Increasing Resiliency in Frequent Fire Forests: Lessons from the Sierra Nevada and Western Australia

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Abstract: *This paper will primarily focus on the management and restoration of forests adapted to frequent, low-moderate intensity fire regimes. These are the forest types that are most at risk from large, high-severity wildfires and in many regions their fire regimes are changing. Fire as a landscape process can exhibit self-limiting characteristics in some forests which can assist managers in mitigating large, severe wildfires. In mixed conifer forests in Yosemite National Park, when the amount of time between successive adjacent fires is under nine years, the probability of the latter fire burning into the previous fire area is low. Analysis of fire severity data by 10-year periods (from 1975-2005) revealed stability in the proportion of area burned over the last three decades; this contrasts with research demonstrating increasing high-severity burning in many Sierra Nevada forests. There is also evidence that intact fire regimes can constrain fire size. One of the world's best examples of a prescribed fire program designed to reduce unwanted fire effects can be found near Perth, Australia. Approximately 8,500 prescribed burns have been conducted burning a total area of 15 million ha since 1950. Over this time an inverse relationship between the area burned by prescribed fire and wildfire has been established. However, the annual area of prescribed burning in this region is trending downwards since the 1980s while the annual area burned by wildfires is trending upwards. In contrast to crown-fire adapted ecosystems, areas that are adapted to frequent, low-moderate intensity fire regimes can be managed today to reduce their susceptibility to high severity fires and increase ecosystem resiliency. The current pace and scale of fuel treatments and managed wildfire are inadequate to increase ecosystem resiliency in forests in the western United States. Continued funding reductions for fuel reduction treatments is one of the most serious issues facing federal resource managers in the western United States working to increase forest resiliency.*

INTRODUCTION

In forests in the western United States, fire hazard reduction treatments have become a priority as the size and severity of wildfires have been increasing in some forest types (Miller and others 2009; Westerling and others 2006; Miller and Safford 2012). However, both the scale and implementation rate for fuel treatment projects is well behind what is necessary to make a meaningful difference across landscapes (USDA Forest Service 2011; North and others 2012). This issue is particularly relevant as wildfire size and intensity are projected to increase in many parts of the western United States based on climate-fire modeling (Lenihan and others 2008; Westerling and others 2011; Yue and others 2013).

In contrast to crown-fire adapted ecosystems, ecosystems that once experienced frequent, low-moderate intensity fires can be managed to reduce their susceptibility to high severity wildfires (Fulé and others 2012) and increase ecosystem resiliency (Stephens and others 2012a, Stephens and others 2013). Research has determined that there are few unintended consequences of forest fuel reduction treatments across forests in the United States, because most ecosystem components (vegetation, soils, small mammals and song birds, bark beetles, carbon sequestration) exhibit very subtle or no measurable effects at all (Stephens and others 2012a). Similar results were found in Western Australia forests and shrublands that were repeatedly prescribed burned over 30 years (Wittkuhn and others 2011). In surface-fire adapted ecosystems, management actions including fuel treatments and managed wildfire (lightning ignitions allowed to burn for resource benefit) can be taken today to reduce the negative consequences of subsequent wildfires (such as large, high severity patches—Collins and Roller 2013) that also meet restoration objectives (North and others 2009).

Of the three principle means of fuels reduction, mechanical, prescribed burning, and wildfire, the latter is often the most expensive (North and others 2012). U.S. Forest Service (USFS) mechanical treatments (thinning, mastication) costs vary widely (Hartsough and others 2008) but costs on average were 3.5 times higher than prescribed fire in large part due to expensive service contracts for removal of small, noncommercial biomass. Wildfire costs were highest but vary tremendously between burns. In general, costs per acre increased as access became more difficult but decreased with fire size (North and others 2012).

