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## BAITING TO REDUCE LOSSES OF CONIFER SEEDS TO SMALL FOREST MAMMALS

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A caged deer mouse (*Peromyscus maniculatus*) can eat from 250 to 350 Douglas-fir seeds per day. At this rate, two deer mice per acre can consume 1 pound of Douglas-fir seeds or about 40,000 seeds in fewer than 80 days.

Deer mice may comprise 60 percent or more of small mammals on cut- or burned-over forest land in western Oregon. Trapping success in the Tillamook burn in 1953, 8 years after the fire, indicated a monthly population of 3.1 (1.4-5.4) deer mice per acre, with the highest densities occurring in late fall and early winter (1). Trapping on clearcuttings in both the Coast and Cascade Mountain Ranges for several years after logging indicated populations of from four to seven deer mice per acre. The remainder of the small-mammal community is composed mainly of shrews (*Sorex trowbridgii* and *S. vagrans*), and chipmunks (*Zapus trinotatus*). All of these small mammals will eat conifer seeds, but the heaviest consumers are deer mice, chipmunks, and creeping mice. Deer mice and other small seed-eating species are sufficiently numerous to nullify seeding efforts before germination begins in late March.

Early efforts in Oregon to reduce losses of conifer seeds and seedlings to small forest mammals were based on use of acute rodenticides such as strychnine, thallium sulfate, sodium fluoroacetate (1080), or zinc phosphide. These rodenticides were applied to a cereal grain, preferably wheat, and broadcast over the forest lands before seeding. Often a buffer strip (up to ¼ mile wide) was treated in conjunction with the area to be seeded. The initial reduction of small mammals was excellent but temporary, and densities of small-mammal populations recovered by immigration before germination of the conifer seeds.

### ENDRIN

Earlier rodenticides were replaced first with tetramine and later with endrin, both of which have the advantage of being applied directly to the conifer seed. Use of tetramine was discontinued because of hazards to human beings during manufacturing and handling. Endrin, however, has been used both as an effective insecticide and as a rodenticide. Endrin is a highly toxic chlorinated hydrocarbon that affects the central nervous system, therefore treated material should be handled with caution. The registered formulation is a 50 percent wettable endrin powder used at the rate of 1 pound to 100 pounds of seed, that is, a 0.5 percent concentration of endrin, based on weight of treated seed. It usually is mixed with an aluminum powder or a green dye that serves to identify treated seeds and to reduce seed consumption by birds. The coloring agents, especially the aluminum powder, are light and readily airborne during handling. Because endrin is absorbed readily through the skin as well as through the respiratory and gastrointestinal systems, personnel handling treated seeds should wear an approved respirator and rubber gloves.

In laboratory tests, deer mice were offered Douglas-fir seeds treated with concentrations of 0.5 and 2.0 percent endrin, with other food available. All treated seeds were eaten freely when first offered. At the lower concentration, 70 percent of the deer mice died within 5 days, but the remainder continued to eat sublethal amounts of seed. The 2.0 percent formulation, however, repelled mice that survived after eating treated seeds. Endrin was equally effective on chipmunks and the Oregon creeping vole.

The degree of success in reducing populations of seed-eating mammals with endrin-treated seeds is affected by weather conditions, available food, and cover. Small mammals are more likely to ingest a lethal amount of seed quickly on burned or other disturbed areas where most food and vegetation has been removed. Marked mice have been removed completely on clearcuttings and burns sown with endrin-treated seed from November to January.

## ANTICOAGULANTS

Many foresters prefer to reduce the number of seed-eating mammals by prebaiting before direct seeding. This method has led to a keen interest in finding anticoagulants to replace 1080. Anticoagulants cause internal hemorrhage and death by reducing or preventing blood clotting and by damaging capillaries.

Anticoagulant rodenticides, such as Warfarin, have been used successfully since 1948 to control commensal rodents such as rats and house mice. Warfarin is slow acting, however, and continued feeding for 7 to 14 days is necessary to produce sufficient internal bleeding to cause death. A disadvantage is that multiple feedings require the use of bait stations or bait boxes, which were economically impracticable in previous attempts to control small forest mammals.

