1980. A variable circular-plot method for estimating bird numbers. Condor 82:309–313.
RISING, J. D. 1970. Morphological variation and evolution in some North American orioles. Syst. Zool. 19:315–351.
———. 1983. The Great Plains hybrid zones. Current Ornithol. 1:131–157.
ROBBINS, C. S. 1979. Effect of forest fragmentation on bird populations. Pages 198–212 *in* R. M. DeGraaf and K. E. Evans, tech. coords. Workshop proceedings: management of north central and northeastern forests for nongame birds. U.S. For. Serv., North Central For. and Range Exp. Stn. Gen. Tech. Rep. NC-51.
SAMSON, F. B., AND F. L. KNOPF. 1982. In search of a diversity ethic for wildlife management. Trans. North Am. Wildl. and Nat. Resour. Conf. 47:421–431.
SCHONEWALD-COX, C. M., S. M. CHAMBERS, B. MACBRYDE, AND L. THOMAS. 1983. Genetics and conservation. The Benjamin/Cummings Publ. Co., Inc., Menlo Park, Calif. 722pp.
SCOTT, J. 1985. Division of Wildlife begins planting cottonwoods and willows along rivers. Colo. Div. Wildl., Wildl. News 10(5):2–3.
SHORT, L. L., JR. 1965. Hybridization in the flickers (*Colaptes*) of North America. Bull. Am. Mus. Nat. Hist. 129:309–428.
SIMPSON, G. G. 1965. The geography of evolution. Chilton Books, Philadelphia, Pa. 249pp.
SIBLEY, C. G., AND L. L. SHORT, JR. 1959. Hybridization in the buntings (*Passerina*) of the Great Plains. Auk 76:443–463.
———, AND ———. 1964. Hybridization in the orioles of the Great Plains. Condor 66:130–150.
———, AND D. A. WEST. 1959. Hybridization in the rufous-sided towhees of the Great Plains. Auk 76: 326–338.
SOULE, M. E. 1985. What is conservation biology? BioScience 35:727–734.
———, AND B. A. WILCOX, editors. 1980. Conservation biology. Sinauer Assoc., Inc., Sunderland, Mass. 395pp.
STEVENS, L., B. T. BROWN, J. M. SIMPSON, AND R. R. JOHNSON. 1977. The importance of riparian habitat to migrating birds. Pages 156–164 *in* R. R. Johnson and D. A. Jones, Jr., eds. Importance, preservation and management of riparian habitat: a symposium. U.S. For. Serv., Rocky Mt. For. and Range Exp. Stn. Gen. Tech. Rep. RM-43.
SUTTON, G. M. 1967. Oklahoma birds. Univ. Oklahoma Press, Norman. 674pp.
THOMAS, J. W., C. MASER, AND J. E. RODIEK. 1979. Wildlife habitats in managed rangelands—the Great Basin of southeastern Oregon. Riparian zones. U.S. For. Serv., Pacific Northwest For. and Range Exp. Stn. Gen. Tech. Rep. PNW-80. 18pp.
WEST, D. A. 1962. Hybridization in grosbeaks (*Pheucticus*) of the Great Plains. Auk 79:399–424.
WHITTAKER, R. H. 1975. Communities and ecosystems. MacMillan Co., New York, N.Y. 385pp.
WILLIAMS, G. P. 1978*a*. Historical perspective of the Platte rivers in Nebraska and Colorado. Pages 11–41 *in* W. D. Graul and S. J. Bissell, tech. coords. Lowland river and stream habitat in Colorado: a symposium. Colo. Chap., The Wildl. Soc., and Colo. Audubon Council, Denver.
———. 1978*b*. The case of shrinking channels—the North Platte and Platte rivers in Nebraska. U.S. Geol. Surv. Circ. 781. 48pp.
WILLIAMS, O., AND G. P. WHEAT. 1971. Hybrid jays in Colorado. Wilson Bull. 83:343–346.

Received 16 July 1985.
Accepted 19 November 1985.

