Artificial Inoculation of Decay Fungi into Douglas-Fir with Rifle or Shotgun to Produce Wildlife Trees in Western Oregon

Gregory M. Filip, *Department of Forest Science, 216 Richardson Hall, Corvallis, OR 97331-5752;* **Catherine G. Parks,** *USDA Forest Service, Pacific Northwest Research Station, 1401 Gekeler Lane, La Grande, OR 97850; and* **Fred A. Baker** *and* **Stephen E. Daniels,** *Department of Forest Resources, Utah State University, Logan, UT 84322-5215.*

ABSTRACT: *A total of 188 Douglas-fir trees were treated to determine whether fungal inoculation with rifle or shotgun promoted stem decay and subsequent use by cavity-nesting birds in the Coast Range in Oregon. Inoculated trees were either live or killed by topping. Topped trees were climbed and severed just below the lowest whorl of live branches. Fungal inoculum was delivered by either a 0.45–70 caliber rifle or a 12-gauge shotgun to tree trunks at a height of about 8 m aboveground. Inoculum of either* Phellinus pini *or* Fomitopsis cajanderi *was grown on small wooden dowels or sawdust and fitted into the rifle slug (dowels) or behind the shotgun slug (sawdust). Sterile dowels or sawdust were used as a control. After 5 years, all topped trees had died, and at least 50% had sap rot as indicated by the presence of conks of* Trichaptum abietinum. *Conks of* Crytoporus volvatus, Fomitopsis pinicola, *or* P. pini *were sometimes observed on topped (dead) trees. Almost half of the topped trees had evidence of wildlife activity including foraging holes, nest cavities, or bark removal. There was no difference in sap rot incidence or subsequent wildlife activity among three treatments (rifle, shotgun, or not shot) or among three inoculum types (*P. pini, F. cajanderi, *or sterile). None of the untopped (live) but artificially inoculated trees had conks or evidence of wildlife use. Of seven live and shot trees that were destructively sampled, there was an average of 68.7 cm^2 of decay area on each wood disc that was associated with each bullet. There was no apparent difference in internal decay area between sterile and viable inoculum, but sample size was small. It appears that tree killing by topping below the live crown is a faster method of creating wildlife habitat than ballistic inoculation of live Douglas-fir trees in the Oregon Coast Range. Topped and dead trees had more avian foraging holes, deep cavities, and bark removed than did live inoculated trees. Based on the seven live shot trees that we sampled for internal decay, it appears that shooting trees with a shotgun or rifle is effective in creating internal decay within 5 years, but it may take several more years to form a decay column large enough to be used by cavity-nesting birds. West. J. Appl. For. 19(3):211–215.*

Key Words: Cavity-nester habitat, *Trichaptum abietinum, Fomitopsis cajanderi*, tree topping, rifle and shotgun inoculation, internal decay.

Several investigators have reported the relationship between cavity-nest sites of birds and internal decay of trees (Shigo and Kilham 1968, Conner et al. 1976, McClelland 1977, Miller et al. 1979). Management of cavity-dependent wildlife is a major issue for State and National Forest system managers who find it difficult to maintain snags (dead standing trees) due to harvesting of snags for fiber and firewood, and the felling of snags for safety reasons. Private land owners often list snag creation and wildlife habitat enhancement as a prime objective for their forest management. Killing trees with herbicides to produce snags for cavity dwellers has been investigated (Conner et al. 1981, 1983a, b, McComb and Rumsey 1983, Bull and Partridge 1986, Brandeis et al. 2000). Observations from some of these studies suggest that trees injected with herbicide fell sooner than trees killed by natural causes, making them of

NOTE: Gregory Filip can be reached at (503) 808-2997; Fax: (503) 808-2469; gmfilip@fs.fed.us. We thank Ann Rogers and Ruthe Smith for help in field data collection and Kyle Woodard, Stig Fremstad, Wes Jones, and Arrin Oishi for tree felling and bucking.ñ

only short-term use for cavity nesters. Bull and Partridge (1986) and Brandeis et al. (2000) evaluated several methods of creating snags and report that removing tree tops and limbs insured tree death. Such trees were more frequently used by cavity nesters than the other trees. Lewis (1998) summarizes information about snag creation techniques currently employed in the western United States.

