Reinhardt, E.D., Keane, R.E., Calkin, D.E., Cohen, J.D. 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western United States. Forest Ecology and Management. 256:1997-2006.

Paper summarizes objectives, methods and expected outcomes of fuel treatments; misunderstandings, and literature. They conclude:

1. Wildlands cannot be fire-proofed and unless vegetation is eliminated, even areas with intensive fuel treatments have residual biomass which can burn. In the western US dry and hot conditions will inevitably lead to conditioning fuels to burn.
2. If treating fuels makes suppression more successful, then less area will burn in the short term and more acreage will burn under extreme conditions. Fire suppression leads to continued fuel accumulation. Treatments should strive to "create conditions where fire can occur without the need for suppression". The behavior of large wildfires may overwhelm the ability of small fuel treatments to facilitate suppression. Examples are provided of fires burning through treated areas due to environmental conditions. Homes burned by igniting directly from firebrands or surface fires contacting the structure, while unconsumed tree canopies existed between the wildfire and destroyed homes. Treating fuels adjacent to structures and the flammability of the structures that determine vulnerability.
3. "Treating fuels to reduce fire occurrence, fire size, or amount of burned area is ultimately both futile and counter-productive" because most acreage burned is under extreme conditions which make suppression ineffective. If, due to treatments, moderate intensity fires are suppressed this leads to most acres burning under extreme conditions. Reducing burned area would not be desirable as large fires were common prior to European settlement and many western plant species are adapted to large, severe wildfires. Large fires generally have many areas lightly to moderately burned. Any fire "could offer a unique opportunity to restore fire to historically fire-dominated landscapes and thereby reduce fuels and subsequent effects."
4. Some fuel treatments may result in increased rate of spread as thinning can result in "surface litter becoming drier and more exposed to wind". It can result in increased growth of grasses and shrubs and a rapidly moving surface fire. Even if spread rate is reduced, spotting can "negate these effects". The goal of fuel treatment should be to reduce burn severity, not spread rate.
5. 1% of fires account for 85% of fuel suppression expenditures and since the "location of these large expensive fires cannot be known in advance, fuel treatment coverage would need to be extremely extensive to prevent these expensive fires". Analysis of 100 fires in Region 1 found that only fire size and private land had a strong effect on expenditures. "Fuel characteristics had no significant effect."
6. Reducing fuel hazard is not the same as ecosystem restoration. Treatments such as mastication and thinning may leave stand conditions that do not mimic historical conditions. Mastication breaks, chips, grinds canopy and surface woody material into a "compressed fuel bed" while thinning that removes fire-adapted species and leaves shade tolerant species do not mimic historical conditions. "Fire itself can best establish dynamic landscape mosaics that maintain ecological integrity."
7. Thinning for fire hazard reduction should concentrate on the smaller understory trees to "reduce vertical continuity between surface fuels and the forest canopy." Thinning can increase surface fire behavior for example, it increases surface wind speed and results in solar radiation and drying of the forest floor creating drier surface fuels.
8. Fuel treatments are transient. Prescribed fire creates tree mortality with snagfall contributing to fuel loads, tree crowns expand to fill voids, trees continue to drop litter. Trees cut for harvest or killed by fire contribute limbs to the forest floor, increasing fuel loadings. Up to seven treatments may be needed to "return the area to acceptable conditions that mimic some historical range."

Andrus, R., Veblen, T.T., Harvey, B.J., and Hart, S. 2016. Fire severity unaffected by spruce beetle outbreak in spruce-fir forests in Southwestern Colorado. Ecological Application: 26(3):700-711. DOI: 10.1890/15-1121.

Spruce beetle infestations were found to have no influence between pre-fire beetle severity and fire severity. Findings were consistent across moderate and extreme burning conditions. "In comparison to severity of the pre-fire beetle outbreak, we found that topography, pre-outbreak basal area, and weather conditions exerted a stronger effect on fire severity. Our finding that beetle infestation did not alter fire severity is consistent with previous retrospective studies examining fire activity following other bark beetle outbreaks and reiterates the overriding influence of climate that creates conditions conducive to large, high-severity fires in the subalpine zone of Colorado. Both bark beetle outbreaks and wildfires have increased autonomously due to recent climate variability, but this study does not support the expectation that post-beetle outbreak forests will alter fire severity, a result that has important implications for management and policy decisions."

