

Under-Burning and Dwarf Mistletoe: Scorch 'N' Toe

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Abstract

Relatively little quantitative information has been available on the effects of low-intensity fire (under-burning) on dwarf mistletoe. Here we summarize results from six operational prescribed under-burns in second-growth ponderosa pine in New Mexico (Conklin and Geils, in press). For 1585 trees on 14 plots, crown scorch, bole char, and DMR were significant predictors of post-burn survival in both logistic (3-yr response) and proportional hazard models (over 6 to 10 yrs). Reduction in DMR on surviving trees (scorch pruning) increased linearly with increasing scorch. Reduction in average DMR (sanitation) was observed on 12 plots, and increased with increasing average scorch and mean DMR before fire. A sanitation model estimates that an area with an initial DMR of 3.0 receiving 50% average scorch will have a reduction in mean DMR of 0.7. Longer-term monitoring indicates that burns generating 50% average scorch should provide about 10 years of control. Results indicate that under-burning can be a useful tool for management of dwarf mistletoe, given sufficient fire intensity.

Introduction

Increased understanding of natural fire regimes has led to interest in the use of low-intensity fire (under-burning) for management of dwarf mistletoes, especially in ponderosa pine forests of the interior West. However, relatively little quantitative information has been available on this topic. Early work by Koonce and Roth (1980) and Harrington and Hawksworth (1990) report a reducing effect of under-burning on dwarf mistletoes (*Arceuthobium*), but both are short-term studies involving relatively small samples. In this study, we continue work begun by Conklin and Armstrong (2001) for under-burning of ponderosa pine (*Pinus ponderosa* var. *scopulorum*) infected by southwestern dwarf mistletoe (*A. vaginatum* sp. *cryptopodum*). We relate tree survival following six prescribed under-burns to the risk

factors of initial dwarf mistletoe severity, crown scorch, and bole char; we quantify reduction in mistletoe severity (scorch pruning) for surviving trees; and we assess potential reduction in average mistletoe severity (sanitation) across a range of burn intensities indicated by average crown scorch. In this paper, we summarize methods and results presented with greater detail in Conklin and Geils (in press) and expand further on implications for prescribed fire as a tool for managing dwarf mistletoe.

Field Methods

Study sites were mostly second-growth ponderosa pine (50 to 80 yrs old, with scattered older trees), typical of much of the accessible type in the Southwest. Prior to each fire, we installed rectangular plots in areas where a majority of trees were visibly-infected with dwarf mistletoe. Trees were rated for infection using the standard 6-class DMR system (Hawksworth 1977). Our sample included a total of 1585 ponderosa pine ≥ 4 inch dbh on 14 plots. The fires were operational Forest Service prescribed burns: four were about 200 ac and the others a few thousand acres in size. They were not “shaped” to kill or prune individual trees; the primary objective of each burn was fuels reduction. Most plots burned relatively uniformly and at intensities sufficient to generate some crown (needle) scorch on most trees. Post-burn DMRs were first taken 3 yrs after fire (by that time, scorched needles had fallen and branch mortality had stabilized). All DMRs, as well as crown scorch (percent of crown length affected, rated prior to flush of new growth) and bole char (relative severity class) ratings, were made by the first author (an attempt to maintain consistency in this long-term study). These burns were conducted between 1995 and 1999, and the sites have now been monitored for 8 to 12 years for subsequent mortality (dated to year of death) and changes in DMR.

Results And Discussion

Crown scorch increased with tree DMR on sites not recently thinned, but not on recently thinned sites. (On

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recently thinned sites, scorch was strongly influenced by thinning slash and most heavily-infected trees had been cut.) Harrington and Hawksworth (1990) had similarly reported a pattern of increasing scorch with increasing tree DMR. The most likely explanation for this pattern involves simple difference in crown geometry; differences in fuel loading may also contribute.

Tree survival

High survival (3 yrs post-burn) was observed for trees with <90% crown (needle) scorch; survival at 90% scorch averaged about 65% but was quite variable across sites; survival at 100% scorch ranged from about 10% to 30%. (Note that several trees in our 100% scorch class “torched,” so survival among those affected by convective heating alone was somewhat higher than indicated. Survival of 100%-scorched ponderosa pine has been reported in other studies, but has usually not been emphasized--and remains a surprising phenomenon to many). Only DMR 5 and 6 trees had decreased survival compared to uninfected trees. Bole char, although a more subjective measure than crown scorch or DMR, was clearly a strong and very useful predictor of mortality.

