Wildlife Adaptations and Management in Eastside Interior Forests with Mixed Severity Fire Regimes

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ABSTRACT

Little is known about the effects of mixed severity fire on wildlife, but a population viability analysis framework that considers habitat quantity and quality, species life history, and species population structure can be used to analyze management options. Landscape-scale habitat patterns under a mixed severity fire regime are a mosaic of compositional and structural stages created by a patchy distribution of fire severity. Live and dead early-seral trees are important within stand habitat elements. Are fauna of interior mixed severity forest well adapted to these natural patterns and processes? If true, then a coarse filter approach would be an appropriate management strategy. I used species habitat data to assess the percentage of breeding species associated with early- and late-seral conditions, snags, and down wood in three dominant interior forest types with low, moderate, and high severity fire regimes. Wildlife appear well adapted to patchy mixed severity landscapes. Analysis showed that fauna in the mixed severity Eastside Mixed Conifer Forest of eastern Washington and Oregon was a mix of faunal elements from low severity ponderosa pine and high severity Montane Mixed Conifer Forest. Most species were classed as seral/structural stage generalists (44%) or closed-canopy associates (40%). Two families of species of conservation concern need to be considered for additional fine-filter considerations: low elevation old forest associates and broad elevation old forest associates. The latter group is a quintessential mixed severity group of species, with species associated variously with vegetation conditions created by varying fire severity. The life history of each, e.g. mobility relative to habitat patchiness, needs to be considered to design fuel or forest restoration management projects.

INTRODUCTION

Little is known about the effects of mixed severity fire regimes on wildlife communities and species (Huff and Kapler Smith 2000). We can, however, use general principles and known habitat relationships to understand the ecology of wildlife in mixed severity fire vegetation types. In principle, the bottom line for wildlife in managed forest ecosystems is population viability, i.e., the persistence of a species in a particular area (Lehmkuhl et al. 2001). There fortunately, is a well developed framework for analyzing or assessing species population viability in terms of habitat quantity and quality, species life history traits, and species population structure (Boyce 1992). That framework can be coupled with existing databases on species and environment relationships (e.g., Johnson and O'Neal 2001) to do a general assessment of wildlife in mixed severity fire vegetation types. In this paper I will address habitat and species life history issues affecting forest management.

The critical habitat feature of mixed severity fire regimes affecting wildlife habitat is the mosaic of vegetation conditions created by the combination of low, moderate, and high severity fires, and the dynamic nature of that mosaic over time and space (Agee 1998, this proceedings)

(Figure 1). Hessburg (this proceedings) found that the percentages of low (<20% canopy mortality), moderate (20-70% mortality), and high severity (>70 % mortality) burn areas were about 10%, 60%, and 30%, respectively, in dry forests of eastern Oregon and Washington, rather than a dominant low severity fire regime and associated forest structure. Composition of vegetation patches varies depending on the interaction of existing species and their ability to resist fire and the fire severity level (Agee 1993). Low severity fires typically result in mature single story stands dominated by large trees of fire resistant species such as ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), or red fir (*Abies magnifica*). In relatively mesic sites, understories can have a high component of fire-adapted shrubs. Moderate severity fires typically result in patchy mixed age stands dominated mostly by large trees of those same relatively fire-resistant species with a diverse understory. Species in early-seral to mid-seral patches from high severity fire in mixed severity types can vary depending on the size of the patch, seed source availability, or vegetative regeneration. A critical aspect is the dominance of early-seral tree species.

