stand is suppressed significantly (11). Campbell and Evans (1975 & 1978) estimate that up to 40 percent of the Douglas-fir in a plantation can be browsed without significant growth loss compared to plantations without damage.

*Budding*

Removal of buds and needles by grouse generally is classed as budding (34). Douglas-fir foliage is a preferred food of grouse, and budding is restricted mainly to the Douglas-fir region. Heavy and repeated defoliation has been reported on Douglas-fir plantations on Vancouver Island (22). In the CADS survey, budding by grouse (chiefly sooty grouse) ranked after browsing and clipping in order of occurrence on Douglas-fir plantations. This type of injury mainly occurred in southwestern Washington. No budding was recorded on pine plots (3).

*Barking*

There are two principal types of barking injuries–gnawing and stripping (34); gnawing is the more important type of barking injury to seedlings, saplings, and older trees. Bark stripping is caused mainly by black bears and wood rats, although tree squirrels (pine squirrel, red squirrel, and western gray squirrel) also may strip bark from the upper stem and branches of Douglas-fir and other conifers. In this region, damage by black bears occurs primarily in spring and summer, and is confined mainly to young-growth Douglas-fir. Basal barking may be complete (girdling) or partial. Girdling kills the trees, but partial barking causes reduced growth or increased chance of infection by decay fungi. Bear damage is a serious problem in some localities in western Washington (40) and Northwest Oregon. Dusky-footed wood rats also may cause severe barking damage to Douglas-fir reproduction. Bark stripping usually occurs on upper bole and branches, and causes top killing, if bark removal is extensive (28).

Gnawing injuries are caused by microtine rodents (voles), lagomorphs, pocket gophers, and porcupines. Barking injuries of this type are caused mostly by pocket gophers and porcupines and are most important in the pine region. Pocket gophers gnaw the bark, stems, and roots of seedlings and saplings. This feeding usually occurs under snow in winter. Lodgepole pines have been barked to a height of 5 feet by gophers under snow (36). Barking of seedlings and saplings in the pine region also is caused by porcupines, hares, and rabbits. Porcupines seem to prefer pole-size ponderosa pine, although girdling of seedlings, saplings, and mature trees frequently occurs (14). Barking results in girdling or scarring which often kills seedlings and saplings, or suppresses growth of saplings and older trees. Barking also deforms stems, increases exposure of the tree to infection by insects or disease, and kills tops of older trees. Porcupine damage is locally common in the Douglas-fir region (Evans and Matthews 1972); here, porcupines seem to prefer western hemlock over Douglas-fir (Evans 1977).

*Pulling, Trampling, and Rubbing*

Pulling and trampling injuries to small seedlings are caused almost exclusively by big game and livestock (12). Pulling usually occurs before the roots become established after planting. Ordinarily, these types of injuries are only a minor hazard to regeneration. Rubbing (mainly antler polishing) is caused by deer, elk, and livestock, and is probably unimportant, except for local damage to large seedlings planted at minimum density. Each of these types of injury accounted for less than one percent of damage occurrences on Douglas-fir plantations in the CADS survey (3).

## Summary

Animal damage to forest trees and their seeds is an increasingly serious problem in the Pacific Northwest. Seeds, seedlings, and older trees are exposed to various kinds of damage during stand development by many animals. Although deer browsing of seedlings and saplings is the most widespread and predominant type of animal damage in the region, other types of damage, such as clipping and barking by pocket gophers and mountain beavers are more important in the PNW. Evans (1976). Thus, estimates of damage emphasize the regional diversity in nature and relative importance of different types of animal damage, as seen by forest managers. Part of the difference in emphasis is caused by inclusion of all age classes from young reproduction to mature stands, and by changes in forest-management practices that tend to shift the spotlight from one group of animals to another, for example from seed eaters to pocket gophers.

There is a strong need for repeated and timely field observations, particularly of plantations, and for accurate identification of animal-damage problems before controls are applied. Campbell and Evans (1977). A forest manager must know not only the kinds of damage confronting him, but also be able to identify those needing control as well as those likely to respond to it.

Chemical-control methods are only one of several approaches to controlling animal damage. Direct reduction of populations with rodenticides should be applied only if other methods are not available, and only for purposes of regulation of population levels to control damage to trees (or tree seeds), not for the destruction of individual animals. What is sought when direct reduction of populations is required really should be *alleviation* of damage, including destruction of animals only when that is a necessary adjunct to alleviation of damage (30).

In most instances, therefore, an effective damage-control program calls for a combination of control methods integrated with forest-management practices that tend to modify habitat conditions so as to avoid or alleviate damage.