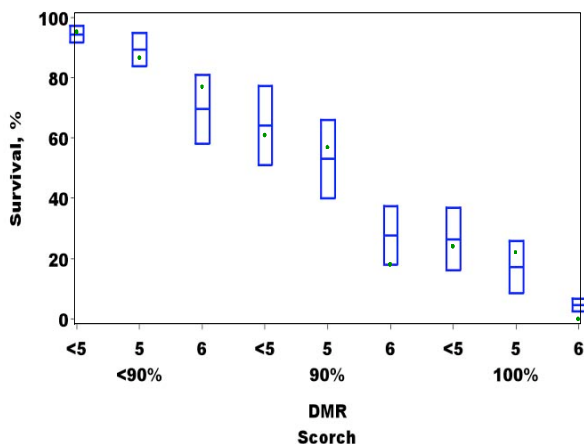


Figure 1—Tree survival 3 yrs post-burn by percent crown scorch and DMR (for average char rating); bars indicate expected tree survival ($\pm$ 95% CL); dot marks observed percent of trees surviving.

Survival 3 yrs post-burn was modeled as a function of scorch, bole char, and DMR (figure 1). The model adequately describes the data (area under the ROC, $c > 0.91$). Note that tree size (dbh) was correlated with other risk factors (especially crown scorch), and (for simplicity and because of its rather negligible added

value) not entered into the logistic model; however, each of these fires tended to provide a thinning-from-below. A proportional hazards model quantifies relative risks of mortality due to scorch, char, and mistletoe over a 6 to 10-yr post burn period (Conklin and Geils in press). A DMR 5 tree had about the same risk as one with 90% scorch, and a DMR 6 tree had about three times the risk of a DMR 5. A drought in 2002 and 2003 increased risk (hazard ratio = 6.2). Crown scorch was not a risk factor after 3 years, while bole char continued to be significant 4 to 6 years post-burn (but not after 6 years). Heavy mistletoe was a significant risk factor in both the initial 3-yr period and later. We observed signs of bark beetle activity on about two-thirds of dead trees, both in the initial 3-yr period and later. Although bark beetles clearly increased total mortality, their role as either causal or opportunistic mortality agent could not be determined for many trees.

Except for the influence of heavy mistletoe infection, our observed survival (3 yrs post-burn) was similar to that in many other reports on post-fire ponderosa pine. Like Harrington and Hawksworth (1990), we found that dwarf mistletoe infection reduces survival of scorched trees. Not only do heavily-infected trees tend to receive more crown scorch, but, at a given level of scorch, they are more likely to die than other trees (presumably because of additional stress from mistletoe). However, this latter effect (described by our logistic model) is considerably less than suggested by Harrington and Hawksworth. More specifically, we found that this effect was significant only among DMR 5 and 6 trees (they assumed an increasing effect throughout DMR classes). In addition, our moderately-scorched DMR 5 and 6 trees had considerably higher survival rates than they reported. Their results (which they rightly described as “preliminary”) were based on a single plot with 191 trees and determined only 1 yr post-burn.

Scorch pruning

Scorch pruning was assessed 3 yrs post burn, and based on surviving trees with an observed reduction in DMR (figure 2). The proportion of trees scorch-pruned increased with increasing scorch ($R^2 = 0.99$). At 30% scorch, about one-fifth were scorch pruned; this increased to about one-half at 60% scorch. Above

40% scorch, an increasing proportion of trees decreased more than one DMR class ($R^2 = 0.83$). Analyses of residuals demonstrate that these relations were largely independent of site, dbh, and initial DMR. Our estimate of scorch pruning is somewhat conservative because some “normal” intensification of mistletoe occurred between pre- and post-burn DMRs. Early reports (Koonce and Roth 1980; Harrington and Hawksworth 1990), due to their short-term nature, appear to have overestimated scorch pruning: we observed that usually about one-half the scorched portion of a ponderosa pine crown survives—along with any mistletoe present—due to bud survival.

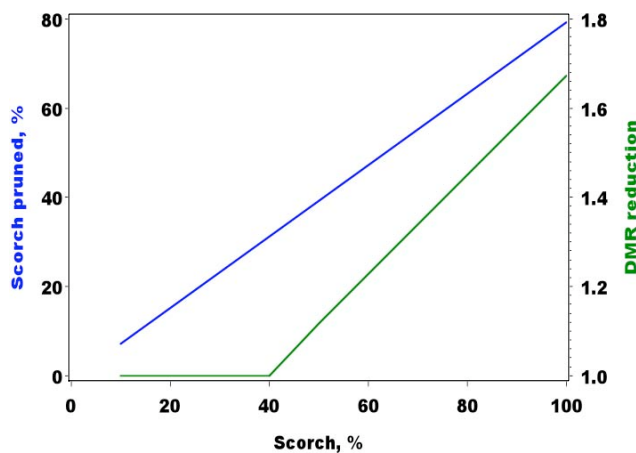


Figure 2—Proportion of initially infected, surviving trees with a reduction in DMR 3 yrs after fire (upper, blue line) and expected reduction in DMR of trees for which DMR decreased (lower, green line).

