Operational Effectiveness of Maintaining Large, Old Trees in Prescribed Burns

by Robert Gray

Large diameter, old trees are often the focus in biodiversity management in both the United States and Canada (Forest Ecosystem Management Assessment Team 1993; British Columbia Ministry of Environment, Lands and Parks and Ministry of Forests 1995). Maintaining, or creating, these structures on the landscape can be found in land-use legislation in both countries. With very high biological and social values attached to them, it is important to find ways to ensure their survival within highly dynamic ecosystems. One such area of concern is the maintenance of large, old Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) and ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) in the dry forests of British Columbia, Canada. Within these forests and sparsely forested grasslands, scattered, large diameter, old trees serve as critical wildlife habitat to a wide range of species ranging from bats to woodpeckers (Bull et al. 1995; Bull et al. 1997; Bate et al. 1999). These trees also offer a host of important historic information including disturbance (fire and insects) and climate history. Protecting these structures from losses due to timber harvest has been the focus of attention for wildlife managers and environmentalists. Through their efforts many of these structures are now retained in static zones on the landscape, such as Wildlife Tree Patches or Old Growth Management Areas (British Columbia Ministry of Environment, Lands and Parks and Ministry of Forests 1999). The increased demand for active restoration of interior dry forests has focused the protection of these structures through the mechanical thinning phase of restoration. At the same time very little attention has been placed on potential losses due to fire damage during ecosystem restoration activities. This paper provides quantitative results of the effectiveness of several strategies for large tree retention through the prescribed burning phase of restoration operations.

Study and Methods

A primary goal in lower elevation, dry forests restoration is the creation of historic stand conditions through thinning and prescribed fire. Dry forest ecosystems in the Anderson Lake area of British Columbia historically supported densities ranging from 15 – 75 trees/ha. These densities were comprised of large diameter (40 – 100 cm DBH) old (Douglas-fir range from 160 – 600 years, while ponderosa pine range from 160 – 400 years) trees with clear boles and large, open crowns. Low- to moderate-intensity, frequent (mean fire interval = 5.9 years) surface fires maintained this overstory structure. The last recorded fire in the study area occurred in 1909 and resulted in the regeneration of a high-density (1200 – 5000 trees/ha) stand of mostly Douglas-fir (Gray 2001). This current stand structure is highly susceptible to crown fire, insects, and diseases. In 2000 the Squamish Forest District Small Business Forest Enterprise Program began a series of ecosystem restoration treatments aimed at reducing the density of the younger cohort while maintaining the old stand structure. Combinations of manual and mechanical thinning were used to thin the increased tree density while prescribed fire was used to reduce the large accumulation of surface fuels resulting from fire exclusion plus fuels produced from the thinning treatment. Through 3 such operations we have observed and quantified the effectiveness of retaining the large, old structures through the prescribed burning phase of the restoration operations. Key factors affecting the survival of these trees are: 1) the presence of fire-scar cavities on the lower bole; 2) the presence of other cavities and rotten limbs higher on the bole, especially on Douglas-fir; 3) heavy accumulations of duff and litter at the base of the tree, and; 4) the local population level of bark beetles. These threats can be divided into 3 categories: open wounds and cavities that when burned cause structural failures; fuel accumulations adjacent to the bole or roots that can lead to cambium or feeder root damage; and, secondary threats caused by the burn such as bark beetle attack.

Open wounds and cavities are often found in the form of fire scar cavities, cavities resulting from the loss of large limbs, excavations by woodpeckers, and large, broken limbs with rotten cores. Fire entering any one of these cavities or wounds often consume enough bole material to weaken the tree structurally. The result is a fallen tree burned out at the base (fig. 1) or a snag with part of the upper bole standing and part on the ground (fig. 2). Fuel accumulations at the base of trees, when smoldering, result in sustained high temperature beyond critical threshold levels for various living parts of the tree. Adjacent to the bole high heat for prolonged periods can cause cambium death for all or a part of the trees circumference. Adjacent to the feeder root zone, the damage is associated with dead roots. Bark beetles, specifically Douglas-fir beetle (*Dendroctonus pseudotsuga*) and red turpentine beetle (*D. valens*), are secondary disturbance agents often associated with burned sites (Furniss & Carolin 1992). An attack on trees within the burn unit does not have to be preceded by any damage to the tree.