Although dead trees are the most common habitat for cavity dwellers, live trees may also accommodate them. It has been suggested by Affeltranger (1971) and Conner et al. (1983 a, b) that live trees might be made suitable for cavity excavation at younger ages than normally expected by artificial inoculation with stem decay fungi. Conner et al. (1983a, b) report an 80% success rate for inoculation of *Spongipellis pachyodon* and *Laetiporus sulfureus* into living oaks (*Quercus* spp.) Parks et al. (1995) report that after 5 years, 50% of artificially inoculated western larch (*Larix occidentalis*) trees in one stand were being used by cavity nesters in northeastern Oregon. Trees were climbed and inoculated at least 8 m aboveground to reduce predation from ground-dwelling predators. Successful inoculation of living trees produces a wildlife tree less likely to fall within a short time or to be harvested. Also, live trees continue to form a sound rind of wood around the decayed area as the decay is compartmentalized within the tree (Shigo and Kilham 1968).

Climbing trees with ladders or climbing equipment to inoculate them is time-consuming and dangerous. Baker et al. (1993, 1996) report a possible technique using rifles and shotguns to deliver inoculum of decay fungi to living trees. They shot freshly cut bolts of Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) with 0.45–70-caliber rifles containing bullets with stained woody inoculum and with 12-gauge shotguns containing stained sawdust infected with fungal mycelium. Fungi tested included *Phellinus pini* and *Fomitopsis cajanderi*, two common decay fungi found in living Douglas-fir in western Oregon. After shooting, bolts were returned to the lab, and fungi were cultured from the largest pieces of stained woody inoculum. Both species of fungi survived shooting into the trees, but success of inoculum shot into trees in producing decay that is excavated by cavity nesters needs to be tested.

Objectives of our study were to evaluate the effectiveness of inoculating live or topped (killed) Douglas-fir trees with rifles and shotguns. Effectiveness was measured by the incidence of foraging and cavity formation by birds and by the presence of wood decay as indicated by fungal conks. Specifically, we examined effectiveness in: (1) live trees versus killed (topped) trees; (2) artificial inoculation (shot) versus natural inoculation (not shot or shot without inoculum); and (3) *P. pini* versus *F. cajanderi* inoculum. We tested the hypothesis that inoculation of trees with rifles and shotguns is effective in causing decay and subsequent use by cavity-nesting birds.

Methods

The study was conducted on the Oregon State University McDonald-Dunn Forest, specifically in the Lakeland and Dill Timber Sale Areas, located about 10 km north of Corvallis, OR (44°40′05.2″ N, 123°14′20.5″ E). The site is flat to rolling, at an elevation of 120–275 m, and with annual precipitation of about 100 cm, mostly as rain in the winter. Douglas-fir is the predominant tree species with lesser amounts of grand fir (*Abies grandis*), bigleaf maple (*Acer macrophyllum*), and Oregon white oak (*Quercus garryana*). Understory shrubs include an abundance of Himalaya blackberry (*Rubus procerus*) and poison oak (*Rhus diversiloba*). The site is typical of a relatively dry Douglas-fir forest on the eastside of the Coast Range just above the Willamette Valley floor.

A total of 188 Douglas-fir were selected for treatment. In Mar. 1997, each tree was marked with a numbered, aluminum tag at 1.4 m aboveground, and diameter (dbh to nearest cm) was recorded at the nail. Trees ranged from 23 to 105 cm in dbh. A total of 120 trees were topped by severing at a height of 18 m, just below the live crown to ensure tree death. For topping, trees were climbed using spurs and belts, and severed with a chainsaw just below the first whorl of live branches. Topped trees received one of the following treatments: (1) shot with a 0.45–70 rifle; (2) shot with a 12-gauge shotgun, or (3) untreated (not shot) trees. Another 68 trees were not topped (living) and were inoculated by either shotgun or rifle (34 trees each). Table 1 provides a summary of the treatments.

On Mar. 21 and 22, 1997, each of 136 trees was shot two or three times at about 3–5 cm between hits and at a height of about 8 m aboveground. Two shooters were used, and they attempted to stay within sight of each other. Both shooters wore blaze-orange clothing and hearing protectors (Silencio RangeSafe Model RSX85). These allowed the shooter to hear normal conversation but blocked out the shooting noise.

Before assembling the ammunition for the 0.45–70-calibur rifle, we machined the bullets to hold wooden dowels colonized with one of two test fungi: *Phellinus pini* or *Fomitopsis cajanderi.* Inoculum was grown on hardwood dowels for 12 weeks for rifle inoculation. We used 400-grain 0.458-caliber flat-nose bullets (Speer) machined to create a cavity 0.76 cm in diameter and 1.0 cm deep. New brass cases were primed (CCI

Table 1. Summary of treatments to inoculate 188 Douglas-fir trees with decay fungi on the McDonald-Dunn Forest, western Oregon. Numbers in parentheses indicates the number of trees originally treated.