Harris, N.L.; Hagen, S.C.; Saatchi, S.S.; Pearson, T.R.H.; Woodall, C.W.; Domke, G.M.; Braswell, B.H.; Walters, B.F.; Brown, S.; Salas, W.; Fore, A.; Yu, Y. 2016. Attribution of net carbon change by disturbance type across forest lands of the conterminous United States. Carbon Balance and Management. 11(1): 24. 21 p. http://dx.doi.org/10.1186/s13021-016-0066-5.

Carbon change in US forest lands was evaluated. For the western US, "C loss in the western US (44 ± 3 Tg C per year) was due predominantly to harvest (66%), fire (15%), and insect damage (13%)." Across the US, the various disturbances (harvest, fire, insect, wind and forest conversion) reduced the estimate of potential Carbon sink of the US forests by 42%."

Restaino, JC, Peterson, DL. 2013. Wildfire and fuel treatments effects on forest carbon dynamics in the western United States. Forest Ecology and Management 303:46-60.

Life cycle analyses of fuel reduction treatments including removal of woody biomass, combustion of fuel in logging machinery, transport, burning of slash, milling energy use, and other factors lead to the conclusion that over the long term, carbon losses from treatment projects may exceed those from wildfire because most of the carbon mass remains on site unburned during fire. The authors further note that, “Studies at large spatial and temporal scales suggest that there is a low likelihood of high-severity wildfire events interacting with treated forests, negating any expected C benefit from fuels reduction.”

Collins, B., C. Rhoades, R. Hubbard, M. Battaglia. 2011. Tree Regeneration and future stand development after bark beetle infestation and harvesting in Colorado lodgepole pine stands. Forest Ecology and Management 261: 2168-2175.

Advance regeneration in untreated beetle infected stands exceeded 1000 stems/ha on 76% of plots, “suggesting that in the absence of management intervention most future stands will be adequately stocked.” Only half the shrub, grass and forb cover was present in treated stands compared to untreated stands.

Dixon, G.E., 2002. Essential FVS: a user’s guide to the forest vegetation simulator. Internal Report, USDA Forest Service, Forest Management Service Center, Fort Collins, CO, p. 202. Available from: http://www.fs.fed.us/fmsc/ftp/fvs/docs/gtr/EssentialFVS.pdf.

Using the Forest Vegetation Simulator (FVS), the authors determined that total forest basal area would return to pre-outbreak levels 25 years sooner in untreated stands than in treated stands (80 vs 105 yrs). Based on the paper, it appears that leaving the stands untreated will result in greater and more rapid regeneration, greater herbaceous plant cover and more carbon storage than engaging in the proposed treatments following beetle infestations.

Rhodes, J.J.; Baker, W.L. 2008. Fire probability, fuel treatment effectiveness and ecological tradeoffs in western U.S. public forests. The Open Forest Science Journal 1: 1-7.

Analysis of fuel treatments and fire occurrence in the western US Forest Service managed lands determined that fuel treatments have a probability of 2.0 - 7.9% of encountering moderate or high-severity fire in a 20 year period of reduced fuels (estimated time frame for return of fuels to prior levels or the "window of effective fuel reduction").

Campbell, J.L., Harmon, M.E., and Mitchell, S.R. 2012. Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? Frontiers in Ecology and Environment 10(2):83-90. doi:10.1890/110057.

Both fuel treatments and wildfire remove Carbon from forests. A simulation showed that even in mature ponderosa pine forest, protecting one unit of Carbon from wildfire combustion came at a cost of removing three units of Carbon with treatments. "The reason for this is simple: the efficacy of fuel reduction treatments in reducing future wildfire emissions comes in large part by removing or combusting surface fuels ahead of time. Furthermore, because removing fine canopy fuels (ie leaves and twigs) practically necessitates removing the branches and boles to which they are attached, conventional fuel-reduction treatments usually remove more C from a forest stand than would a wildfire burning in an untreated stand." The analysis showed that thinning and other fuel treatments to reduce high-severity fire, although considered to keep Carbon sequestered, do not do so. High carbon losses came from treatments while only small losses were associated with high-severity fire and these were similar to the losses with low-severity fire that treatments are meant to encourage.