Figure 1. A fire-scarred ponderosa pine following the burn-out of the catface. Long-burning fires burnout enough of the wood holding the tree up that it cannot structurally support itself.

Observations in the early part of the burn program led us to conclude that some mitigation of fuel conditions or structural weak points was necessary if we were to successfully carry out restoration treatments in the future and not lose large numbers of these biologically important structures. We also found that there was very little we could do to control insect populations post-burn.

Our efforts at mitigating fuel accumulations and structural weak points focused on fuel removal from the immediate vicinity of the tree bole and wrapping cavities with fire shelter material.

Results

Starting in 2001 we began experimenting with the use of fire shelter material to cover wounds and cavities on the lower bole of large, old trees. The majority of these cavities were fire scars. This initial unit contained a high surface fuel loading of slash remaining after the thinning operation.

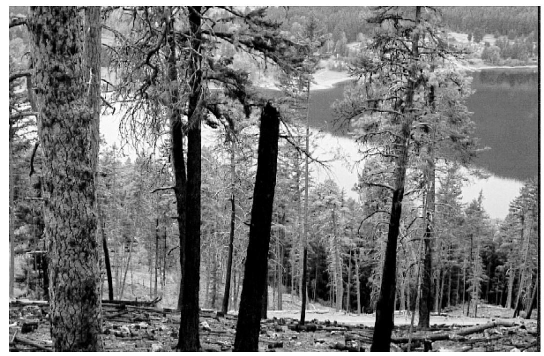

Figure 2. Old Douglas-fir killed when fire ran up the bole, entered the heartwood through a rotten limb, and broke-off. The standing bole's are typically very sound, providing good, solid, long-term snags.

A second unit was treated in the spring of 2002 with a random design of treated/untreated fire-scarred trees. Treatment included both fuel pullback and wrapping. This unit differed from the previous unit in its very low fuel loading; the surface fuel was mostly grass versus the slash fuel found in the thinned unit. In the first unit 123 trees were wrapped with fire shelter material purchased from Cleveland Laminating Corp. Of the 123 trees, 22 (18%) were Douglas-fir, and 101 (82%) were ponderosa pine. The shelter material was placed over the wound and stapled into place. The bottom of the material was anchored to the ground with rocks. Mortality post-burn was 30 trees (24% of the total); seven Douglas-fir (32% of fire-scarred trees) and 23 ponderosa pine (23% of fire-scarred trees). All seven Douglas-fir had burned through the wrap and then burned out at the base and fell over. Of the 23 pine that were killed, 13 (57%) had burned through the wrap and were hand felled because they were deemed a worker hazard, while 10 (43%) burned through the wrap, burned out the base, and fell over. In several cases the burn crew observed the fire burning through the wrap and igniting the wound. Efforts to intervene, however, were unsuccessful due to the long burn out time of fuels in the treatment unit. In an attempt to determine whether the wrap would be more effective in lighter fuels the experiment was repeated in the spring of 2002 on an 11 ha thin and burn restoration unit. In this unit the majority of Douglas-fir ingrowth trees were felled and scattered. A total of 18 trees were randomly located and wrapped in the unit; 14 were ponderosa pine and four were Douglas-fir. Surface fuels were also pulled back 1.0m from the bole of the tree. No wrapped trees were lost to the burn in this second experiment. Detailed results of both of these operational trials are reported in Gray & Blackwell [in press].