Tree condition	Inoculum delivery	Inoculum type
Living trees (68)	Rifle (34)	*P. pini* (11)
		F. cajanderi (11)
		Sterile (12)
	Shotgun (34)	*P. pini* (11)
		F. cajanderi (11)
		Sterile (12)
Topped (killed) trees (120)	Rifle (34)	*P. pini* (11)
		F. cajanderi (11)
		Sterile (12)
	Shotgun (34)	*P. pini* (11)
		F. cajanderi (11)
		Sterile (12)
	Not shot (52)	None (52)

Table 2. Number (percentage) of Douglas-fir trees with fungal conks, foraging holes, cavities, and bark removed for trees inoculated with two species of decay fungi by rifle, shotgun, or not shot after 5 years in western Oregon.

Treatment/inoculum	Total trees (no.)	No. (%) of trees with							
		Conks by species				Foraging holes			Bark removed
		Trichaptum abietinus	*Cryptoporus volvatus*	*Fomitopsis pinicola*	*Phellinus pini*	≤5 cm	5–10 cm	Cavities	
Topped trees (killed)									
Rifle									
P. pini	9	5 (56)	1 (11)	0 (0)	1 (11)	5 (56)	1 (11)	3 (33)	1 (11)
F. cajanderi	9	3 (33)	0 (0)	1 (11)	1 (11)	3 (33)	3 (33)	5 (56)	1 (11)
Sterile	7	3 (43)	0 (0)	0 (0)	0 (0)	3 (33)	1 (11)	2 (29)	0 (0)
Tot. or ave.	25	11 (44)	1 (4)	1 (4)	2 (8)	11 (44)	5 (20)	10 (40)	2 (8)
Shotgun									
P. pini	11	8 (73)	0 (0)	0 (0)	0 (0)	5 (45)	1 (9)	4 (36)	2 (18)
F. cajanderi	10	5 (50)	1 (10)	1 (10)	1 (10)	4 (40)	1 (10)	3 (30)	1 (10)
Sterile	6	3 (50)	0 (0)	0 (0)	1 (17)	2 (33)	1 (17)	1 (17)	1 (17)
Tot. or ave.	27	16 (59)	1 (4)	1 (4)	2 (7)	11 (41)	3 (11)	8 (30)	4 (15)
Not shot	49	23 (47)	3 (6)	3 (6)	6 (6)	17 (35)	13 (27)	14 (29)	8 (16)
Tot. or ave.	103	50 (49)	5 (5)	5 (5)	10 (10)	39 (38)	21 (20)	32 (31)	14 (14)
Not topped (live)									
Rifle	29	0	0	0	1	0	0	0	0
Shotgun	26	0	0	0	2	2	1	0	0
Tot. or ave.	53	0	0	0	3	2	1	0	0

200 primers), filled with 45 grains of DuPont IMR 4320 powder, and the machine bullets were seated. This load has been proven safe in our firearms, but it may not be safe in others. Within 48 hours of shooting, a fungal-colonized dowel was placed in the bullet cavity, and the opening was sealed with silicone. For controls (no wooden dowel), we used Remington factory-loaded ammunition with 400-grain bullets. We used a custom bolt-action 0.45–70-calibur rifle with a 6× scope, or a Marlin 1895SS lever-action rifle with a 1.75–5× scope to inoculate trees.

For the shotgun inoculation, Federal Gold Medal hulls were primed with W-209 primers and were filled with 31 grains of DuPont 800X powder. A BPGS gas seal was seated, followed by three 0.95-cm (3/8 in.)-thick Butler fiber wads. Conifer sawdust was inoculated with one of the two test fungi and incubated for 12 weeks. Colonized sawdust was packed into the hollow base of a 475-grain lead slug, cast with a Lyman 2654012 slug mold, and sealed in place with silicone seal applied to a 0.127-cm (0.05-in.) card wad. This load has been proven safe in our shotguns but may not be safe in others. Within 72 hours of shooting, slugs were inserted into the prepared case and roll crimped to secure the load. Uncolonized controls used the same load without the sawdust.