***Wildl. Soc. Bull.* 14:142–146, 1986**

METHODS OF KILLING TREES FOR USE BY CAVITY NESTERS

EVELYN L. BULL, ***U.S. Forest Service, Forestry and Range Sciences Laboratory, La Grande, OR 97850***

ARTHUR D. PARTRIDGE, ***University of Idaho, College of Forestry, Moscow, ID 83843***

The value of snags for cavity-nesting birds is well documented (Davis et al. 1983), and the removal of snags is detrimental to cavity nesters (Scott and Oldemeyer 1983, Frissell 1984). National Forest System managers find it difficult to maintain snags in some forests because of intensive timber management and harvesting of snags for firewood. Trees may have to be killed to provide the desired tree species and number of snags necessary for cavity nesters.

Killing trees to produce snags for cavity-

Table 1. Temporal trends in percentage of ponderosa pine dead and standing or dead and fallen as affected by treatment method, Wallowa-Whitman National Forest, Oregon.

	Years since treatment											
	0		1		2		3		4		5	
Treatment	Standing	Down	Standing	Down	Standing	Down	Standing	Down	Standing	Down	Standing	Down
Topping by chainsaw	100	0	100	0	100	0	100	0	100	0	100	0
Herbicide	82	0	98	0	98	0	95	3	86	12	75	25
Topping by dynamite	74	0	88	0	88	0	88	0	87	1		
Girdling	0	0	17	0	44	0	46	0	45	2	42	6
Fungal inoculation	1	0	16	0	41	0	42	1	41	2	41	5
Pheromone application	0	0	38	0	42	0	39	4				
Natural	100	0	96	4	79	21	78	22	63	37	44	56

nesting birds has only recently been investigated. Conner et al. (1981) discussed the potential of herbicide-killed trees for cavity excavation, and Conner et al. (1983*b*) compared girdling and injecting trees with 2,4-D as woodpecker habitat, though no woodpecker nests were found in either study. Cavities were found in trees injected with herbicides in later years (R. N. Conner, South. For. Exp. Stn., pers. commun.). Conner et al. (1983*a*) discussed the inoculation of hardwoods with heartrots to create suitable nest trees. McComb and Rumsey (1983) reported use by cavity-nesting birds of trees killed by picloram (a herbicide).

We evaluated 6 methods of creating snags and compared the use by cavity nesters of snags created by these methods with use of naturally occurring snags.

METHODS

This study was conducted on the Starkey Experimental Forest, Wallowa-Whitman National Forest, 30 km southwest of La Grande, Union County, Oregon. We selected ponderosa pine (*Pinus ponderosa*) for treatment because cavity nesters frequently use it in the study area (Bull 1980). One hundred trees each were treated with 1 of 6 procedures (600 trees total): girdling, topping with chainsaw, topping with dynamite and inoculating with fungi, girdling and inoculating with fungi, injecting with herbicide, and baiting with an insect pheromone. In each treatment 50 trees were >30 cm dbh (diameter at breast height) and 50 were 10–30 cm dbh. Each treatment included 4 plots with 25 trees each at different locations. Plots were <2 ha in size, similar in slope and stand condition (mature mixed conifer), adjacent to a forest opening, and ≥0.5 km apart.

Trees girdled with a chainsaw were cut twice with a continuous cut around the tree about 1 m above ground and 1–3 cm into the sapwood. Trees topped with a chainsaw were cut half way up the tree 3–20 m above ground and all limbs were removed to facilitate climbing with spurs. Trees topped with dynamite were cut half way up the tree (3–20 m above ground) and simultaneously inoculated with a fungus (*Dichomitus squalens*) (Bull et al. 1981). Limbs were not removed on trees climbed with ladders (23% of trees). Each girdled tree treated with fungi was inoculated with *Fomitopsis pinicola* and *D. squalens*. Patches of bark (60 cm^2) were removed on opposite sides of each tree, a hole was bored with an increment borer in each patch, an agar culture of 1 fungus was independently inserted in each hole, and the holes were plugged with the increment core (5 mm diam).

