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Seeing the forest for the fuel: Integrating ecological values and fuels management

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Abstract

Management of dry forests often involves trade-offs between ecological values, particularly those associated with closed-canopy forests, and reduction of severe wildlife risk. We review principles and our ecological research that can be used to design stand- and landscape-level fuel treatments in dry coniferous forests of western North America. The focus of ecological values is on the ecological web that includes the northern spotted owl (*Strix occidentalis caurina*), its two primary prey species the northern flying squirrel (*Glaucomys sabrinus*) and bushy-tailed woodrat (*Neotoma cinerea*), and the vegetation (live and dead), mycorrhizal fungi, and arboreal lichens that support those prey species. For the landscape level, we describe an ongoing project to develop the *FuelSolve* computer tool that optimizes the area and location of a fuel treatment by minimizing potential fire behavior and minimizing loss of spotted owl habitat from treatment and potential fire. Some species will gain and some species will lose habitat when stand structure or composition is changed during fuel reduction treatments. Stand-level prescriptions might be altered to maintain or create patchiness of closed-canopy habitat elements, such as snags, down wood, mistletoe-infected trees, and large old trees, and open-canopy habitats can be tailored to ensure creation of suitable composition and structure for wildlife. Allocation of treatments across the landscape might be managed to minimize cumulative effects and impacts on target species populations. General approaches to landscape-level planning of ecologically sound fuel treatments include coarse- and fine-filter approaches. A coarse-filter approach would use some definition of the historical or natural range of variability to define the composition and pattern that might reasonably be expected to sustain the forest ecosystem. Three general approaches can inform fine-filter analysis and development of fuel reduction treatments at the landscape level. Population viability analysis provides sound principles based on attributes of the species population structure, life history and behavior, and environment (habitat) for guiding fine-filter analysis. Fine-filter analysis can be informed by operational modeling of treatment alternatives. Research publications can guide dry forest landscape management. Our *FuelSolve* optimization model described in this paper differs from other fuel planning models in this class by equally considering multiple optimization objectives for fuel treatment and ecologically important resources. We describe the results of *FuelSolve* prototype development, an evaluation of outputs for field use, and future development efforts.
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1. Introduction

Changed fire regimes and increases in lethal fire in dry forests of western North American during the last 80–100 years have been well described, particularly during the last 15 years (Agee, 1993; Hann et al., 1997; Schoenagel et al., 2004). Fire regimes in those dry forests have shifted mainly from low-intensity and high-frequency regimes to moderate- and high-severity regimes, with consequent increases in uncharacteristic large-scale stand-replacing fires. As a result, forest research, management, and policy have focused on ways to restore dry forest stands and landscapes to historically prevalent stand structures and landscape patterns that will minimize fire effects, support low-intensity fire regimes, and restore dry forest ecosystems (Hann et al., 1997; Graham et al., 2004; Raymond and Peterson, 2005).

Prescriptions for restoring dry forests generally have focused on reducing fuels and changing stand or landscape structure to minimize potential fire behavior. Stand-level prescriptions focus on reducing surface fuels, increasing height

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to live crown, decreasing crown density, and favoring fire-tolerant species, especially the largest or oldest trees (Brown et al., 2004; Agee and Skinner, 2005). Landscape-scale prescriptions likewise have the goal of minimizing potential fire behavior by either a strategic placement of fuel reduction treatments (Finney, 2001; Loehle, 2004) or by some optimal allocation of treatments based on ecological or economic constraints (Chew et al., 2004; Ramon Gonzalez et al., 2005; Calkin et al., 2005; Finney et al., 2006). In most approaches, ecological considerations are secondary objectives, or ''constraints'' in optimal modeling parlance.

Not ''seeing the forest for the fuels'', or a back seat for ecological considerations, can be a result of land management agency ''culture'', scientific and operational uncertainty about how to achieve ecological goals with fuel treatments, and concerns over unit-costs ($/ha of treatment). Excessive focus on keeping unit costs down can result in treatments that are the ''easiest and cheapest'' but not necessarily the most effective or ecologically important. In addition, many fire and fuels managers are not familiar and comfortable with interdisciplinary project planning where ecological considerations can be integrated into project design and implementation. Information and tools that help to achieve better resource integration of fuels reduction and ecological values are needed.