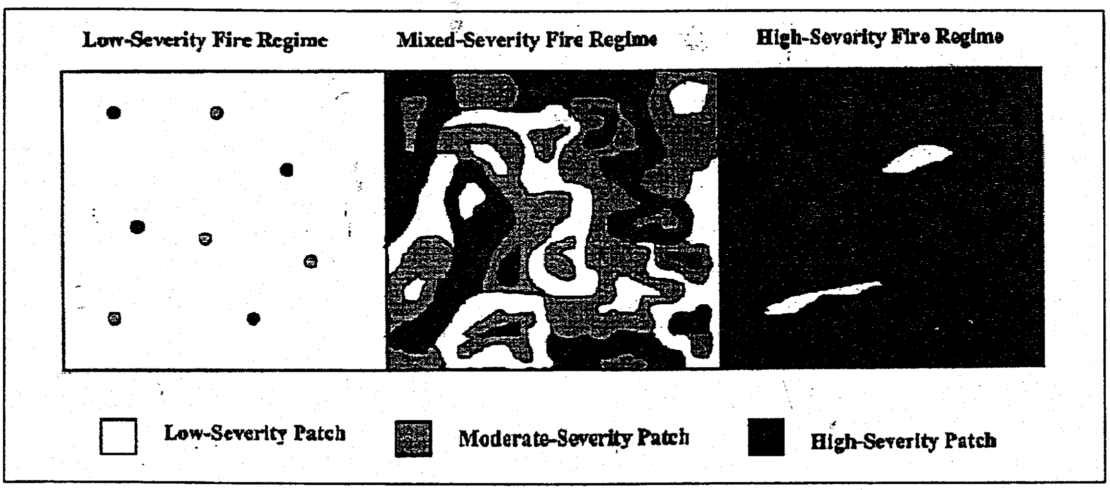

Figure 1. A schematic of landscape pattern created by fire regimes (from Agee 1998).

The dynamics of course woody debris (snags and logs) and a critical wildlife habitat element are complex, with consumption of debris on the forest floor compensated by the creation of snags in patches burned at moderate and high severities (Agee 2002). On average, woody debris appears relatively abundant in mixed severity vegetation types, but availability varies over time depending on the fire return interval (Figure 2). Snags created from fire-resistant trees (western larch, Douglas-fir, ponderosa pine) that would normally dominate canopies under normal fire return intervals of 25-100 years (Agee 1993) would also provide high quality snags for cavity nesting species (Bull et al. 1997, Lehmkuhl et al. 2003).

Forest landscape mosaics with mixed severity fire regimes have complex patterns (Figure 1) with many potential impacts on wildlife depending on species life history and population structure. Agee (1998) summarized landscape characteristics of mixed severity forest types. Sizes of mixed severity forest patches fall in a medium range between 1-300 ha (2.5-750 acres) vs. 1 ha (2.5 acres) for low severity fire regimes and 1000+ ha (2500+ acres) for high severity fire regimes. Patchiness at a smaller stand scale also occurs as canopy gaps of 0.0025-0.04 ha (0.006-0.1 acres) as a result of small-scale disturbances. Mixed severity fire landscapes have abundant patches with complex edges created by complex burning patterns. The patchiness of a mixed forest landscape might be misconstrued to mean that habitats are highly fragmented in the sense that habitat patches do not occupy a large fraction of the landscape and are disjunct or not well connected. However, an important and often ignored distinction needs to be made between inherent, or natural, patchiness of landscapes, such as mixed fire landscapes, and the fragmentation of habitats in landscapes that is induced by human activity (Sallabanks et al. 1999, Bunnell 1999).

