Fuels Treatment Longevity Report for the Washington DNR

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**Introduction**

Forest managers and scientists of western dry forests widely support an increase in the pace and scale of fuels and restoration treatments such as thinning and prescribed burning, to mitigate the negative effects of fire suppression (cite). Treatments can serve a variety of purposes, depending on location and details of prescription. These purposes can include:

* Reducing wildfire hazard to communities and economic assets (cite).
* Easing fire suppression operations (cite).
* Increasing forest resiliency to wildfire, drought, insects, and disease (cite).
* Stimulating understory plant diversity (cite).
* Improving habitat for open forest animal species (cite).
* Stimulating tree growth for timber (cite).

The short-term benefits of fuels and restoration treatments in dry forests are well-supported by many studies, but the longer-term fuel and vegetation pattern are less well-known. Even as little as five years after treatment, there is little information to help managers predict the state of a treated stand. Because of the relative lack of information on treatment longevity, it can be difficult or impossible to:

* Plan optimal treatment rotations.
* Assess tradeoffs between conducting restoration treatments (treating untreated stands) and maintenance treatments (re-treating ‘restored’ stands).
* Assess whether maintenance treatments can provide enough merchantable timber to help offset the cost of treatment, because much of the merchantable material is often removed in the initial restoration treatment.
* Forecast carbon dynamics in treated stands.
* Predict prescribed fire behavior in maintenance treatments.
* Plan efficient and safe fire suppression operations in treated landscapes.
* Model future wildfire behavior in treated landscapes.
* Understand plant and animal habitat quality in treated landscapes.

Given the scope of the modern wildfire problem in fire suppressed forests of the interior west, and the limited resources available to public and private forest landowners, scientists must address the knowledge gap in treatment longevity so that managers can efficiently plan treatment rotations and know what to expect from treated stands. In this report, we touch on some key concepts in treatment longevity from the scientific literature, and then synthesize data from all the published studies of treatment longevity that we could find from the western dry forests, including three in-progress studies led by our team, of forests in eastern Washington State. Our work is meant to highlight both what scientists know about treatment longevity, and the research gaps that remain.

**Concepts in Treatment Longevity**

*Definitions*

The first hurdle in determining treatment longevity is defining it. There is likely no magic number of years past which a particular treated stand serves its purpose, even though it will be necessary in many cases to decide on an exact treatment rotation for planning purposes. Instead, changes to forest structure, fuels, and potential fire behavior happen gradually, which also causes a gradual change in the risk of a damaging wildfire. Therefore, the fuels treatment rotation must be based on judgement of acceptable risk within the treated stand and any values in its proximity, in addition to scientific information on likely forest structure, fuels, and fire behavior patterns with time.

One way to judge fuels treatment longevity is by looking at what the fuels themselves do over time, and comparing that to the pretreatment values. Longevity could be thought of as the time it takes for fuels to get back to pretreatment values. This approach is complicated, however, by the wide variety of live and dead vegetation forms that contribute to ‘fuels’. These include litter, duff, downed sticks and logs of different sizes, grasses, forbs, shrubs, tree seedlings, tree saplings, and mature tree canopies. Each of these fuel components can response differently to treatment over time and potentially cause different types of fire behavior. Therefore, assessment of fuels treatment longevity based on fuels patterns should be accompanied with as assessment of expected fire behaviors from different relative levels of different fuel components. This ‘fuels-based’ approach allows for assessment of relative benefits of treating different stands. It is not very precise for forecasting expected fire behavior in any given stand, as some differences in amounts of fuel may not result in ecologically meaningful differences in fire behavior. Therefore, it is probably best used in situations where maximizing forest resilience to wildfire across a large landscape is a primary management goal, but where no single stand is crucial to protect.

The issues caused by analyzing multiple fuels components can be somewhat simplified by instead looking at changes over time of modelled fire behavior, such as flame length, rate of spread, torching index, and crowning index. This method may be more meaningful for many managers and scientists because potential wildfire behavior is often a central focus of treatment. It should be used with caution, however, because fire is a notoriously complicated process, and the most commonly-used family of fire models (Rothermel-based) is not good at incorporating fuels variability, linking surface and crown fire behavior, or incorporating spot fires. Results can be sensitive to the ‘fuel-model’ chosen by the user. Furthermore, wildfire behavior is largely contingent on fire weather, so interpretations of fire models will vary with user-inputted weather parameters, which should be chosen based on expected local weather behavior during wildfire season. Fire models are often effective at comparing relative differences in fire behavior even when they are inaccurate at predicting absolute behavior, so they are useful for comparing pretreatment and posttreatment values, or differences between different stands. Use of fire models alone may obscure deeper understanding of long-term fuels patterns, so data on fuels and forest structure patterns should be paired with fire model data when feasible, both as a ‘gut-check’ on model outputs and as a measure of other ecosystem values.

