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Research Note

Overestimation of Fire Risk in the Northern Spotted Owl Recovery Plan

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Abstract: *The U.S. Fish and Wildlife Service's recent recovery plan for one of the most carefully watched threatened species worldwide, the Northern Spotted Owl* (Strix occidentalis caurina), *recommended a major departure in conservation strategies in the northwestern United States. Due to concern about fire, the plan would switch from a reserve to a no-reserve strategy in up to 52% of the owl's range. Fuel treatments (e.g., thinning) at regular intervals also would occur on up to 65–70% of dry forests in this area. Estimations of fire risk, however, were based on less than a decade of data and an anecdotal assessment of a single, large fire. We found that decadal data are inherently too short, given infrequent large fires, to accurately predict fire risk and trends. Rates of high-severity fire, based on remote-sensing data, are far lower than reported in the plan and in comparison with the rate of old-forest recruitment. In addition, over a 22-year period, there has been no increase in the proportion of high-severity fire. Our findings refute the key conclusions of the plan that are the basis for major changes in conservation strategies for the Spotted Owl. The best available science is needed to address these strategies in an adaptive-management framework. From the standpoint of fire risk, there appears to be ample time for research on fire and proposed treatment effects on Spotted Owls before designing extensive management actions or eliminating reserves.*

Keywords: dry forests, fuel treatments, high-severity fire, Northern Spotted Owl, *Strix occidentalis caurina*, wildfire

Sobreestimación del Riesgo de Fuego en el Plan de Recuperación de *Strix occidentalis caurina*

Resumen: *El reciente plan de recuperación del Servicio de Pesca y Vida Silvestre de E. U. A. para una de especies amenazadas más cuidadosamente observada en el mundo,* Strix occidentalis caurina, *recomendó una desviación importante en las estrategias de conservación en el noroeste de Estados Unidos. Debido a la preocupación por el fuego, el plan cambiaría de una estrategia de reservas a una estrategia sin reservas hasta en 52% de la distribución del búho. Los tratamientos de combustible (e.g., aclareo) a intervalos regulares también ocurrirían hasta en 65–70% de los bosques secos de esta área. Sin embargo, las estimaciones del riesgo de fuego se basaron en datos de menos de una década y una evaluación anecdótica de un incendio de gran extensión. Encontramos que los datos son inherentemente cortos, debido a pocos incendios extensos, para predecir los riesgos y tendencias del fuego con precisión. Las tasas de fuego de alta severidad, basadas en datos de percepción remota, son mucho más bajas que lo reportado en el plan y en comparación con la tasa de reclutamiento de bosques maduros. Adicionalmente, a lo largo de 22 años, no ha habido incremento en la proporción de fuego de alta severidad. Nuestros resultados refutan las conclusiones principales del plan que son la base para los cambios mayores en las estrategias para* S. o. caurina. *Se requiere la mejor ciencia disponible para atender estas estrategias en un marco de manejo adaptativo. Desde el punto de vista del riesgo de fuego, parece haber suficiente tiempo para investigar sobre los efectos del fuego y los tratamientos propuestos sobre* S. o. caurina *antes de diseñar acciones de manejo extensivas o eliminar reservas.*

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Palabras Clave: bosques secos, fuego de alta severidad, fuego no controlado, *Strix occidentalis caurina*, tratamientos de combustible

Introduction

The effects of wildfires have become a central concern for one of the world's most watched threatened species, the Northern Spotted Owl (*Strix occidentalis caurina*). Recent management of extensive federal lands in the northwestern United States has focused on this owl's viability. The 1994 Northwest Forest Plan (NWFP) increased protection for most remaining owl habitat from timber harvest of old forests by placing ~30% of 9.9 million ha of federal lands in reserves. The implications are far reaching and provide a global model for reserve-based species conservation (DellaSala & Williams 2006). Nevertheless, a new recovery plan for the owl (USDI 2008) could fundamentally alter this model. Although reserves were designed to accommodate natural disturbances, which were below expectations as of 2006 (Thomas et al. 2006), in 2008 the plan (p. 12) listed "ongoing loss of suitable habitat as a result of timber harvest and catastrophic fire" as one of three main threats to Spotted Owl viability.