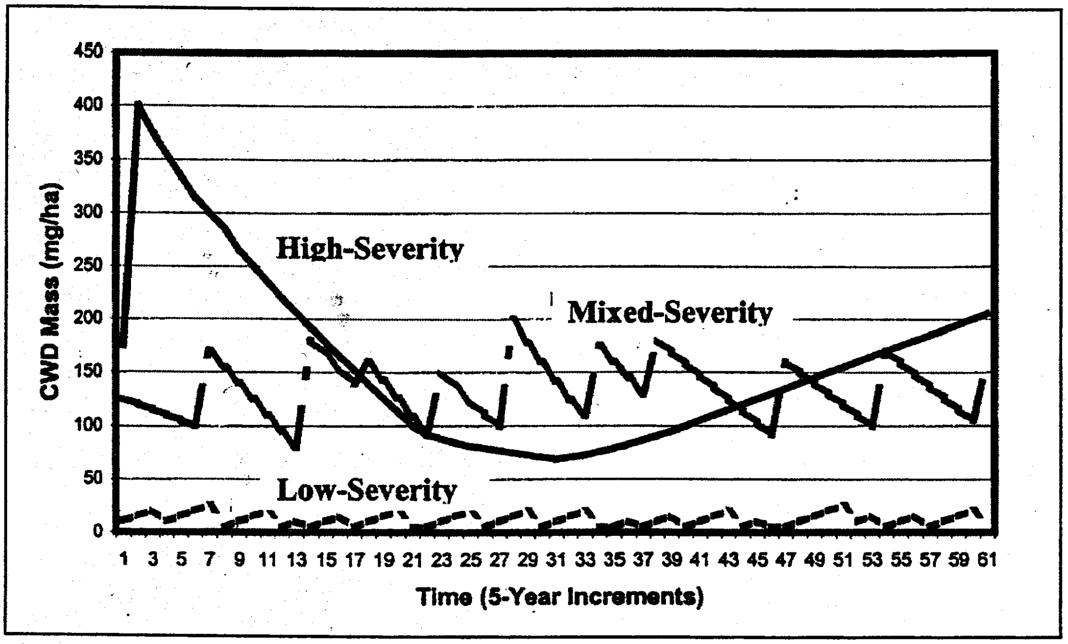

Figure 2. Levels and variability of course woody debris over time under different fire regimes (from Agee 2002).

Wildlife in the interior West appeared to be well adapted in terms of their life history and population ecology to the inherent disturbance regimes and patchy, or otherwise, patterns of forested landscapes. Bunnell (1995) found that the structure of wildlife communities was highly correlated with fire disturbance regimes in 12 vegetation types of coastal and interior British Columbia. Proportions of species breeding in early-seral stages of plant succession tend to increase with increasing fire size or burn rate (ha/year) (i.e. high severity fires); whereas, species breeding in late-seral vegetation decrease. Proportions of species breeding in cavities decrease as fire size and intensity increase with consequent losses in snags and woody debris. Proportions of species using downed wood to breed increase as the interval between fires increases and downed wood accumulates. Sallabanks et al. (2002) found little specialization of birds to age/structural classes in grand fir forests of the Blue Mountains of Oregon, except that some species are associated with early-seral open conditions. Kotliar et al. (2002) found mixed responses to stand replacement vs. unburned forests among 41 well-studied bird species in the northern Rocky Mountains: 34% were more abundant in unburned forests, 44% were equally abundant in burned and unburned forests or had varied responses, and 22% were consistently more abundant in high severity burned forests. They concluded that those responses corresponded well to the range of stand conditions created by mixed severity fires.

I tested the hypothesis that wildlife species are well adapted to the disturbance regimes and consequent landscape patterns of three dominant forest types in the interior Pacific Northwest. If true, then management that emulates natural patterns and processes should work as a coarse-filter management approach (Hunter et al. 1988). I first tested Bunnell's (1995) hypotheses on percentages of species using the early-seral structural stage, downed wood, and snags relative to fire size and burn rate for eastern Washington and Oregon. I also developed hypotheses based on stand development patterns (Agee 1993, Agee 2002) that distinguished late-seral single-story and multi-story structural conditions that were not addressed by Bunnell. I hypothesized that wildlife in mixed severity forest types would have a pattern of forest structure stage use intermediate between low and high severity forest types. Moreover, I predicted that patchiness of forest types in mixed severity vegetation types would support a wildlife community that was a mix of species typical of low and high severity fire regime vegetation types. I discuss coarse and fine filter management implications for species of conservation concern.