Uncertainty in knowledge and application of ecological forest restoration and disturbance management is high (Graham et al., 1999, 2004), and new knowledge is being acquired gradually as priorities for wildland fire research emphasize physical and social issues (~75% of US Forest Service National Fire Plan budget, E. J. DePuit, US Forest Service, Pacific Northwest Research Station, Wenatchee, WA, personal communication) versus integrated science and adaptive management (e.g., fuels reduction). Uncertain ecological objectives, then, are more difficult to integrate into fuels management compared to the relatively simple and better-known objectives and methods of fire and fuel management. Thus, fuel reduction programs tend to be oriented to fuels more than forest restoration, hence attract litigation or require extensive consultation on ecological effects, e.g., impacts on threatened or endangered species like the northern spotted owl (*Strix occidentalis caurina*) in the Pacific Northwest.

In this paper, we review principles and our published, or ongoing, ecological research that can be used to design stand- and landscape-level fuel treatments in dry forests. The focus of ecological values is on the ecological web that includes the northern spotted owl, its two primary prey species the northern flying squirrel (*Glaucomys sabrinus*) and bushy-tailed woodrat (*Neotoma cinerea*), and the vegetation (live and dead), mycorrhizal fungi, and arboreal lichens that support those prey species. For the landscape level, we describe an ongoing project to develop the *FuelSolve* computer tool that optimizes the area and location of fuel treatments that minimize potential fire behavior *and* minimize loss of spotted owl habitat from treatment and potential wildfire. The spotted owl habitat goal, however, could be generalized to model solutions for any ecological values that can be defined on a map.

2. Stand-level guidelines

Dry forest landscapes are heterogeneous in topography, microclimates, and fire regimes, especially in the northern parts of western North America (Brown et al., 1999; Agee, 2003; Ehle and Baker, 2003; Schoenagel et al., 2004). However, a basic and useful dichotomous classification of dry forest vegetation conditions and associated species describes closed-canopy mixed-conifer forest (e.g., Douglas-fir [*Pseudotsuga menziesii*] and grand fir [*Abies grandis*]) and open-canopy ponderosa pine (*Pinus ponderosa*) dominated forest. Most fuel reduction treatments reduce closed-canopy habitats and create open-canopy habitats by reducing the complexity of crown structure and reducing key dead-wood micro-habitats in the form of snags and down wood (Agee, 2002). Some species will gain and some species will lose habitat when stand structure or composition is changed during fuel reduction treatments. Yet, a summary of costs and benefits to species is not a simple calculation of closed-canopy habitat lost and potential gain in open-canopy habitat. Stand-level prescriptions might be altered to maintain most (e.g., Buchanan et al., 1993; Everett et al., 1997) or some important closed-canopy habitat elements, open-canopy habitats can be tailored to ensure creation of the suitable structure for focal wildlife species, and the allocation of treatments across the landscape might be managed to minimize cumulative effects and impacts on target species populations.

Within the spotted owl dry forest ecological web, the northern flying squirrel is a good closed-canopy focal species for designing ecologically friendly dry forest treatments. It is an important prey species for forest carnivores (Carey, 1993; Forsman et al., 2004). It is a critical link in the tree-truffle-carnivore ecological web (Fogel and Trappe, 1978; Maser et al., 1978; Carey, 2000a). Lehmkuhl et al. (2006b) showed that flying squirrel fitness is associated with understory vegetation diversity, dead wood, defective trees, and ectomycorrhizal truffle and lichen biomass and communities. Stand-level dry forest fuel reduction treatments might be modified in several ways to maintain or even enhance flying squirrel habitat, including habitats for fungal and lichen communities that support flying squirrels. Those same practices that retain dead wood and mistletoe-infected trees would also benefit the habitat generalist bushy-tailed woodrat, another key prey species of northern spotted owls and other forest carnivores (Lehmkuhl et al., 2006a).

Similar to recommendations by Carey (2000b) for flying squirrels in wet coastal forests in the Pacific Northwest, some form of variable-retention thinning for fuel reduction may create heterogeneous, or patchy, stand conditions that maintain key habitat elements for the owl ecological web (Lehmkuhl et al., 2006b). Open-canopy patches might favor the growth of fruit and mast producing shrubs that are important for flying squirrel recruitment and survival. Retention of down wood and cool-moist microenvironments in closed-canopy patches within treated areas likely would maintain diversity and production of truffle foods (Lehmkuhl et al., 2004) that are associated with high recruitment and survival of flying squirrels (Lehmkuhl et al., 2006b). Retention of large old