The most recent operational trial involved a thinned unit with post-thinning fuels similar in loading to the first unit we experimented with in 2001. This unit contained 397 old trees in a 38 ha unit. Douglas-fir comprised 73% of the trees (288) while ponderosa pine made up the remainder 27% (109). Out of 397 trees, 92 had fire scars (23%). Forty-one trees (45%) had fuels pulled back 0.5m, 45 trees (49%) had fuels pulled back 0.5m and were wrapped, and, 6 trees (6%) had no treatment. The reason for the low control population in this experiment was the fear of losing too many old trees if some kind of mitigation treatment wasn't attempted. The results, post-burn, are detailed in Table 1. The highest mortality rate occurred in the fuel pullback and wrap treatment population at 40%. The treatment fuel pullback, but no wrapping, had a significantly lower mortality rate of only 20%. Based on these results it would appear that fuel pullback is sufficient and the added expense of wrapping trees is actually detrimental.

Table 1. Treatment success rate for fire-scarred trees.

	Fuel pullback/ no wrap (%)	Fuel pullback/ wrapped (%)	No fuel pullback/ no wrap (%)
Live	33 (80)	27 (60)	5 (83)
Dead	8 (20)	18 (40)	1 (17)

The breakdown by species (fig. 3 & 4) suggests that Douglas-fir is the more sensitive of the two species to the success of the treatment. Regardless of whether the treatment included both fuel pullback and wrapping, significantly more Douglas-fir were lost than ponderosa pine.

Table 2. Survival rates by species and treatment type for fire-scarred trees.

	Fuel pullback/ no wrap (%)	Fuel pullback/ wrapped (%)	No fuel pullback/ no wrap (%)
Live Fd	20 (74)	12 (43)	4 (80)
Dead Fd	7 (26)	16 (57)	1 (20)
Live Py	13 (93)	15 (88)	1 (100)
Dead Py	1 (7)	2 (12)	0 (0)

Statistics for survival/mortality of trees that did not contain fire scars was limited by the small number of trees killed. Out of 305 trees that did not have fire scars only 3 were killed (1%). In this case all were Douglas-fir and all were lost when fire ran up the bole and burned into the heartwood through a rotten limb. Each snapped-off at least 10m off the ground leaving a short, but hard snag and a large piece of surface CWD. None of the 3 trees killed had fuels pulled away from the bole.

Discussion

Through the 3 operational trials it has become evident that some form of fuel mitigation is required if these structures are going to survive the burning phase of restoration. In light fuels, a simple fuel pullback of at least 1.0m appears to be sufficient to prevent or slow the ignition of these trees. Even if a fire-scarred tree did ignite, with the rapid burn-out time of light fuels, crews could safely enter the burn unit and extinguish these trees before they are lost.

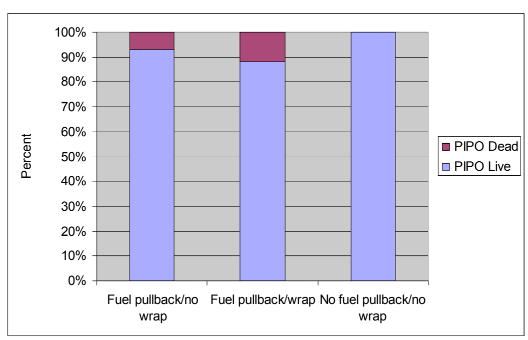

Figure 3. Percent survival rate for ponderosa pine by treatment type.

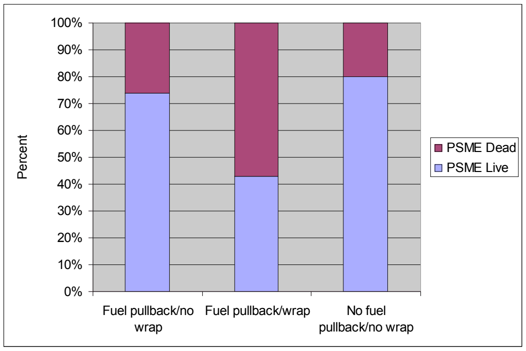

Figure 4. Percent survival rate for Douglas-fir by treatment type.