METHODS

I used wildlife habitat relationships data for forest cover types described by Johnson and O'Neal (2001) for Oregon and Washington to describe breeding use of forest types, seral/structural conditions, snags, and downed wood. Wildlife data were compiled for the three principal forest cover types in eastern Washington and Oregon: Ponderosa Pine and Eastside White Oak Forest & Woodland (PIPO), Eastside (Interior) Mixed Conifer Forest (EMCF), and Montane Mixed Conifer Forest (MMCF). Fire regimes of low, mixed, and high severity were assigned to PIPO, EMCF, and MMCF, respectively, based on descriptions by Chappell et al. (2001) and O'Neal et al. (2001). I derived estimates of mean fire patch size (regeneration patch) and fire return interval from Agee (1998) and Chappell et al. (1995) for testing Bunnell's (1995) hypotheses as described earlier.

Only wildlife species that were associated or closely associated with the forest type, structural class, or habitat element (snags, downed wood) were considered (O'Neal et al. 2001). Species were clustered by examining patterns of use among seral classes. Observed patterns were reported by classes adapted from Sallabanks et al. (2002). Similarities in wildlife species composition among cover types and structural stages were assessed with Sorenson's index.

RESULTS & DISCUSSION

As predicted, fauna appeared to be well adapted to the mix of forest types and structural conditions in the mixed severity EMCF. EMCF faunal composition was a mix of low severity PIPO and high severity MMCF fauna, even though about 40% of all species were shared in common among the three types. The greater similarity between EMCF and MMCF fauna (84%) than between EMCF and PIPO forests (71%) agrees with Hessburg et al.'s (this proceedings) finding that dry forest landscapes like EMCF historically had more moderate severity (60%) and high severity (30%) patches than low severity (10%) patches. Such patterns of similarity are expected from stand development patterns in moderate and high severity regimes that support similar closed canopy forests because of relatively low canopy mortality in the moderate severity forest and long fire return intervals in high severity forest, compared to low severity PIPO forest. The relatively similar percentages of species in EMCF and MMCF using closed canopies (i.e., the non-SI structural category) compared to PIPO, where canopies are more open, also supports that finding (Figure 3). Apparently, small differences of 10% in the percentages of species using different types may seem insignificant, but were found to be significant by Bunnell (1995).

The mixed faunal nature of EMCF was further supported by the percentage of early-seral species (Figure 3). EMCF was more similar to PIPO in supporting relatively more generalist or early-seral (i.e., SI) species than MMCF. That pattern of early-seral species composition was counter to Bunnell's (1995) prediction that high severity forest types like MMCF should have more early-seral species because of higher stand-replacement burn rates compared to other forest types (Table 1). That discrepancy might stem from two factors. There could be differences in assigning breeding use in the different species/habitat relationship databases used for the analyses; or, despite higher average burn rates the longer fire return intervals and residence time of closed canopy forest in high severity fire regimes supports relatively more closed vs. open canopy or early-seral species.