Conklin and Armstrong (2001) discuss an attempt to estimate reductions in mistletoe populations in scorched crowns—an initial estimate was later determined to be about 40% high! Note that virtually all reduction in tree DMR after fire resulted from “lifting” of the live crown (figure 3); heat (or smoke) alone appeared to have little effect on mistletoe shoots. In a broader sense, scorch pruning can be considered any fire-induced mortality of infected branches, regardless of effect on DMR. Some scorched trees whose crown geometry is not changed enough to reduce DMR will have delayed intensification; conversely, rebound (faster than normal intensification) will occur on some trees that show measurable reduction. On recently infected trees, scorch can eliminate latent infections (i.e., new infections without visible shoots), effectively preventing or delaying mistletoe development. Scorch

pruning will tend to improve host vigor, as well as reduce reproduction and spread of the parasite; however severely-scorched trees will experience growth loss, offsetting some of these gains. Long-term benefits/effects of scorch pruning will undoubtedly vary from tree to tree. Following an under-burn of sufficient intensity, it seems reasonable to expect that enough trees would benefit from scorch pruning to make a difference in the long-term development of the stand.



Figure 3—A portion of one study plot 6 yrs after fire. These trees each experienced 90 to 100% crown (needle) scorch. Three were lightly-infected before fire; two of them appear to have been completely sanitized.

Sanitation

Reduction in mean DMR (sanitation) was observed on 12 of 14 plots three years after fire. The two exceptions had < 10% average crown scorch. Reductions were a result of biased mortality (skewed toward heavily-infected trees) and scorch pruning; scorch pruning was the greater contributor on most plots. While reduction increased with increasing average crown scorch, its magnitude was also dependent on mistletoe severity (average DMR) before fire; at similar levels of scorch, plots with higher pre-burn DMR experienced greater reduction.

A sanitation model (figure 4), based on the combined tree-level logistic model for mortality and linear models for scorch pruning, determined expected plot-

level reductions that correlated well ($r = 0.95$) with observed reductions. Expected reductions were positive above DMR 1.0 and 25% average scorch and increased to 1.2 for an initial DMR of 4.5 and 85% average scorch.

The model estimates reduction of 0.7 with 50% average scorch and initial DMR of 3.0. Our sanitation model fit well with independent data from a prescribed fire in northern Arizona (observed reduction here 4 yrs post-burn was 0.5, equal to the model's expected reduction). Similar reductions in average DMR may be obtained in other ponderosa pine stands in the Southwest and Rocky Mountain regions after prescribed under-burning. The model should perform best for areas with relatively uniform fire intensity.

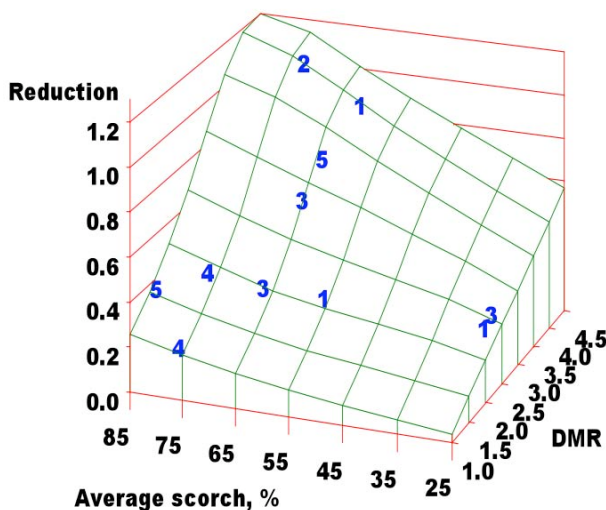


Figure 4—Expected reduction in average DMR (sanitation) for groups of trees 3 years after fire. Surface is smoothed estimate from combination of expected mortality (a logistic model) and expected scorch pruning. Labels indicate observed reduction, scorch, and DMR for 11 plots with adequate and even under-burning.

