Partial Harvest in Water and Lake Protection Zones to Support Fire Resilient, Ecologically Diverse Stands and Associated Ecosystem Services

Introduction

The Board of Forestry and Fire Protection (Board) has received several comments expressing concerns that riparian zones may be contributing to the size and severity of recent fires due to management exclusions. California's history of fire exclusion is now being followed with a policy of management exclusion in Water and Lake Protection Zones (WLPZs) and is resulting in increased occurrences of catastrophic wildfire. While critical functions must be maintained to support wildlife, appropriate stand structure, and essential functions related to soil and water quality, recent conditions indicate that fire severity in riparian zones may be producing significant adverse effects on many of these critical functions. Moving forward, these management strategies warrant re-assessment and trade-offs must be considered. In some cases, the development of resilient forests may warrant the use of timber harvesting strategies that utilize certain heavy equipment in WLPZs to prevent extreme fire conditions and subsequent soil, water quality, and species composition impacts.

Limited timber harvest activities in WLPZs are currently supported under the California Forest Practice Rules (FPRs) if endorsed by a Registered Professional Forester (RPF) as an en leiu practice and validated by appropriate scientific explanation. This White Paper pulls from scientific studies to validate this practice and inform the forestry community regarding the appropriate use of certain heavy equipment in WLPZs to reduce wildfire severity without significant adverse impacts when site-specific conditions are fully considered and Best Management Practices (BMPs) are employed.

Historic and Current Conditions of Riparian Forests

Historic Fire Return Intervals

Many studies have illustrated that modern fire return intervals have deviated significantly from historic fire return intervals, with associated changes in intensity and severity. The van de Water and North (2010) study presents a model-based comparison of present and reconstructed fire histories and stand structures. Using three regions of the northern Sierra Nevada, dead trees with long fire histories were sampled in riparian and upland areas. Tree samples were analyzed to develop fire return intervals before and after 1850 as well as to determine the seasonality of burns. The study found that fire histories between upland and riparian areas were very similar, indicating that "riparian forests bordering many montane streams might be managed for fuel loads and fire return intervals similar to adjacent upland forests."

Several other studies indicate that historic fire regimes were often composed of frequent, low-intensity fires and highlight the importance of heterogeneity on the landscape. This heterogeneity tends to produce a patchwork of fire severities, creating a more diverse landscape that is better able to slow high-intensity fires while maintaining smaller areas of high-severity fire that facilitate stand diversity (Kilgore & Taylor, 1979).

High Stand Density and Resulting Fire Regimes in Riparian Areas

Anecdotal evidence is noted in several studies, and the York & Roughton, 2019 presentation suggests that stand densities in riparian forests are higher than they have been historically and may be linked to increased fire behavior across California. For example, Dr. York provides comparative images in his presentation showing the difference between managed upland stands and excluded riparian stands. Additionally, Blodgett Forest suffered the King Fire in 2014, which burned across riparian and upland areas. A visual assessment of the land post-fire showed some live trees in upland regions and black, dead trees in riparian zones, indicating that the fire may have burned more severely in riparian areas.

Several empirical studies support this notion, indicating that stand densities are higher and stand composition dynamics are making these areas more fire-prone (Jurgensen et al., 1997; van de Water & North, 2011). Van de Water and North (2011) suggest that California's history of fire suppression, management exclusion areas, and higher moisture content have resulted in high stem densities and fuel loads in riparian zones. It has been proposed that the difference in spatial severity seen in this fire and in others may subsequently be the result of over-stocked riparian corridors.

In their 2011 study, van de Water and North model reconstructed historic stand conditions for riparian and upland forests. They then compare these reconstructed models to current stand conditions to approximate departure from historic stand conditions and fire regimes. Results found that both riparian and upland forests have significantly greater basal area, stand density, snag volume, canopy bulk density, duff, and total fuel load when compared with the reconstructed stands. Also noted were significantly lower torching and crowning indices. Additionally, a comparison between current upland and riparian stands indicates that riparian forests have lower quadratic mean diameter, canopy bulk density, and proportion of fire-tolerant species; higher stem density, probability of torching, and greater predicted mortality than upland stands. Indeed, van de Water and North state that "denser riparian stands composed of primarily fire-intolerant species with more vertical continuity of canopy fuels may result in higher riparian fire severity," and cite "observations of greater occurrence of crown fire near stream channels." In contrast, reconstructed riparian and upland forests appeared to have no significant difference in fire intensity indices, consistent with their earlier findings (van de Water & North, 2010).