Meigs, G. W., J. L. Campbell, H. S. J. Zald, J. D. Bailey, D. C. Shaw, and R. E. Kennedy. 2015. Does wildfire likelihood increase following insect outbreaks in conifer forests? Ecosphere 6(7):118. http://dx.doi.org/10.1890/ES15-00037.1

Analysis of pine beetle and spruce beetle outbreaks and the likelihood of large scale wildfires in the Pacific Northwest forests east of the Cascade Range, these beetle outbreaks affected less than 2% of any ecoregion. In recent decades, wildfire likelihood did not "consistently increase or decrease following insect outbreaks." Following mountain pine beetle activity fire likelihood was not higher or lower than in non-affected forests. Following spruce beetles fire likelihood was lower. It is concluded that other factors such as climate control the large fire years. "Thus, although both bark beetles and defoliators alter fuels and associated fire potential, the windows of opportunity for increased or decreased fire likelihood are too narrow—or the phenomena themselves too rare—for a consistent signal to emerge across PNW conifer forests."

Odion DC, Hanson CT, Arsenault A, Baker WL, DellaSala DA, et al. (2014) Examining Historical and Current Mixed-Severity Fire Regimes in Ponderosa Pine and Mixed-Conifer Forests of Western North America. PLoS ONE 9(2): e87852. doi:10.1371/journal.pone.0087852

Analysis of fire severity patterns in western ponderosa pine and mixed conifer forests showed that " that the traditional reference conditions of low-severity fire regimes are inaccurate for most forests of western North America. Instead, most forests appear to have been characterized by mixed-severity fire that included ecologically significant amounts of weather-driven, high-severity fire."

"Biota in these forests are also dependent on the resources made available by higher-severity fire. Diverse forests in different stages of succession, with a high proportion in relatively young stages, occurred prior to fire exclusion. Over the past century, successional diversity created by fire decreased. Our findings suggest that ecological management goals that incorporate successional diversity created by fire may support characteristic biodiversity, whereas current attempts to ‘‘restore’’ forests to open, low-severity fire conditions may not align with historical reference Conditions in most ponderosa pine and mixed-conifer forests of western North America."

Six, D.L., Biber, E., Esposito, E.L. 2014. Management for mountain pine beetle outbreak suppression: does relevant science support current policy?. Forests 5(1):103-133. DOI: 10.3390/f5010103.

This review questions current policy and whether it is based in science. Lack of monitoring of post treatment effects leaves questions as to the efficacy of treatments. " While the use of timber harvests is generally accepted as an effective approach to controlling bark beetles during outbreaks, in reality there has been a dearth of monitoring to assess outcomes, and failures are often not reported. Additionally, few studies have focused on how these treatments affect forest structure and function over the long term, or our forests' ability to adapt to climate change. Despite this, there is a widespread belief in the policy arena that timber harvesting is an effective and necessary tool to address beetle infestations. That belief has led to numerous proposals for, and enactment of, significant changes in federal environmental laws to encourage more timber harvests for beetle control."

Beschta, R.L., Kauffman, J.B., Dobkin, D.S., and L.M. Ellsworth. 2014. Long-term livestock grazing alters aspen age structure in the northwestern Great Basin. Forest Ecology and Management. 329(30-36). **http://dx.doi.org/10.1016/j.foreco.2014.06.017**

Age structure of aspen was determined in Hart Mountain National Antelope Refuge to determine the relationship to the presence of livestock and climate. A significant decline in aspen recruitment occurred in the late 1800s that coincided with the onset of high levels of livestock grazing. Livestock grazing was terminated in 1990 and aspen recruitment increased "by more than an order of magnitude". Climate variables were not a significant factor. " Where long-term declines in aspen are currently underway on grazed lands in the western US, land managers need to carefully consider the potential effects of livestock and alter, as needed, management of these ungulates to ensure retention of aspen woodlands and their ecosystem services."

Simard, M., Romme,W.H., Griffin, J.M., and M.G. Turner. 2011. Do mountain pine beetle outbreaks change the probability of active crown fire in lodgepole pine forests? Ecological Monographs 81(1):3-24.

A study of fire behavior following outbreaks of mountain pine beetle in the Greater Yellowstone area found that dead surface fuels were not different among undisturbed, red and gray-aged stands. Red aged stands were defined as 1 - 2 years post outbreak. Gray aged stands were 3 - 5 years post outbreak. Canopy bulk density was 53% lower in red and gray vs. undisturbed stands while canopy fuel load was

42% lower and canopy moisture was 29% lower. Modeling results indicate that mountain pine beetle outbeaks may "reduce the probability of active crown fire in the short term by thinning lodgepole pine canopies".