Trees treated with herbicide had monosodium methanearsonate (MSMA) injected into axe frills (1/2.5 cm dbh cut at a 45° angle) made through the bark with a hypohatchet. About 1 cc of MSMA/frill was applied 1.5 m above the ground.

The pheromone of western pine beetle (*Dendroctonous brevicomis*), which was present on the study area, was applied by attaching small vials containing a pheromone to the tree (Hall et al. 1982). The pheromone consisted of 1 part exo-brevicomin, 6 parts frontaline, 6 parts 3-carine, and 6 parts myrcene (G. Pitman, For. Res. Lab., pers. commun.). The pheromone was removed after 15 days. Beetles had been attracted and had attacked by that time. The pheromone was applied to trees in July 1981, trees were topped using dynamite in June 1980, and the other treatments were applied in February 1979.

We picked 100 trees that had died from mountain pine beetle (*D. ponderosa*) attack in 1979. There were 4 locations with 25 trees at each.

Each autumn we recorded the condition of all trees (live, dead, or down) and evidence of cavity nester use (nests and feeding). Nests were completed cavities, and feeding sites were holes in the bark or bark chipped

Table 2. Use of dead ponderosa pines as feeding strata by cavity nesters and cost of treatments, Wallowa-Whitman National Forest, Oregon.

Treatment	Percentage of trees with feeding activity[a]	Cost/tree ($)	Adjusted cost/tree[b] ($)
Topping by chainsaw	82	18.95	18.95
Topping by dynamite	61	30.00	34.19
Pheromone application	58	5.85	14.75
Girdling	53	3.15	8.12
Fungal inoculation	38	4.65	12.85
Natural	31		
Herbicide	13	4.35	4.81

[a] Evidence of feeding observed in ≤5 years.
[b] Calculated by dividing the total treatment cost for 100 trees by the average number of trees that were dead and standing each year.

off the tree. Usually snags were also visited in the spring to confirm species nesting in the trees; otherwise nest entrance diameter was used to determine the species.

Labor, equipment, and travel required for each treatment were recorded. An overall cost for each treatment was calculated using $10/hour for labor (except topping with the chainsaw, which was $200/day), 160 km for travel/day of work at $0.32/km, $200 for pheromone, and $50 for MSMA. An adjusted treatment cost was calculated by dividing the total cost of treating 100 trees by the average number of trees that died and remained standing each year. This figure gave a cost of providing dead trees in treatments where all trees did not die.

The number of dead trees after 3 years were compared among treatments with a 1-way analysis of variance and Tukey's procedure (Steel and Torrie 1960:99–110). Numbers of dead trees used and not used for foraging were compared with Chi-square analysis.

RESULTS

Mortality and Falling Rates

Mean total mortality after 3 years was higher ($P < 0.05$) for trees that were topped or treated with MSMA than for trees that were girdled, inoculated, or baited with pheromone. The latter 3 treatments killed less than half the trees treated (Table 1).

Herbicide-treated trees began falling within 3 years of application; 25% fell within 5 years. After 5 years, 13 and 11% of the dead trees that had been girdled and inoculated, respectively, had fallen. More than half the trees that had died naturally had fallen within 5 years (Table 1). In contrast, <1% of the topped trees fell during this time.

Wildlife Use

Many trees (89%) that died after treatment were attacked by bark beetles (*Ips* spp., *D. valens, D. brevicomis*) in early summer. Hairy (*Picoides villosus*) and black-backed (*P. articus*) woodpeckers were observed feeding on these insects in the first and second year. Numbers of dead trees used and not used for foraging differed ($P < 0.05$) among treatments. Trees that were topped were most frequently used for foraging; herbicide-treated trees were used least frequently (Table 2).

Nest holes were found in 11 dead trees. Eight trees topped with a saw contained nests, and 1 nest occurred in each of 3 other treatments (herbicide, topped with dynamite, and natural). The first nest was excavated after 2 years. Within 5 years, northern flickers (*Colaptes auratus*), Williamson's sapsuckers (*Sphyrapicus thyroideus*), hairy woodpeckers, red-breasted nuthatches (*Sitta canadensis*), and western bluebirds (*Sialia mexicana*) had nested in the trees. One of the topped trees contained 3 nest cavities, and Williamson's sapsuckers and red-breasted nuthatches nested simultaneously in the tree.