The departure from historic stand conditions in both upland and riparian stands may be contributing to the extreme fire regimes California has been experiencing. More importantly, riparian stands are more divergent from historical structures than upland stands, putting these areas at greater risk for high-severity fires. As linear landscape features, this increase in fire severity in riparian areas may also contribute to larger fires; over-stocked riparian areas are noted to act as “wicking” agents along their length, sometimes carrying fire into unaffected upland areas (Pettit & Naiman, 2007; van de Water & North, 2011). Riparian areas historically served as moist areas that could lessen the intensity of fires or stop their spread upon approach, but this function has been less so in recent years and in some instances inverted.

Impacts of High-Severity Fire on Water Quality and Site Productivity

In addition to anthropogenic impacts on stand density and composition in riparian areas, changes in climatic conditions are resulting in significant increases in tree mortality across the landscape. Longer and more intense droughts have become a common occurrence in California, resulting in increased drought-related mortality and susceptibility to pests and diseases. This increase in mortality contributes to fuel loads in riparian zones and is likely to drive more frequent and more severe fires in the future (Pettit & Naiman, 2007; van Mantgem et al., 2013, 2009). The implications of these changes in fuel loading are wide-reaching, particularly in riparian areas where downstream effects can span miles of river.

Ice, Neary, and Adams (2004) summarize a variety of effects that may result from severe wildfires and highlight the importance of these impacts for riparian areas. As more severe fires burn closer to water courses, impacts are more likely to affect watershed processes. Specifically, soil can be impacted by increased fire temperatures resulting in the exposure of mineral soil as the fire consumes organic layers. A layer of negatively charged, hydrophobic soil can also develop on the surface. Poor soil cover and a hydrophobic top layer can result in dry ravel, reduced infiltration and percolation, increased surface flows and subsequent surface erosion, slope failures and debris torrents, stream in-fill, changes in nutrient cycling, changes in annual and peak flow, and related impacts to wildlife. For example, sediment concentrations and annual flow measurements have been shown to double or triple following wildfire, resulting in higher turbidity, reduced channel scouring, changes in primary productivity in streams, and extreme water flows that may produce further bank failures or over stocking of woody debris in streams (Dahm, Candelaria-Ley, Reale, Reale, & van Horn, 2015; Ice et al., 2004).

Soil health issues are compounded by reduced vegetation and canopy cover on riparian banks post-fire, which can result in severe increases in stream temperature and reduced bank stability. Additionally, Dahm et al. (2015) notes changes in stream pH, conductivity, and dissolved oxygen, which may strongly affect macroinvertebrate community structure and could produce hypoxic conditions that would have a significant impact on aquatic wildlife.

As severe wildfire impacts on riparian and aquatic ecosystem processes and wildlife become more apparent, it is important to consider that fire severity and location are much stronger determinates for soil and watershed responses to fire than the presence of fire itself (Ice et al., 2004). Restoration of historic fire regimes and stand densities will be an important component of fire prevention in future years, and careful management of these areas to prevent adverse effects to water quality as well as riparian and aquatic wildlife will be essential.

Restoring Pre-Colonization Stand Dynamics

In an environment that has evolved with fire serving as an integral part of the life cycle, it is not surprising that anthropogenic exclusionary practices have been associated with structural and compositional changes in forests (Messier, Shatford, & Hibbs, 2012). Several studies have cited increased stand densities and increased fire severity in historically fire-prone areas, both of which have implications for stand complexity (Agee, 1993; Kilgore & Taylor, 1979; North, 2012).