The new threat of fire was considered so high that the plan (p. 20) proposed sweeping changes, including a no-reserve strategy for three Cascade provinces (Washington Eastern Cascades [WEC], Oregon Eastern Cascades [OEC], and California Cascades [CAC]): "...the rate of loss of older forests to stand-replacement wildfire has been relatively high...there is evidence that wildfire activity will continue or increase...thus, it is unlikely that designating Spotted Owl habitat reserves within fire-prone landscapes will be effective." In addition, the plan (pp. 22–23) called for fuel treatments at regular intervals on up to 65–70% of the three provinces' dry forests. A no-reserve strategy is also "expected" (p. 24) under the plan in the two Klamath Mountains provinces (Oregon Klamath [ORK] and California Klamath [CAK]). Collectively, the five provinces represent 52% of NWFP area, where the reserve-based strategy could be dropped.

The plan called high fire risk a recent trend (p. 20) on the basis of data from several sources (p. 97). It estimated decadal high-severity fire rotation (expected time to burn across a particular area one time) of 69 years in OEC old forest based on less than a decade of fire data (Moeur et al. 2005) and estimated 10,000 ha of old forest was lost in the 2003 B & B fire based on anecdotal evidence (Spies et al. 2006). These estimates were then extrapolated to the other dry Cascades provinces. In the Klamath the plan used a 105-year high-severity rotation from ORK, also derived from less than a decade of data (Haynes et al. 2006).

The plan's fire-risk estimates warrant scrutiny because presumed relationships between fire and owls may drive forest management over an extensive area and also have implications for Spotted Owls, as well as reserve-based conservation in general. The plan stated, "care should be taken when interpreting the losses of forests to high-severity wildfire over only a decade but the trend is very troubling." (p. 97). We used a data set over twice as long as that used for the plan and varied the length of the analysis period to examine whether decadal trends are reliable and to test the plan's hypothesis that fires are becoming more severe. Then, using the same analysis procedure as in the plan, but more complete quantitative data, we analyzed and compared rates of high-severity fire in old forests with those in the plan and with old-forest recruitment rates to test the plan's hypothesis that old-forest loss to wildfire has occurred since the NWFP was put in place. We specifically evaluated the plan's basis for recommending sweeping changes, but our analysis has broader implications for reserve management in dynamic landscapes.

Methods

A federal program provided remote-sensing fire-severity data for 1984–2005 fires of over 405 ha (www.mtbs.gov) based on the relative delta normalized burn ratio (RdNBR). We used these data to calculate high-severity fire rotations for all conifer forests in the dry NWFP provinces, test whether there has been an increase in fire severity over time, and estimate the occurrence of high-severity fire in old forests under the NWFP. Data from RdNBR were not available for fires <405 ha, but these cumulatively represent only 5.2% of the total area burned. Their inclusion, if it were possible, would only slightly shorten high-severity rotations.

The RdNBR data adjust for differing preburn vegetation to identify high-severity fire (Miller et al. 2009), which we defined as RdNBR $\geq$ 800. For context, Miller et al. (2009) estimated that basal-area mortality of >75% corresponds to a mean RdNBR of 798. Nevertheless, this threshold may overestimate high severity because many field validation plots had basal-area mortality from 0% to 50%, despite RdNBR values >800, particularly in Klamath forests, where large, old trees dominated forest stands. Forty-two percent of plots RdNBR classified as high severity were actually low or moderate severity in field validation (Miller et al. 2009). Mortality also can be overestimated if field validation subjectively classifies live trees as dead

Table 1. High-severity fire rates (1996–2005) versus recruitment rates of old forest within dry-forest provinces of the Northwest Forest Plan.

Province[a]	Old forest (ha)	Decadal high-severity fire area in old forest (ha)	Decadal rate of high severity (%)[b]	High-severity fire rotation (years)[c]	Ratio of old-forest recruitment area to high-severity burned area[d]
WEC	66,619	1,790	2.69	372	7.06 (3.53)
OEC	90,185	1,919	2.13	469	8.92 (4.46)
CAC	144,444	316	0.22	4,545	86.36 (43.18)
Cascades (all)	301,248	4,025	1.34	746	14.18 (7.09)
ORK	291,332	12,518	4.30	233	4.42 (2.21)
CAK	742,338	5,468	0.74	1,351	25.68 (12.84)
Klamath (all)	1,033,670	17,986	1.74	575	10.92 (5.46)

[a] Abbreviations: WEC, Washington Eastern Cascades; OEC, Oregon Eastern Cascades; CAC, California Cascades; ORK, Oregon Klamath; CAK, California Klamath.
[b] Calculated as 100 times column 3 divided by column 2.
[c] Calculated as period divided by fraction burned, so 10 years/(column 4/100).
[d] High-severity area in old forest is from our data. Average and estimated low old-forest recruitment rate data are from Moeur et al. (2005). Ratios based on the estimated low recruitment rate are in parentheses.