Managing fire for multiple objectives instead of a narrow focus on fire suppression is producing some positive outcomes such as when fire exhibits self-limiting characteristics (reduce area and severity) in some ecosystems (Figure 1). Recurring fires consume fuels over time and can ultimately constrain the spatial extent and lessen fire-induced effects of subsequent fires. In montane forests in Yosemite National Park, United States, when the amount of time between successive adjacent fires is under nine years, the probability of the latter fire burning into the previous fire area is low (Collins and others 2009).

Our analysis of fire severity data by 10-year periods revealed stability in the proportion of area burned over the last three decades among fire severity classes (unchanged, low, moderate, high). This contrasts with increasing high-severity burning in many USFS Sierra Nevada forests from 1984 to 2010 (Miller and Safford 2012), which suggests that freely burning fires over time in some forests can regulate fire-induced effects across the landscape (Figure 2) (Stephens and others 2008; Miller and others 2012). It should be noted that the USFS has not used prescribed fire or managed wildfire to the degree that the U.S. National Park Service has which has influenced current burning patterns.

Current wildfires are burning large areas, but there is some evidence that intact fire regimes (those minimally affected by fire exclusion for several decades) can constrain fire size (Stephens and others 2013). For example, in montane forests of Yosemite National Park, where lightning fires have been allowed to burn under prescribed conditions for 40 years, a pattern of intersecting

Figure 1. Jeffrey pine forests that have been repeatedly burned by managed wildfire in the Illilouette Creek basin is in Yosemite National Park. Re-introduction of a functioning fire regime in 1973 has produced a forest that is resilient to fire and climate change. Photo by Scott Stephens.

fires emerged that limited the extent of subsequent fires to less than 4000 ha (9884 acres) (van Wagtendonk and others 2012). However, wildfires have grown to over 40,000 ha (98,842 acres) on areas in or adjacent to the park where fires have been routinely suppressed and the resulting burn severity patterns (especially large patch sizes) are not within desired ranges to conserve ecosystem resiliency (Miller and others 2012).

Fire and Fuels Management in USFS Lands in the Sierra Nevada

A recent analysis determined that fuels reduction was occurring on USFS lands in the Sierra Nevada at very low rates (North and others 2012). With less than 20% of USFS lands in the Sierra Nevada receiving needed fuels treatments, and the need to frequently re-treat many areas, the current pattern and scale of fuels reduction is unlikely to ever significantly advance restoration efforts. One means of changing current practices is to concentrate large-scale strategic (Finney and others 2008) fuels reduction efforts and then move treated areas out of fire suppression into fire maintenance. A fundamental change in the scale of fuels treatments is needed to emphasize treating entire firesheds and restoring ecosystem processes (North and others 2009, 2012). Without proactively addressing this situation, the status quo will relegate many ecologically important areas (including sensitive species habitat) to continued degradation from either no fire or wildfire burning at high severity (North and others 2012).

Figure 2. High severity patch in upper elevation mixed conifer forest in the Illilouette Creek basin is in Yosemite National Park. Median high severity patch size in this forest is < 4 ha (Collins and Stephens 2010) and the amount of high severity fire has not changed since the early 1970's (Collins and others 2009). Photo by Scott Stephens.

Ironically, current USFS practices intended to protect resources identified as having high ecological value often put them at a greater risk of large, high-severity fire (Collins and others 2010, North and others 2012). A policy focused on suppression, which ultimately results in greater wildfire intensity, means that fuels reduction becomes the principle method of locally affecting fire behavior and reducing severity (Collins and others 2010). Forest areas identified as having high conservation value, such as riparian conservation areas (van de Water and North 2010, 2011) and protected activity centers (PAC) for threatened and sensitive wildlife often have management restrictions and higher litigation potential, resulting in minimal or no fuels reduction treatment (North and others 2012). Stand conditions in these protected areas often consist of multi-layered canopies with large amounts of surface fuel, resulting in increased crown-fire potential (Spies and others 2006; Collins and others 2010). Following a particularly high-intensity 2007 wildfire in the Sierra Nevada (Moonlight), riparian and PAC areas had some of the greatest percentage of high-severity effects of any area within the fire perimeters (Safford and others 2009). In contrast, low- and moderate-severity wildfire and prescribed burning in Yosemite National Park maintained habitat characteristics and density of California spotted owls (*Strix occidentalis*) in late successional montane forest (Roberts and others 2011).