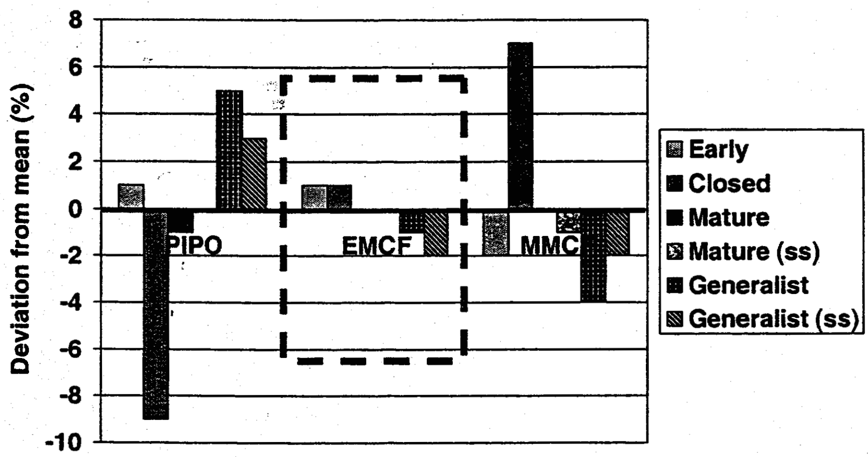

Figure 3. Fauna in Eastside Mixed Conifer Forest (EMCF) show a pattern of mixed use of forest seral conditions intermediate between Ponderosa Pine (PIPO) and Montane Mixed Conifer Forest (MMCF) as shown by low deviations of the percentages of species using forest seral conditions from overall (all types) mean percentages. "SS" indicates single-story stands vs. multi-story stands.

Table 1. Predicted relative rank among forest cover types and observed percentages of species breeding in different seral/structural stages in eastern Washington and Oregon.

	Early-seral		Mid-seral		Late-seral, single story		Late-seral, multi story	
Forest type	Pred.	Obs.	Pred.	Obs.	Pred.	Obs.	Pred.	Obs.
Ponderosa pine	low[a]	63%	na	90%	high[b]	79%	low[b]	74%
Eastside Mixed Conifer	medium	53%	na	89%	medium	79%	medium	81%
Montane Mixed Conifer	high	49%	na	91%	low	76%	high	80%

[a] Bunnell's (1995) hypotheses based on fire size and burn rate.
[b] Based on stand development described by Agee (1993, 2002).

Predictions about occurrence of late-seral species were equivocal. Bunnell (1995) found that late-seral species declined with increasing burn rates, i.e., late-seral species are relatively fewer in high severity fire forest types like MMCF. The analysis for Washington and Oregon found the opposite trend for late-seral, multi-story forest, with a greater percentage of late-seral species in EMCF and MMCF vs. PIPO forest (Table 1). That pattern was congruent with the opposite trend in early-seral species, and followed predictions in this paper based on stand development patterns described by Agee (1993). The percentages of species using late-seral, single story stands were not supported, however. All three forest types showed nearly equal numbers of species using late-seral, single-story stands, whereas, PIPO was predicted to have the highest number followed by EMCF and MMCF. However, some weak support for that prediction was found in the relatively higher percentage to generalist species using late-seral, single-story stands in PIPO.

Predictions based on fire regimes about the percentage of species using snags and downed wood were not supported for birds, but were consistent for mammals with EMCF intermediate between PIPO and MMCF (Table 2). Equal percentages of birds used snags in all forest types, whereas snag use was predicted to decline from PIPO through MMCF. The observed equality of bird use among types was likely driven by high snag dependency in unburned and burned forest (Hutto 1995, Kotliar et al. 2002), not low snag availability with increasing burn rates in high severity forest as hypothesized by Bunnell (1995). The higher percentage of mammals breeding in snags in low severity PIPO forest vs. other forest types was likely a function of ~50% fewer mammal species in PIPO compared to other types: the absolute numbers of species using snags were similar (14-16) among types.

Table 2. Predicted relative rank among forest cover types (Bunnell 1995) and observed percentages of bird and mammal species breeding in snags and downed woody debris in eastern Washington and Oregon.

	Downed wood				Snags			
	Birds		Mammals		Birds		Mammals	
Forest type	Pred.	Obs.	Pred.	Obs.	Pred.	Obs.	Pred.	Obs.
Ponderosa Pine	low	17%	low	90%	high	58%	high	67%
Eastside Mixed Conifer	medium	18%	medium	97%	medium	61%	medium	42%
Montane Mixed Conifer	high	16%	high	100%	low	59%	low	39%

Among the three forest types, about equally low percentages of birds used downed wood for breeding (Table 2). Nearly all mammals used downed wood for breeding, and there was a slightly increasing trend from PIPO to EMCF to MMCF. Despite relatively low amounts of downed wood in low severity PIPO forest (Agee 2002), a high percentage of mammals used it for breeding.