Messier, Shatford, and Hibbs (2012) look specifically at fire exclusion effects on riparian forests, the impacts of reserve systems, and public policy related to forestry and prescribed burning in riparian zones. They ask: Do separate management strategies for riparian and upland forests with similar fire histories make sense; and how does fire exclusion in combination with these different management strategies affect riparian stand dynamics? Study results reveal that historic riparian forests were maintained by a mixed-severity fire regime which resulted in "complex, multi-aged stands with large, old fire-resistant trees" and a heterogenous nature that included variety in gap creation and unburned areas for fire-sensitive species (Messier et al., 2012). Changes in this dynamic are resulting in higher retention rates in riparian zones and subsequently higher stand density. This increased stand density favors more shade-tolerant species and prevents the gap creation that historically allowed for the establishment of new shade-intolerant conifer species, resulting in reduced heterogeneity in stand density and age structure. Additionally, the preference for shade-tolerant species creates issues for wildlife as large stream-side conifers are often important for woody debris in streams and snag recruitment; with predicted lower future recruitment of these trees to replace the dominant canopy trees, these critical habitat features may decline.

Messier, Shatford, and Hibbs (2012) conclude that current riparian management policies may be "detrimental to the long-term health of riparian forests in regions shaped by fire." They further assert that these exclusionary areas can represent a large percentage of the landscape in some cases and that restrictions in these areas may be limiting treatment of upland forests by reducing harvestable area, thereby decreasing the economic feasibility of treating that specific region.

Keane et al. (2002) reference similar conclusions; namely, that fire and management exclusion are resulting in higher stand densities which may be having detrimental effects on riparian ecosystems. They reference several effects, including: decreased biodiversity, increased crown and surface fuels, increased instances of fire-sensitive invasive species, increased pest infestations, changes in soil absorption which may limit flowing water in adjacent streams, and changes in stand and landscape level composition and structure. Keane et al. (2002) cite many of the compositional and structural changes documented by Messier, Shatford, and Hibbs (2012), such as a shift to shade tolerant species, increased density, and changes in retention rates and successional patterns. However, Keane et al. (2002) also note the invasion and overgrowth of brush and shrubs into grasslands and shrublands because regular disturbance is no longer regulating the size and number of these fuels. This may also hold true in some forested lands with adequate light penetration to allow the growth of brush and shrubs, increasing surface fuels and fire hazards in these areas.

Keane et al., (2002) and Messier et al. (2012) both assert that neither thinning nor prescribed burning is independently sufficient to restore historical fire regimes. For the restoration of historical stand dynamics that are more conducive to lower severity fires, Keane et al. (2002) suggest the inclusion of thinning treatments as well as prescribed fire to restore ecosystem processes and prevent large, severe fires that kill more plants and alter more ecosystem processes. Messier, Shatford, and Hibbs (2012) echo these sentiments for riparian areas. They suggest that “large canopy gaps, un-treated ‘islands’, clumps and irregularly spaced trees” may be appropriate methods of thinning riparian areas to mimic historical disturbances, and that these treatments in addition to prescribed fire will “promote the recruitment of shade-intolerant, fire-resistant tree species, increase overall tree vigor, increase structural diversity, and create a more discontinuous forest canopy, restricting the spread of high-severity crown fires” (Messier et al., 2012).

Potentially Improved Habitat Conditions Resulting from Riparian Treatment

As detailed in previously referenced studies, wildfire has significant impacts on riparian areas and the wildlife that depend on them. This is particularly true in the case of high-severity fires, which are becoming more common in California following an era of fire exclusion and management exclusion policies in riparian zones (Dwire, Meyer, Riegel, & Burton, 2016). Changes to soil structure can result in declines in water quality and water infiltration, negatively impacting aquatic species and downstream habitat; changes in tree vigor, stand composition, and age structure due to overstocking can result in declines in woody debris recruitment and inadequate habitat for some riparian species; increased incidence of invasive species and pest infestations due to management exclusion can add to fuel loads and can increase surface fuels post-fire. The list of potential habitat degradation that can result from severe riparian fires is endless. Indeed, the many impacts have the potential to cascade through the ecosystem and downstream to many locations and species. Efforts to more closely mimic historic stand and fire dynamics in riparian zones to shape a more frequent, less severe fire regime are essential for establishing fire resilience and restoring habitat value, which in turn support healthy water, soil, and wildlife. While thinning operations can have significant impacts, several studies have stated that thinning efforts and prescribed burning may be a more controlled and less impactful method of management than the current fire regime, particularly when BMPs are employed (Keane et al., 2002; Messier et al., 2012; Scott, James, & Ralph, 2012).