Five years after treatment from Apr. to Oct. 2002, all sample trees were examined and the following data recorded for each tree: (1) tag number; (2) dbh; (3) condition (live, dead, topkill, or broken top); (4) approximate number and species of fungal conks on the tree bole; (5) number of foraging holes <5 cm in diameter and 5–10 cm diameter; (6) number of cavities >15 cm deep; and (7) bark removed >100 cm^2 in area.

Seven trees were destructively sampled in Aug. 2002 by felling each tree and dissecting a 0.3-m-long bolt where the slugs/bullets entered the tree trunk (about 8 m aboveground and usually indicated by resin flow or visible wound). Bolts were further cut into 5-cm-thick disks to locate at least one of the slugs/bullets and determine presence of wood decay near the slug. The following information was collected for each stem disk: (1) tree number; (2) disk diameter inside bark (nearest cm); (3) tree age at the disk; (4) stain/decay area (length × width [nearest cm] × 0.75); and (5) distance (nearest cm) from disk edge to bullet.

Results and Conclusions

Only 156 of 188 trees were relocated 5 years after treatment. All 103 topped trees that were found were dead 5 years after treatment. Only one of 53 untopped and live trees was dead after 5 years. Half (50%) of the topped and killed trees had considerable sap rot as indicated by the presence of conks of *Trichaptum abietinum* (Table 2). Conks of *Cryptoporus volvatus, Fomotopsis pinicola*, or *Phellinus pini* were sometimes observed on topped trees. Brandeis et al. (2000) also found *T. abietinum* and *C. volvatus* to be the most common sap rot fungi on artificially made Douglas-fir snags on a western Oregon site only a few kilometers from our study site. The frequency of decay fungal species, as indicated by conks, did not differ among trees that were (1) shot with rifle or shotgun or were not shot, or (2) inoculated with *P. pini* or *F. cajanderi*, or were sterile. Almost half of the topped trees had some evidence of wildlife activity, including foraging holes, nest-cavities, or bark removed (Table 2). There were no differences in the incidence of wildlife activity among the treatments (rifle, shotgun, or not shot).

Only one of 53 live trees that was shot (sterile inoculum) had any conks, and these were of *P. pini*, which may have been present before treatment. Of the seven live and shot trees that were destructively sampled, stem disks cut at the bullet entry site averaged 52 years in age and 38.5 cm in diameter, and bullets penetrated a mean of 9.8 cm into the wood (Table 3). All seven shot trees had internal decay that

Table 3. Characteristics, decay area, and treatments for 5-cm-thick wood disks dissected at a height of about 8 m aboveground from seven Douglas-fir trees that were live (not topped) but shot with decay fungi 5 years previously.

Disk dia. (cm)	Disk age (yr)	Decay area (cm^2)	Distance (cm) from disk edge to bullet	Treatment/fungal inoculum
49.8	56	72.9	–	Rifle/sterile
32.5	64	58.1	–	Rifle/sterile
55.4	54	96.8	10.2	Rifle/*P. pini*
26.7	50	59.4	10.9	Shotgun/?
38.1	–	58.1	8.9	Rifle/sterile
30.5	34	48.4	8.9	Rifle/*F. cajanderi*
36.8	55	87.1	10.2	Rifle/sterile
Mean				
38.5	52.2	68.7	9.8	

Figure 1. Trunk wound (top of disk) at about 8 m aboveground caused by a fungal-inoculated rifle bullet (white spot below stain) and subsequent wood decay (stain) in a live Douglas-fir inoculated 5 years previously.

averaged 68.7 cm^2 in the area near the bullets (Figure 1). The species of fungi causing the decay were not determined. There were no apparent differences in the amount of decay between bullets with fungal inoculum and bullets with sterile inoculum, but our sample size was small (Table 3) None of the untopped (live) trees had wildlife activity, except for one tree with foraging holes <5 cm deep.

It appears that tree killing by topping below the live crown is a faster method of creating wildlife habitat (foraging and nesting) than ballistic inoculation of live Douglas-fir trees in the Oregon Coast Range. Topped and dead trees had more foraging holes, deep cavities, and bark removed than did live inoculated trees. Based on the seven shot trees that we sampled for internal decay, it appears that shooting trees with a shotgun or rifle is effective in creating internal decay within 5 years, but it may be take several more years to form a decay column large enough to be used by cavity-nesting birds. We will continue to monitor treated trees to see if wildlife activity increases with time. Whether artificial inoculation of live trees with decay fungi is needed to create internal decay is still a question, because it appears that trees shot with sterile inoculum had as much decay as trees shot with fungal inoculum, but our sample size was small (Table 3).

