fire behavior, and fire effects into the base model of forest stand development.

There have been several large efforts to empirically and theoretically derive models to estimate fuel consumption in the interior West (Brown and Reinhardt 1991, Reinhardt et al. 1997, Albin and Reinhardt 1997), Pacific Northwest (Ottmar et al. 1993, Ottmar et al., *In press*), Southwest (Harrington 1987, Sackett and Haase 1998), and South (Hough 1968). These models require preburn fuel loads, fuel moisture content, fuel arrangement, and weather information for calculating fuel consumption. Fuel consumption equations have been incorporated into a user-friendly program called CONSUME for use in logging slash, piled slash, and natural fuels (Ottmar et al., *In press*). The program also calculates total emissions produced from a fire. Albin and Reinhardt (1997) have developed a simulation model called BURNUP for the burning of large, woody, natural fuels based on theoretical design in combination with empirically derived coefficients. The model is being incorporated into the First Order Fire Effects Model 5.0 (Lutes *In press*).

Fire management decisions rely on the analysis of expected future weather and stochastic events. Several new products are online or will be online shortly that will assist with wildland fire and prescribed fire decision making including (1) MMS mesoscale meteorological modeling at several different resolutions (Ferguson 2000), (2) lightning, wind, precipitation, temperature, relative humidity, and instability analysis to model event beginning and event ending fire conditions (Rorig and Ferguson 1999), (3) assessments of air quality climates in the Columbia River basin (Ferguson 1998), (4) the development of a high-resolution smoke dispersion potential, and (5) the linking of diagnostic wind models to physical models to estimate surface winds at high resolutions. Finally, the Meteorology for Fire Severity Forecasting (MfFSF) includes monthly fire weather forecasts that can provide fire managers with a quick and easy planning tool (<http://www.fire.org>).

Potential hazard of fires across the United States has been calculated and displayed by Hardy and Bunnell (1999). BEHAVE (Andrews 1986) was developed to model fire behavior with direct user inputs. Finney (1998) developed FARSITE, a fire growth simulation model that uses spatial information on topography and fuels along with weather and wind files. The Fire Information Retrieval System (FIRES) provides methods for evaluating the performance of fire danger rating indices. Finally, the National Fire Danger Rating System (Deeming et al. 1977) provides indexes for measuring fire potential in wildlands. A family of up-to-date decision-support tools is available on the Joint Fire Science Program web site http://www.nifc.gov/joint_fire_sci, Fire and Environmental Research Applications Team web site <http://www.fs.fed.us/pnw/fera>, or <http://www.fire.org>.

FOFEM: a First Order Fire Effects Model, predicts the direct consequences of prescribed fire and wildland fire, including fuel consumption, tree mortality, soil heating, and smoke emissions (Reinhardt et al. 1997). Fire and Fuels Extension (FFE) (Beukema et al. 1999) incorporates models of fuel dynamics, fire behavior, and fire effects into a base model of forest stand development. A computerized simulation model called the Fire Effects Tradeoff Model (FETM) has been developed to demonstrate the fire effects and economic tradeoffs between prescribed fire, mechanical fuels treatment, logging, and wildland fire (Schaaf 1996).

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The National Wildfire Coordinating Group and the Environmental Protection Agency recently sponsored a strategic plan for the development of models and data systems for managing air quality effects from fires (Sandberg et al. 1999). The Pacific Northwest Research Station has developed the Emissions Production Model (Sandberg and Peterson 1984) to estimate the rate of smoke production from prescribed fires and wildland fires. The emission rate is used to drive dispersion models that predict concentrations of smoke transported downwind from a prescribed fire. Some of the available dispersion models, including SASEM (Sestak and Riebau 1988), NFSPUF (Harrison 1995), V-Smoke (Harms and Lavdas 1997), and CALPUFF (Scire et al. 1995), are used to assess the effect of smoke on cities and rural communities and on visibility in sensitive areas such as National Parks, Wilderness areas, highways, and airports. A summary and comparison of each dispersion model has been prepared by Breyfogle and Ferguson (1996).

Sociodemographic information can help establish an important frame of reference for people's general attitude toward forest management issues including prescribed fire and mechanical thinning. A survey was conducted in the Blue Mountain communities in 1996 determining that residents are receptive and in many cases strongly supportive of both prescribed fire and mechanical thinning as fuels reduction techniques (Shindler and Reed 1996).

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Note

This special issue of *Northwest Science* is a set of papers reviewing the state of knowledge about disturbance processes in eastern Oregon and Washington, related management practices, and effects on key management issues.