A new anticoagulant, Rozol, was tested on caged mice at the Forest Research Laboratory. The active ingredient was chlorophacinone, available as a 2-percent concentrate.<sup>1</sup> Caged mice were offered oat-groat bait (dyed green), with  $\frac{1}{2}$  pound of concentrate to 99 $\frac{1}{2}$  pounds of bait, plus untreated pelleted food. An average consumption of 12 grams of treated oat groats during a 4-day period killed all deer mice and house mice tested. Animals were exposed to ambient outside temperatures in winter (freezing nights and cold days). The test animals ate all the bait offered (4.69 g per animal) the first day, but less on subsequent days. House mice stored some pellets, but no oats. Deer mice stored large amounts of treated oats and pellets. Control animals ate all of the untreated oats offered and survived.

Field tests (3) were conducted in northern California in 1967 with crimped oat groats containing 0.01 percent diphacinone broadcast by cyclone seeder at the rate of 2 pounds (908 g) of bait per acre. Post-treatment censusing indicated 100 percent reduction of pretreatment animals, although new untagged mice were caught 2 weeks after treatment. Similar results were obtained in 1970, and in 1971 the application rate was reduced to 1 pound of 0.01 percent chlorophacinone bait per acre with similar results (5, 6).

Chlorophacinone was compared with endrin in a direct-seeding operation in Oregon in November 1973 on two areas that had been clearcut in 1971. Slash had been burned on only one area. On the unburned area, chlorophacinone-treated wheat was applied at the rate of 2 pounds per acre, and a month later endrin-treated seed, at the registered formulation, was applied at the rate of  $\frac{3}{4}$  pound per acre. Only endrin-treated seed was sown, at the rate of  $\frac{3}{4}$  pound per acre, on the area that had been broadcast burned.

Pretreatment censuses indicated a density of 11.5 animals per acre, mostly deer mice, on both areas. Post-treatment results indicated a density of only 0.25 animal per acre on the area baited with both chlorophacinone and endrin, and 1.7 animals on the plot treated with endrin only. Five months after baiting the densities were similar on both areas, 1.5 and 1.7 animals per acre.

<sup>1</sup> The chemical formula for chlorophacinone is:  
2-[(*p*-chlorophenyl) phenylacetyl] -1,3 - indandione.

## DISCUSSION

Small forest mammals are a major hazard to direct seeding, and their seed consumption must be reduced to insure successful reforestation. They consume, damage, or cache large amounts of seed. We have found more than 250 Douglas-fir seeds germinating from caches attributed to chipmunks in western Oregon. Germinating clumps of more than 50 ponderosa seeds are common in the pine region of Oregon.

There are several disadvantages in relying on endrin alone as a seed protectant. Endrin may reduce the germination capabilities of Douglas-fir seed up to 20 percent (Unpublished data). Moreover, it is acceptable in sublethal doses by deer mice, so that there is a small but constant attrition of available seed.

The indandione anticoagulants, such as chlorophacinone or diphacinone, are faster acting rodenticides than is Warfarin and, therefore, make possible fewer feedings. They cause no discomfort that the animal can relate directly to the bait, and therefore lessen the possibility of bait shyness. Prebaiting with an anticoagulant will eliminate seed eaters successfully, so that seed losses caused by attrition are reduced. Howard and his co-workers (2, 4) noted that seed eaters have a sharp sense of smell that enables them to be efficient foragers for stored food. Anticoagulants are therefore not only initially successful, but may decrease the threat from invading animals and lessen caching of tree seeds.

Chlorophacinone is only slightly toxic to blackbirds, ducks, and ring-necked pheasants (U.S. Fish and Wildlife Service, Denver, Colorado. Unpublished data), and studies in France (G. Grolleau, Laboratoire despetis Vertébrés, Jouy-en-Josas) showed that it was not toxic to chickens or guinea fowl. In tests at Olympia, Washington, by the U.S. Fish and Wildlife Service (Unpublished data), units of 0.01 percent diphacinone killed deer mice, and the dead mice caused secondary poisoning when fed to weasels, saw-whet owls, and great-horned owls. Hazard of secondary poisoning is reduced in the wild, however, because affected animals become ill and seek the shelter of their burrow before death, thus reducing availability of the anticoagulant to predators.

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