Heavier fuel loadings are more problematic because of the longer burn-out time, higher heat transfer, and higher potential to cause an ignition in or on these structures. Earlier study results appeared to support the time and expense of fuel pullback and wrapping as a successful treatment. The most recent trial suggests that fuel pullback alone is not only sufficient but significantly more successful in the end. Upon closer inspection it appears that the combination of fuel pullback and wrapping created a false sense of security for ignition crews who were less diligent igniting adjacent to wrapped trees than they were igniting adjacent to unwrapped trees. When encountering unwrapped trees, ignition crewmembers were more cautious; often puling additional fuels back and waiting longer for fuels to burnout before proceeding. This psychological response had an unexpectedly confounding effect on the outcome of this particular trial.

Even with this introduced bias certain trends are still apparent from this trial that provide useful direction for future operations. For example, Douglas-fir experienced significantly higher mortality than ponderosa pine regardless of the treatment. Old Douglas-fir have deep, fissured bark that has variable bulk density (porosity), and is often coated in resin. Lower bulk density conditions make ignition by an ember much easier. Ponderosa pine have deep, fissured bark as well, but have very high bulk density and rarely are coated in resin. The bark of Douglas-fir is much more flammable than ponderosa pine. Douglas-fir also holds the heat from smoldering bark adjacent to the bole where flaming or smoldering pine bark flakes off – removing the heat from adjacent to the cambium. Ponderosa pine is weakest at the fire-scar cavity or other cavity at the base of the tree. Because it's bark is less flammable fire is less likely to climb the bole and damage the tree by entering a rotten limb or cavity higher on the bole. Douglas-fir, however, is weak not only at the fire-scar, but at any point on the bole due to the flammability of the bark. Both trees are susceptible to post-fire insect attack regardless of whether they are fire-damaged or not.

Literature Cited

Bate, L.J., E.O. Garton, and M.J. Wisdom. 1999. Estimating snag and large tree densities and distributions on a landscape for wildlife management. U.S.D.A. Forest Service, General Technical Report PNW-GTR-425, Portland, Oregon.

British Columbia Ministry of Forests and Ministry of Environment, Lands and Parks. 1995. Biodiversity Guidebook, Victoria, B.C.

British Columbia Ministry of Forests and Ministry of Environment, Lands and Parks. 1999. Landscape Unit Planning Guide, Victoria, B.C.

Bull, E.L., T.R. Torgerson, A.K. Blumton, C.M. MacKenzie, and D.S. Wyland. 1995. Treatment of an old-growth stand and its effects on birds, ants, and large woody debris: a case study. U.S.D.A. Forest Service, General Technical Report PNW-GTR-353, Portland, Oregon.

Bull, E.L., C.G. Parks, and T.R. Torgerson. 1997. Trees and logs important to wildlife in the Interior Columbia River Basin. U.S.D.A. Forest Service, General Technical Report PNW-GTR-391, Portland, Oregon.

Furniss, R.L., and V.M. Carolin. 1992. Western forest insects. U.S.D.A. Forest Service Miscellaneous Publication No. 1339, Washington, D.C.

Gray, R.W. 2001. Historic vs. contemporary interior Douglas-fir structure and processes: managing risks in overly allocated ecosystems. *in*: Proceedings of the management of fire-maintained ecosystems workshop. May 23-24, 2000. Whistler, British Columbia. Forestry Continuing Studies Network and B.C. Ministry of Forests, Squamish Forest District, Squamish, B.C.

Gray, R.W., and B.A. Blackwell. [in press]. The maintenance of key biodiversity attributes through ecosystem restoration operations. U.S.D.A. Forest Service, General Technical Report PSW-GTR-xxx, Riverside, California.