An alternative view of sanitation was developed for 3 sites with 10 years of observation (figure 5). Two of these fires (Road 145 and San Juan Mesa), each generating about 50% average scorch, provided about 10 years of control, i.e., 10 yrs of stand growth before average DMR returned to its pre-burn level. On the Blanco site, both the reduction in average DMR and the “years of control” may well approach the maximum sanitation possible without actively shaping

an under-burn to reduce mistletoe. Note that post-burn intensification of dwarf mistletoe was similar on each of these 3 sites, and similar to that observed on similar unburned plots in northern New Mexico.

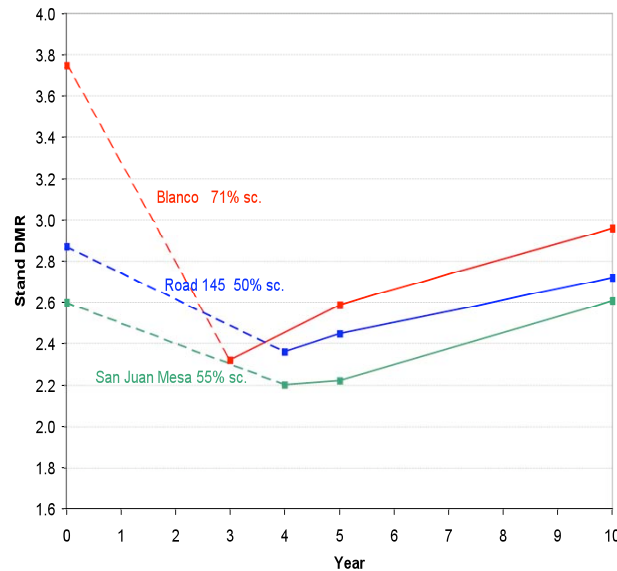


Figure 5—Observed change in average DMR for three under-burned sites monitored over a 10 yr period. Dashed lines represent observed reduction 3 yrs after fire (3 or 4 yrs after plot installation).

Additional Implications

The sanitation model provides expected reductions in average DMR within infested portions of stands. Because of spread from ballistic seed (with limited range), dwarf mistletoes usually have patchy distributions within stands and across larger landscapes. Study plots were intentionally located within mistletoe “infection centers” (rather than using a random or systematic design) to allow efficient sampling of infected trees. Although the model applies most directly at the patch scale, it should clearly have application at both the stand and landscape level.

The potential for sanitation in any given area necessarily depends on the proportion of the area infested—and the coverage and intensity of the fire. Most areas with “light” infestation include areas without mistletoe; clearly the potential for reduction (in absolute numerical terms) in these areas is less than in those with heavier, more extensive infestation. Also note that most infested stands, like our 14 plots, contain a broad range of dwarf mistletoe severity (DMR classes) on individual trees: the difference

between a “lightly-infested” and a “heavily-infested” stand is usually more a difference in size of the infection centers than in the proportion of lightly- and heavily-infested trees. (These spatial relations can be quantified with the alpha-statistic described by Robinson and Geils, 2006.) The potential for sanitation in recently thinned areas may be less than in others, since thinning itself often reduces average DMR. Nonetheless, under-burning in both lightly-infested and recently thinned areas can potentially set back mistletoe for several years.

We studied relatively young, relatively open stands because it is easier to quantify mistletoe infection and changes in DMR in these conditions than in older and/or denser stands. However, our data suggest that these results should apply in somewhat older and/or denser forest conditions. Each of these 6 burns was conducted during dormant seasons; higher mortality might be expected in summer burns. Because these fires were not intentionally shaped to discriminate against mistletoe, results should also generally apply to wildfires or Wildland Fire Use areas (or at least portions of these) that burn at relatively low intensity. Although its controlling effect is more modest than previously suggested, our results indicate that under-burning can be a viable tool for managing dwarf mistletoe, given sufficient fire intensity. Burns generating little or no crown scorch would have little or no effect on dwarf mistletoe. Furthermore, we suggest that burns of such low intensity will often

have relatively little effect on fuels, fire hazard, or other forest conditions.

Under-burning appears to be a good ecological approach for managing dwarf mistletoes on many ponderosa pine sites in the Southwest and Interior West. Periodic/repeat burning should provide additional mistletoe reduction, depending upon stand age and how much the crowns were lifted by the initial burn. Mistletoe control is usually not the primary objective of prescribed burning, but it is one of many potential benefits and should be an important consideration in the development of burning plans. There is general agreement that a century of fire suppression/exclusion has been favorable to dwarf mistletoes.



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