Cost

The cost/tree for each treatment ranged from $3.15 to $30.00 (Table 2). The adjusted cost shows that the less successful treatments were more costly/tree because some trees did not die.

DISCUSSION

Of the 6 treatments, the trees topped with a saw provided the best potential nest sites. These trees died immediately, had the lowest rate of falling, and were most frequently used by cavity nesters for foraging and nesting. Removing the limbs and tops insured the trees' deaths and reduced wind resistance. Bark beetles attacked the topped trees, and provided prey for foraging woodpeckers. The beetles apparently introduced decay organisms that deteriorated the wood (Berryman 1972) and enabled woodpeckers to excavate nest cavities. Topped trees best simulate natural nest sites of woodpeckers in the Pacific Northwest (Bull 1980).

All trees died that were topped with explosives and had limbs removed; however, 52% of the 23 trees that were topped with explosives only did not die. Removing limbs should kill all the trees and improve conditions for nest use.

Although herbicide killed the trees, the trees frequently fell and were seldom used for foraging or nesting.

Considering relative cost and effectiveness, girdling, fungal inoculation, and use of pheromones are not good management techniques for killing trees for cavity nesters. Less than half the trees died, the fall rate was higher than for topped trees, and cavity nesters did not nest in these trees.

To provide snags for cavity nesters in conifer forests of the intermontane West, we recommend ponderosa pines be topped 15–25 m above the ground. No cavity nesters require nest heights higher than this (Thomas et al. 1979). Topped trees should be ≥50 cm dbh so all cavity nesters, including pileated woodpeckers (*Dryocopus pileatus*), can use them. Large, dead trees stand longest and have the greatest amount of nest use (Thomas et al. 1979).

Because killing trees is costly (Table 2), it is wise to protect the snags from woodcutters by attaching twisted wire fence stays to the trunk at a cost of $3.50/snag for materials and labor (Styskel 1983). Keep and protect existing snags rather than kill trees to meet a specified snag level if possible.

Acknowledgments.—Funding was provided by the U.S. For. Serv., Pacific Northwest Res. Stn. We thank W. Williams and graduate students at the Univ. Idaho for field assistance. R. N. Conner and J. W. Thomas provided useful reviews of the manuscript.

LITERATURE CITED

BERRYMAN, A. A. 1972. Resistance of conifers to invasion by bark beetle-fungus associations. BioScience 22:598–602.

BULL, E. L. 1980. Resource partitioning among woodpeckers in northeastern Oregon. Ph.D. Thesis, Univ. Idaho, Moscow. 109pp.

———, A. D. PARTRIDGE, AND W. G. WILLIAMS. 1981. Creating snags with explosives. U.S. For. Serv., Pacific Northwest For. and Range Exp. Stn. Res. Note PNW-393. 4pp.

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.

———, ———, AND J. H. WILLIAMSON. 1983*a*. Potential woodpecker nest trees through artificial inoculation of heart rots. Pages 68–72 *in* Snag habitat management: proceedings of the symposium. U.S. For. Serv., Rocky Mt. For. and Range Exp. Stn. Gen. Tech. Rep. RM-99.

———, J. C. KROLL, AND D. L. KULHAVY. 1983*b*. 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.

DAVIS, J. W., G. A. GOODWIN, AND R. A. OCKENFELS, technical coordinators. 1983. Snag habitat management: proceedings of the symposium. U.S. For. Serv., Rocky Mt. For. and Range Exp. Stn. Gen. Tech. Rep. RM-99. 226pp.

FRISSELL, S. 1984. The impact of firewood cutting on hole nesting birds. West. Wildlands 4:28–30.

HALL, R. W., P. J. SHEA, AND M. I. HAVERTY. 1982. Effectiveness of carbaryl and chlorpyriphes for protecting ponderosa pine trees from attack by the western pine beetle. J. Econ. Entomol. 75:504–508.