Recent estimates determined that at current treatment rates, the deficit of forestland "in need" of treatment would be approximately 1.2 million ha (approximately 30 million acres) in the Sierra

Nevada (approximately 60% of USFS lands in the Sierra Nevada), of which 670,000 ha (16.5 million acres) are ponderosa (*Pinus ponderosa*) and Jeffrey pine (*Pinus jeffreyi*) dominated forest types (North and others 2012). This is a very conservative estimate of the deficit because it assumes that mechanical, prescribed fire, and wildfire areas never overlap and that all wildfires are restorative in their ecological effects, which is not the case. Although current policy recognizes the importance and need for managed wildfire (FWFMP 2001; USDA/USDI 2005; FWFMP 2009) studies have found very low rates of implementation. In 2004, land management agencies only let 2.7% of all lightning ignitions burn (NIFC 2006), consistent with a recent analysis in the Sierra Nevada that less than 2% of USFS lands were burned under managed wildfire between 2001–2008 (Silvas-Bellanca 2011). The most significant factor associated with USFS District Rangers using managed wildfire was personal commitment, while the main disincentives were negative public perception, resource availability, and perceived lack of agency support (Williamson 2007).

With less than 20% of the landscape that needs fuels treatments receiving them and the need to re-treat many areas every 15–30 years depending on forest type (Stephens and others 2012b), the current pattern and scale of fuels reduction is unlikely to ever significantly advance restoration efforts, particularly if agency budgets continue to decline. Treating and then moving areas out of fire suppression into fire maintenance is one means of changing current patterns (North and others 2012).

As fuel loads increase, rural home construction expands, and budgets decline, delays in fuel treatment implementation will only make it more difficult to expand the use of managed fire after initial treatments. Increases in managed wildfire may be criticized given current constraints but at least it could stimulate discussions between stakeholders, air quality regulators, and forest managers about current and future management options (North and others 2012). Without proactively addressing some of these conditions, the status quo will relegate many ecologically important areas to continued degradation from fire exclusion and high severity wildfires. In some forests, revenue generated in the initial entry (Hartsough and others 2008) may be the best opportunity to increase the scale and shift the focus of current fuels reduction toward favoring long-term fire restoration (North and others 2012).

Fire and Fuels Management in Western Australia

One of the world's best examples of a fire management program designed to reduce wildfire impacts can be found in Australia (Boer and others 2009). In the fire-prone forests and shrublands of south-west Western Australia, prescribed burning of native vegetation is an important management strategy for achieving conservation and land management objectives (Wittkuhn and others 2011). Prescribed burning done at the appropriate spatial and temporal scales reduces the overall flammability and quantity of fuels in the landscape, thereby reducing the intensity and spread rate of wildfires (Stephens and others 2013).

Broad area fuel reduction burning as a key asset protection strategy has been implemented in south-west Western Australia since the mid-1950s (Figure 3). Approximately 8,500 prescribed burns have been conducted burning a total area of 15 million ha (37 million acres) (Stephens and others 2013). Over this time, an inverse relationship between the area burned by prescribed fire and wildfire has been established (Boer and others 2009), i.e., prescribed burning has reduced the impact of wildfires by reducing their size and intensity. This Australian example could be of interest for regions that continue to focus solely on fire suppression.