MANAGEMENT IMPLICATIONS

The results show that coarse filter management practices that emulate natural disturbance regimes (Hunter 1993) in mixed severity forest should be appropriate for the mix of species that use them (Bunnell 1995, Sallabanks et al. 2001). In addition, a fine filter species approach will need to be considered for species of conservation concern (Hunter et al. 1988, Haufler et al. 1996). Wisdom et al. (2000) described two families of 29 species of conservation concern that are adapted to low and mixed severity fire regimes: low elevation old forest associates and broad elevation old forest associates. Both families have suffered habitat loss as a result of fire exclusion and will benefit from restoration of natural patterns of forest composition and disturbance processes.

The family of broad elevation old forest species, in particular, is a quintessential mix of species adapted to mosaic forest conditions created by mixed severity fires. All species are variously associated with single- and multi-story stages of forest structure, created by varying fire severities, as source habitats. Stand replacing burns and beetle-infested trees provide source habitat for some woodpeckers. Large snags and downed wood are important habitat elements for restoration that have been lost in old and younger forests alike (Hann et al. 1997, Hessburg et al. 1999). Fifteen species depend on snags for nesting or foraging, with four depending on hollow trees. Four species use downed logs and several avian and mammalian carnivores indirectly benefit from downed wood habitat for their prey species. The juxtaposition of early- and late-seral conditions is needed to meet all life functions of bats and other species. That juxtaposition, however, is countered by the need for habitat connectivity of several species in the family that are associated primarily with old forest conditions. Small-scale patchiness created by mixed severity burns would benefit closed canopy species, such as the northern flying squirrel (*Glaucomys sabrinus*), for which diverse understory development is critical for population fitness and persistence (Lehmkuhl et al., in review).

Such contrasting habitat needs require consideration of individual species' life history traits in landscape planning of forest restoration or fuel management projects. For example, the fitness value of a landscape for a particular species will be a function of both the amount and connectivity of habitat. The viability of an animal's population in a landscape will be a function primarily of habitat area until some threshold of area is reached when connectivity becomes important. That threshold, in general, will vary with the life history of the species, in particular,

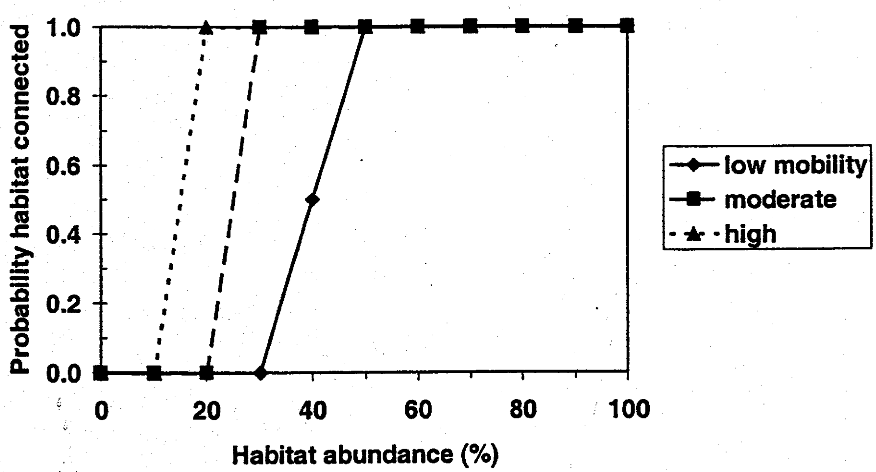

Figure 4. Habitat connectivity thresholds vary with the mobility of the species. (Adapted from Fahrig 1999).

the mobility of the species (With and Crist 1995, Fahrig 1999): mobile species can accommodate greater habitat loss than sedentary species before connectivity becomes an issue (Figure 4). Issues and strategies for restoring habitat of species of conservation concern that address the broader issues of large-scale habitat restoration are detailed in Wisdom et al. (2000).

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