(Odion & Hanson 2008). Thus, RdNBR analysis remains inexact, but a threshold of 800 is congruent with current estimates of high-severity fire and is less subject to misclassification error than a lower threshold would be (Miller et al. 2009). High-severity percentages based on this threshold are similar to those used in a comprehensive analysis of western U.S. fires since 1984 conducted by the U.S. Geological Survey and U.S. Forest Service (Schwind 2008).

We used all available RdNBR data (1984–2005) to analyze fire-severity trends and test the effect of length of analysis period on high-severity fire rotation. We included all conifer forest in the dry provinces in these analyses, rather than limiting them to old forest, because the old-forest mapping (Moeur et al. 2005) did not predate 1996. We calculated and compared fire rotation during four 5-year periods, two 10-year periods, and the 20-year period 1986–2005. We used the Mann–Kendall nonparametric statistic, commonly used with non-normal data (Yue et al. 2002), to test the null hypotheses of no rank-order upward trend in annual area burned or percent area burned at high severity from 1984 to 2005.

For the old-forest analysis, we used federal GIS maps of old forest, as of 1996 (see Moeur et al. 2005 for detailed methods and accuracy assessment); NWFP federal lands; and dry-forest provinces (data available from www.reo.gov/gis/data/gisdata/index.htm). We used the Moeur et al. (2005) old-forest maps because they are the best data currently available and because we were replicating methods used in the calculation of fire rotations in the plan, which relied on old-forest mapping in Moeur et al. (2005). Accuracy of old-forest mapping was poor in many provinces, which could mean some additional old-forest areas were affected by high-severity fire (Moeur et al. 2005). Inclusion of such areas, were it possible, would increase the total area of high-severity fire along with the area of old forest.

Using GIS overlays we estimated the area of high-severity fire in old forest on NWFP federal lands in dry-forest provinces (Table 1). We used these data to calculate high-severity fire rotation (period divided by fraction burned) in old forest at the decade scale (1996–2005) to compare fire rotations derived from the best available data with fire rotations used in the plan. We analyzed only high-severity fire over a decade, which does not present a comprehensive picture of fire effects or include the other natural disturbances that affect forest structure, because we were replicating the analysis in the plan. We compared the rate of high-severity fire to the average estimated old-forest recruitment rates from Moeur et al. (2005) to test for old-forest loss. Moeur et al. (2005) derived the average rate (19% per decade) from remeasurement of inventory plots. No plots were located within designated wilderness or national parks, so Moeur et al. (2005) conservatively estimated that these generally high-elevation, unproductive forests would have a rate of one-half the average. We also included results with these low recruitment estimates from Moeur et al. (2005).

Results

Five wildfires accounted for 69.3% of 129,568 ha of high-severity fire (1984–2005) in the dry NWFP provinces (Figs. 1a & 1b). It is not surprising that for 5-year estimates of fire rotation (Fig. 2) the shortest rotations (266–875 years) were in the four 5-year periods (of eight in the Cascades and Klamath) with major fires, whereas rotations in the other four 5-year periods were long (1433–4482 years). This pattern was repeated with 10-year periods, but rotations varied less (449–1460 years). Twenty-year estimates of high-severity fire rotation were 599 years in the Klamath, 889 years in the Cascades,