MCCOMB, W. C., AND R. L. RUMSEY. 1983. Characteristics and cavity-nesting bird use of picloram-created snags in the central Appalachians. South. J. Appl. For. 7:34–37.

SCOTT, V. E., AND J. L. OLDEMEYER. 1983. Cavity-nesting bird requirements and responses to snag cutting in ponderosa pine. Pages 19–23 *in* J. W. Davis, G. A. Goodwin, and R. A. Ockenfels, tech. coords. Snag habitat management: proceedings of the symposium. U.S. For. Serv., Rocky Mt. For. and Range Exp. Stn. Gen. Tech. Rep. RM-99.

STEEL, R. G. D., AND J. H. TORRIE. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York, N.Y. 481pp.

STYSKEL, E. W. 1983. Problems in snag management implementation—a case study. Pages 24–27 *in* J. W. Davis, G. A. Goodwin, and R. A. Ockenfels, tech. coords. Snag habitat management: proceedings of the symposium. U.S. For. Ser., Rocky Mt. For. and Range Exp. Stn. Gen. Tech. Rep. RM-99.

THOMAS, J. W., R. G. ANDERSON, C. MASER, AND E. L. BULL. 1979. Snags. Pages 60–77 *in* J. W. Thomas, ed. Wildlife habitats in managed forests—the Blue Mountains of Oregon and Washington. U.S. Dep. Agric., Agric. Handb. 553. Washington, D.C.

Received 2 July 1985.
Accepted 8 October 1985.

***Wildl. Soc. Bull.* 14:146–150, 1986**

AVAILABILITY OF BOBWHITE FOODS AFTER BURNING OF PAN AMERICAN BALSAMSCALE[1]

BEN H. KOERTH, ***Department of Range Science, Texas A&M University, La Copita Research Area, Route 1, Box 203, Alice, TX 78332***

JAMES L. MUTZ, ***Department of Range Science, Texas A&M University, La Copita Research Area, Route 1, Box 203, Alice, TX 78332***

JAMES C. SEGERS, ***Department of Entomology, Texas A&M University, Texas Agricultural Research and Extension Center, Route 2, Box 589, Corpus Christi, TX 78410***

Pan American balsamscale (*Elyonurus tripsacoides*) is a warm-season, native, perennial grass that is locally abundant on sandy and sandy loam soils in south Texas (Gould and Box 1965). Balsamscale is of fair to poor forage value to cattle, primarily during early spring growth. Under use for several years causes a thick mulch layer to accumulate. This lowers herbaceous production and further decreases use by livestock. Prescribed burning improves the forage quality, production, and use of Pan American balsamscale by domestic livestock (Mutz et al. 1985).

Landowners in south Texas have expressed concern that large-scale burning of rangeland dominated by balsamscale might suppress northern bobwhites (*Colinus virginianus*), an important source of revenue through lease hunting. Therefore, we determined the effects of burning on the availability of insects and seeds eaten by bobwhite chicks.

[1] Approved by the Director, Texas Agricultural Experiment Station, as TA-20583.

STUDY AREA

The study was conducted near Hebbronville, Texas, in Jim Hogg County on the western edge of the Wild Horse Desert (Inglis 1964:91). The desert is a deep sand range site that occupies about 600,000 ha. The primary soil series are Nueces and Sarita with lesser amounts of the Delmita and Falfurrias series. These soils generally support a grassland dotted with mottes of brush composed of a honey mesquite (*Prosopis glandulosa*) overstory with a mixed-brush understory (Mutz 1980).

Average annual rainfall in Jim Hogg County is 52.8 cm (Pass and Harris 1979:328). Rainfall during the first year of this study was 61.9 cm with 75% occurring during February–May. Rainfall during the second year was 39.1 cm with 18% occurring during February–May.

METHODS

Burning of a 1,012-ha pasture was conducted by ranch personnel in late January 1982. No data on temperature, wind speed, or humidity were recorded at the time of the burn. The entire pasture was burned with the exception of brush mottes and a brushy drainage that did not have enough fine fuel to carry the