However, the annual area of prescribed burning in the south-west Western Australian region is trending downwards since the 1980s (mainly because of the reduced area of prescribed fire), while the annual area burned by wildfires is trending upwards (Stephens and others 2013). In recent years there has been a spate of wildfires that have not been experienced in the region since the 1960s. Key drivers of these trends are (Stephens and others 2014):

- Climate change. Since the 1970s, the climate has become warmer and drier (Bates and others 2008) reducing the window of opportunity for safely carrying out prescribed burning. Longer periods of hotter, drier weather result in longer periods of high fire risk.
- Population growth in the urban-wildland interface. More people are living in fire-prone settings. In many instances, local by-laws and land use planning policies do not adequately consider the risk of wildfires, or are not adequately enforced. People are building and living in dangerous locations and often are not taking adequate fire protection measures.
- Fire management capacity. Resources and personnel for fire management have not kept pace with the increasing demands and complexity of managing fire. Additional staff is needed and training programs are necessary to allow this new group to become familiar with prescribed fire planning and operations.

Figure 3. Prescribed fire in mixed eucalyptus forests near Busselton, Western Australia. Note the variety in fire severity with some areas unburned and others burned at high intensity which is the common goal in this area. Regrowth is already occurring only two months after the prescribed fire. Photo by Scott Stephens.

- Smoke management. Managing air quality and the impacts of smoke on adjacent land users or home-owners further narrow burning windows and reduce the size and number of prescribed burns that can be conducted.

Effective management of wildfire risk will require the incorporation of larger-scale management processes across landscapes (at the 10,000 - 30,000 ha scale, 25,000-75,000 acre scale) (North and others 2012; Stephens and others 2014). This can be done with large scale prescribed burning programs, mechanical fuel treatments, combinations of mechanical and fire treatments, or allowing wildfires to burn under desired conditions. Managed wildfire probably has the greatest ability to meet restoration and fuel management goals in the western United States because it can be implemented at moderate-large spatial scales with the lowest cost (North and others 2012) whereas in Australia, the Mediterranean Basin, the U.S. Great Plains, and the Southern United States, prescribed burning is preferable (Stephens and others 2013). Regardless of how a fire is ignited, smoke will likely be a large concern, especially its impact on human health. However, it is important to contrast the human health effects of smoke from prescribed fires and managed wildfires with those of large, severe wildfires, which can affect large regions for weeks or months.

CONCLUSION

Federal forest managers have a great challenge in promoting forests that are resilient to changing climates. Forests that once experienced frequent, low-moderate intensity fire regimes can be managed today to reduce the negative impacts of subsequent wildfire. Increased use of fire and fire surrogates treatments (McIver and others 2009; Schwilk and others 2009; Stephens and others 2012a) and increased use of management wildfire for resource objectives are the only possibilities for managers to achieve desired conditions. Current rates of treatments on federal lands in the western United States are inadequate to conserve forests into the future (North and others 2012). This treatment deficit has the potential to adversely impact critical ecosystem services that are derived from U.S. forests.

One of the largest challenges faced by U.S. federal land managers is the continued reduction in funding for fuels programs which subsequently emphasizes managed wildfires as their primary management option. Funding for prescribed fire, thinning, and mechanical fuels treatments has been reduced in the last two years and the 2013 U.S. federal budget reduces it by over 85% in comparison to resources allocated in this area in the early 2000's. Managed wildfire is appropriate in wilderness, roadless areas, and other remote areas but is not applicable to large areas of federal land because of human infrastructure. Managing wildfires for weeks or months can produce positive ecological outputs but is much riskier than performing fuels treatments over relatively short time intervals. Managers need access to all forest management options to increase resiliency in the forest areas of the United States; removing options will further increase the back-log of areas in need of restoration.

California can learn from a successful prescribed fire program in southwestern Western Australia (Sneeuwjagt and others 2013). While the ecosystems in these two areas are different they both evolved with frequent fire in Mediterranean climates. Southwestern Western Australia has successfully implement a prescribed fire program that has reduced the incidence of wildfires (Boer and others 2009) while conserving ecosystems (Wittkuhn and others 2011). The challenge is for California managers to produce a similar outcome for frequent fire ecosystems in the Sierra Nevada.

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