Alternatively, the definition of treatment longevity could be based on meaningful thresholds of expected fire behavior or effects, such as the acceptable crown fire risk or expected tree mortality. This approach is best-suited for situations where high value assets need to be protected in particular location, and is not as good for comparing relative benefits of treating different stands. Fire models should be used with caution for all the reasons highlighted in the previous paragraph. Because they are not always accurate at predicting absolute fire behavior, they are best paired with local knowledge of how modelled wildfire behavior compares with real wildfire behavior, when high-value assets are at stake. Additionally, the weather factor adds another aspect to the risk assessment process, as a manager using the threshold approach must decide what weather conditions to design treatment rotations for. Even good treatments are often not effective at preventing tree mortality or stopping flame spread during very extreme fire weather conditions, at least when untreated area exceeds treated area. These very extreme conditions are becoming more common with climate change, so it is probably unreasonable and/or inefficient to plan fuels treatments to control fire behavior in the most extreme possible conditions.

Treatment rotation age can also be based on non-fuels resources while still being effective at managing fuels, provided the rotation is shorter than longevity. The literature on traditional knowledge of fire use has many examples of pre-colonial tribes deciding cultural burning frequency based on non-fuels resources, such as stimulating huckleberry growth or quality of hazelnut shoots, in ways that likely kept the wildfire hazard low. Examples from western management include endangered species management, like red-cockaded woodpecker habitat in the longleaf pine (*Pinus palustris*) stands of the southeast and Kirtland’s warbler habitat in jack pine (*Pinus banksiana*) stands of the upper Midwest. And a timber management example? One traditional knowledge based critique of western fire management and fire science is that it does not consider broader ecosystem values even when relatively minor changes in fire management, such as seasonality of burning, may have relatively large benefits. Our report focuses on efficient management of fuels, which often needs to be the primary consideration in modern dry forest management because of the legacy of fire suppression. However, we want to emphasize here that fuels management is not the only consideration in planning thinning and/or prescribed burning rotations, and that in some cases other ecosystem management goals can be fundamentally compatible with fuel management.

*Statistical significance*

Most studies of fuels treatment longevity fail to find statistically significant differences between different types of treatments or between pretreatment and longterm sample periods for most fuels metrics, but this does not necessarily mean there is no effect of treatment. Statistical significance is a tool used to account for the uncertainty caused by having data from only a portion of the area of interest. When only a fraction of a stand is sampled, managers and researchers produce a range of values they think of as the ‘truth’; for example, a manager may conduct a timber cruise and find a basal area of 90 feet squared per hectare, but treat the actual mean basal area as lying somewhere between 80 and 100. The width of this ‘confidence interval’ depends on the variability in basal area from plot to plot, and the number of plots. This is important to keep in mind for fuels surveys because many fuels metrics have high variability, and fuels surveys are intensive so there often isn’t money to sample a huge number of plots. There are often localized areas of very high surface and/or canopy fuel loads that make the confidence intervals much wider.

Statistical significance is inherently conservative in that it tries to minimize the chance of declaring a difference between two tested entities, such as different types of fuels treatments. The result

**Factors that affect fuels treatment longevity**

*Site productivity*

Fuel treatment longevity is integrally linked to site productivity, which heavily influences vegetation growth and decay rates (Jain et al. 2012), as well as twig and litterfall rates (Keane et al. 2012). In general, more productive sites will tend to have faster decay rates of dead woody fuel, but also greater rates of litterfall, greater recruitment of ladder fuels, and faster canopy response to openings. Therefore, longevity is likely to be greater on drier sites, shallower soils, and nutrient-poor soils, as well as cooler or drier regions. Managers can take advantage of this knowledge, by preferentially treating stands with relatively low productivity to increase average longevity over a landscape, when overall landscape resiliency to fire is the primary goal. Topography was a major driver of local-scale vegetation and fuel variability in precolonial forests, with ridgetops and drier south/west facing mountainsides sustaining lower fuel loads, so topography is good starting point for local/landscape scale planning. In areas where high value assets coincide with productive sites, managers will likely need to treat stands often to maintain low fire hazard.

*Treatment type*

Existing studies show that