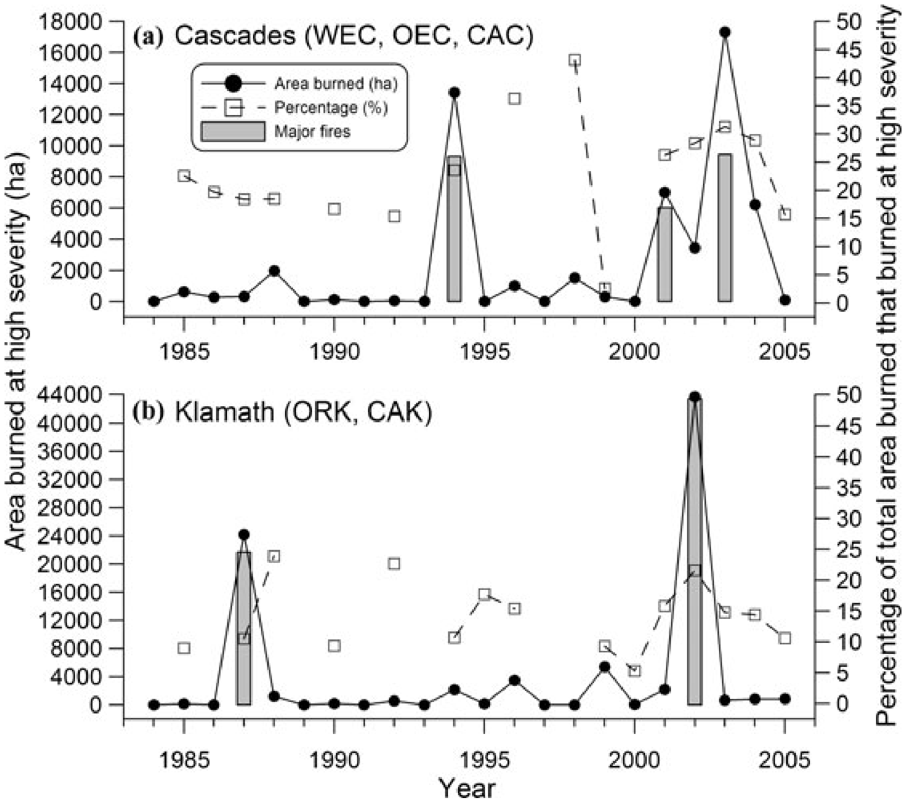

Figure 1. Area burned annually at high severity and percentage of total area burned at high severity in dry forests of the (a) Cascades (Washington Eastern Cascades, Oregon Eastern Cascades, California Cascades) and (b) Klamath (Oregon Klamath, California Klamath) provinces over the 22-year period (1984–2005) for which fire-severity data were available. Shaded bars are area of major fires (1987 complex in the Klamath, 2002 Biscuit fire in the Klamath, 1994 Tyee Creek fire in the Cascades, 2001 Rex Creek complex in the Cascades, and 2003 B&B fire in the Cascades).

and 710 years when pooled (Fig. 2). Even in the shortest period (5 years) centered on the largest fire (2002 Biscuit), the high-severity rotation at the province scale was 218 years.

Using data from 1984 to 2005, the null hypothesis of no increase in annual area burned at high severity (Figs. 1a & 1b) was rejected ($\alpha = 0.05$) for the Klamath ($z = 1.69$, $p = 0.045$) but not the Cascades ($z = 1.41$, $p = 0.080$). The null hypothesis of no trend in annual high-severity proportion was not rejected for either region (both $z = 0.35$, $p = 0.360$, Figs. 1a & 1b).

In areas classified as old forests in the NWFP dry provinces, decadal high-severity fire rotations were 746 years in the Cascades, 575 years in the Klamath, and 233–4545 years among provinces (Table 1). Rotations were 469 and 233 years in OEC and ORK, respectively, much longer than the 69 and 105 years reported in the plan. In OEC we found less (838 ha) old-forest high-severity fire in the B&B fire than the anecdotal 10,000 ha relied on in the plan. Using our data on area of high-severity fire in old forest and average old-forest recruitment rates from Moeur et al. (2005), we

Figure 2. High-severity fire rotations estimated with 5-, 10-, and 20-year observation periods. These estimates are based on total area burned on federal lands, not area burned in old forest because there was no pre-1996 map of old forest.

found that old-forest recruitment was 14.2 (Cascades) and 10.9 (Klamath) times the rate of high-severity fire in old forest (Table 1). On the basis of the low recruitment rate estimated by Moeur et al. (2005), which is for the least-productive forests, old-forest recruitment was still 7.1 (Cascades) and 5.5 (Klamath) times the rate of high-severity fire in old forest (Table 1).

Discussion

Predictions of risk and trend in area burned are inherently imprecise with short-term data and infrequent, major wildfires, but it is typical for a high percentage of total burned area (i.e., > 90%) to accrue from the small percentage of wildfires (i.e., < 5%) that are large and infrequent (Moritz et al. 2005). In our results, area affected by high-severity fire exhibited great variation over 22 years because of five major wildfires (Figs. 1a & 1b). Also, fire trends caused by multidecadal drivers, such as the Pacific Decadal Oscillation (McKenzie et al. 2004), and changes in wildfire management, ignitions, and land use are not captured by data at temporal scales of 5, 10, or even 20 years.