Certainly, in topped and dead trees, artificial inoculation with decay fungi by rifle or shotgun made no difference in the amount of sap rot or use by wildlife after 5 years. This may seem obvious because topped trees were inoculated with fungi that usually colonize and decay only living trees, and therefore sap rot in dead trees would only occur naturally by fungi other than *P. pini* or *F. cajanderi*. However, at the time it was not known how long it would take for the topped trees to die after inoculation by rifle or shotgun. Some of the dead trees may have internal decay caused by *P. pini* or *F. cajanderi* as a result of rifle or shotgun inoculation, but this was not determined.

The question of snag (dead tree) and live-tree longevity has not been answered as yet by our study. Perhaps inoculation and subsequent decay and nest development in live trees take longer than in dead trees, but live trees may provide suitable habitat longer than dead trees, a hypothesis that we will continue to test.

Literature Cited

AFFELTRANGER, C. 1971. The red heart disease of southern pines. P. 96–99 *in* Proc. of symposium of ecology and management of the red-cockaded woodpecker, Thompson, R.L. (ed.). US Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

BAKER, F.A., S.E. DANIELS, AND C.A. PARKS. 1993. Rifle and shotgun delivered inoculum for inoculating trees with wood decay fungi. P. 150–156 *in* Proc. 41st annual western international forest disease work conference, Allison, J.R. (compl.), USDA For. Serv., San Bernadino Nat. For., San Bernadino, CA.

BAKER, F.A., S.E. DANIELS, AND C.A. PARKS. 1996. Inoculating trees with wood decay fungi with rifle and shotgun. West. J. Appl. For. 11(1):13–15.

BRANDEIS, T.J., M. NEWTON, G.M. FILIP, AND E.C. COLE. 2000. Cavity-nester habitat development in artificially made Douglas-fir snags. J. Wildl. Manage. 66(3):625–633.

BULL, E.L., AND A.D. PARTRIDGE. 1986. Methods of killing trees for use by cavity nesters. Wildl. Soc. Bull. 14:142–146.

CONNER, R.N., O.K. MILLER JR., AND C.S. ADKISSON. 1976. Woodpecker dependence on trees infected by fungal heartrots. Wilson Bull. 88:575–581.

CONNER, R.N., J.G. DICKSON, AND B.A. LOCKE. 1981. Herbicide-killed trees infected by fungi: Potential cavity sites for woodpeckers. Wildl. Soc. Bull. 94:308–310.

CONNER, R.N., J.G. DICKSON, AND J.H. WILLIAMSON. 1983a. Potential woodpecker nest trees through artificial inoculation of heart rots. P. 68–72. *in* Proc. of the snag habitat management symposium, Davis, J.W., and R.A. Ockenfels (tech. coords.), USDA For. Serv. Gen. Tech. Rep. RM-99.

CONNER, R.N., J.C. KROLL, AND D.L. KULHAVY. 1983b. The potential of girdled and 2,4-D-injected southern red oaks as woodpecker nesting and foraging sites. South. J. Appl. For. 7:125–128.

LEWIS, J.C. 1998. Creating snags and wildlife trees in commercial forest landscapes. West. J. Appl. For. 13(3):97–101.

McCLELLAND, B.R. 1977. Relationships between hole-nesting birds, forest snags, and decay in western larch-Douglas-fir forests of the Northern Rocky Mountains. Ph.D. dissertation, Univ. of Montana, Missoula, MT. 489 p.

McCOMB, W.C., AND R.L. RUMSEY. 1983. Characteristics and cavity-nesting bird use of pichloram-created snags in the Central Applachians. South. J. Appl. For. 7:34–37.

MILLER, E., A.D. PARTRIDGE, AND E.L. BULL. 1979. The relationship of primary cavity nesters and decay. P. 60–68. *in* Proc. 36th northeast fish and wildlife conf., Trans. Northeast Sect. Wildl. Soc.

PARKS, C.A., E.L. BULL, AND G.M. FILIP. 1996. Using artificially inoculated decay fungi to create wildlife habitat. P. 87–89 *in* Wildlife tree/stand development biodiversity workshop proceedings, Bradford, P., T. Manning, and B. l'Anson (eds.). BC Environment, Victoria, BC, Canada.

SHIGO, A.L., AND L. KILHAM. 1968. Sapsuckers and *Fomes ignarius* var. *populinus.* USDA For. Serv. Res. Note NE-84. 2 p.