A limited analysis area in relation to the largest fires also misrepresents the influence of large fires and precludes statistical assessment of the defining events of fire regimes (Moritz 1997). For example, estimated decadal rates of high-severity fire in old forest were 21–40% (25- to 48-year rotation) in the main Klamath watersheds affected by the Biscuit fire (Healey et al. 2008). The decadal rate was 4.3% (233 year rotation) at the scale of the ORK province, and 1.74% (575 year rotation) at the scale of the Klamath region (Table 1). Thus, fire-regime analysis can be highly skewed when temporal or spatial extents are limited relative to analyses that are appropriately scaled (i.e., many times maximum fire size and nearly a fire rotation of data [Baker 1989]).

Due to substantial temporal variation in area burned, decadal fire-rotation estimates are unreliable, but ours, although still subject to uncertainty, are likely improved over the 69- to 105-year estimates in the plan that were based on shorter-term, incomplete data. Our estimates of 372–4545 years for the Cascades provinces and 233–1351 years for the Klamath provinces (Table 1) show that if any conclusion is to be drawn from 10 years of data, fire risk appears low and fire rotations appear long enough for ample old-forest recruitment. Even though we found a trend of more area burned at high severity recently in the Klamath, old forest appears to be recruiting at ~5.5 (low estimate) to 10.9 (average estimate) times the apparent rate of loss to high-severity fire (Table 1). We estimate that a dramatic increase in high-severity fire relative to current rates (e.g., 5–10 times as many huge fires per decade) would need to occur for old-forest declines to begin. This highlights the importance of considering both rates of old forest loss (e.g., Healey et al. 2008; USDI 2008) and recruitment (Moeur et al. 2005) in determining long-term viability of late-successional reserves. Overall, our results showed sufficient uncertainty in fire-rotation estimates and risk to old-growth reserves that a major shift in land management planning is not warranted.

Moreover, patches of high-severity fire will not necessarily cause a decrease in Spotted Owls or their habitat. Although the plan claimed 23 pairs of Spotted Owls were reduced to six by the B&B fire as an example of fire effects on owls, only one territory was actually occupied at the time of the fire. The plan is incorrect because the owl decline occurred before the fire. One year after fire there were two Spotted Owls (USDA 2005). Results of recent studies show that Spotted Owls use postfire forests and may benefit from successional diversity created by fire because of enhancement of habitat for the owl's small mammal prey (Franklin et al. 2000; Clark 2007). More data are needed regarding owl response to varying spatial configurations of fire, including high-severity fire. This is a key area for future research.

Importantly, the plan recommends abandonment of a reserve-based strategy in favor of broad-scale fuel treatments, even though empirical studies of the effects of fuel treatments (e.g., thinning) on Spotted Owls in dry forests are lacking. This recommendation also overlooks that reserves remain essential to protect Spotted Owl habitat from post disturbance salvage logging, which has accounted for the main increase in old-forest harvests on public lands under the NWFP (Healey et al. 2008).

Difficulties arise in analyzing threats to species viability in dynamic landscapes. For a closely watched species and model of conservation policy like the Spotted Owl, it is especially important that these difficulties be approached in a science-based manner to reduce inherent uncertainties. The new recovery plan for Spotted Owls is based on analyses that are highly uncertain and data that are too short term, incomplete, and spatially limited, yet it recommends sweeping actions with unknown consequences. Without data on the effects of proposed fuel treatments on Spotted Owls in dry forests to guide management, the plan's approach cannot demonstrate an expected decrease in risk to owls from fire. Instead, a small-scale, science-based, adaptive-management framework (Walters 1986; Nichols & Williams 2006), based on essential research, is first needed to reduce uncertainties in fuel treatments. Notwithstanding limitations of existing data, high-severity fire risk appears to be low relative to recruitment of old forest, indicating there may be ample time for needed, focused research to understand owl response to fire and fuel treatments before abandoning reserves and undertaking extensive management action in dry-forest provinces. This essential research would facilitate subsequent scaling up to a larger adaptive-management design that is well-grounded in maintaining and enhancing habitat for Spotted Owls, the focus that made the NWFP a model for international conservation.

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