Growing ecological awareness and concern for the environment have precipitated critical review of pesticide regulations at national, state, and local levels. Many previously approved pesticides and control practices have been curtailed or banned, especially on federal lands. In a practical sense, we have come "full circle" and, with the exception of certain repellents, the forest industry now is limited largely to use of strychnine for control of some nonpredatory animals.

Pesticides reported and recommended in this paper were approved for use as of August 1984. But, because the registration of pesticides and their uses are under constant review by federal and state agencies, a responsible authority should be consulted as to the current status of a repellent or rodenticide before using it.

Some forest mammals causing damage (including hares and rabbits) may be classified as game animals, or as protected species. Permission must be obtained from state wildlife agencies before initiating direct programs of control to alleviate damage caused by these animals.

In conclusion, using rodenticides for control of forest mammals can present situations that are both ecologically sensitive and hazardous. As Canutt (9) observed, mistakes are costly in terms of loss of non-target species, and possible restrictions on future use of useful pesticides. He concluded that an analysis of past problems (of pesticide uses) invariably traces back to failure of the applicator to follow label instructions, to follow prescribed application techniques, or to use common sense. Canutt (9) considered these the most important aspects of any chemical-control program.

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# Appendix

## Life History Information Pertinent to Damage Control, and Control Procedures for Selected Species (modified from Canutt, 1972)

**Vhite-Footed Deer Mouse** *(Peromyscus maniculatus)*

.ife History Information

*'referred Habitat.* Nearly all habitat types on forest lands in the region are occupied by deer nice. Apparently the need for heavy cover is not as great as in the instance of meadow mice nd shrews. Large numbers of deer mice are often found on burned areas, even though ground over may be sparse.

*'eeding Habits.* Seeds, berries, and insects provide the major source of food. Coniferous seeds isually are readily accepted, especially seeds of Douglas-fir, western hemlock, and Sitka spruce.

*lctivity.* Deer mice are active throughout the year. They are primarily nocturnal. The average iome range is about 4 acres.

*Reproduction.* Litter sizes vary from three to seven, and an average of four litters is born each 'ear. The gestation period is from 22 to 25 days. Young mice may breed when 6 to 8 weeks ıld. The population peak is usually in November.

*'ontrol*

Jse of endrin as a conifer seed treatment is not permitted on lands of the U.S. Department of the nterior, and only after review and approval in the Pacific Northwest Region of the U.S. Forest Service.

)n private and state lands in Oregon and Washington, endrin can be used to protect tree seed in reas where deer mice are anticipated to be a problem. Endrin is federally registered as a conifer eed protectant at the rate of one-half percent active endrin and two percent active thiram. The ctive ingredients are bound to the seed coats with rhoplex or latex adhesive. Aluminum flakes have to e added to the formulation. Monastral green dye is included in the treatment to identify the seed and rovide bird repellency and must be used in Oregon.

:ndrin powder is a hazardous material to handle and for this reason it is recommended that eed treatment be contracted to competent commercial seed-treatment plants.

:ndrin-treated seed should not be applied in ecologically sensitive areas, such as, live stream ourses, ponds, lakes, intermittent streams used by anadromous fish, campgrounds, viewpoints, or ther areas in which people congregate. Distribution methods that prevent contamination of the bove areas should be followed. For example, rough terrain may make it impossible to protect a :ream when distributing seed from the air. In such instances, buffer strips should be left along :ream banks for hand application of treated seed.

**Porcupine** *(Erethizon dorsatum)*

*Life History Information*

*Preferred Habitat.* Pine forests where there are rock outcrops or old trees and logs suitable for dens are favored areas. Douglas-fir and hemlock forests on the western slopes of the Cascade Range also provide suitable habitats for porcupines.

*Feeding Habits.* Bark, buds, grasses, and forbs are taken seasonally. Bark feeding usually does not start until late summer after herbaceous vegetation becomes mature and dry. In the Douglas-fir region, bark feeding is most common during winter months.

*Activity.* Porcupines actively forage from dusk through early morning. In the pine region, daily travel is limited and animals often remain in one area for many days. In the Douglas-fir region, porcupines tend to be more nomadic. Seasonal movement often covers several miles and is probably related to changing food preferences.

*Reproduction.* A single young is born each year during May or June. Birth takes place after a gestation period of about 7 months. The minimum breeding age is 1 year.

*Control*

A combination of control techniques may be required to provide effective control.

Restrictions have been placed on the use of strychnine alkaloid for porcupine control on federal lands as a result of Executive Order No. 11643 and its subsequent interpretation by the U.S. Fish and Wildlife Service. Use of strychnine is not permitted, for example, where there is reasonable doubt as to the hazard of secondary poisoning.

*Baiting.* Strychnine-treated salt blocks may be used only in trees according to federal registration.

*Other Control Methods.* Porcupines also may be controlled by trapping or by shooting, especially with the aid of over-snow vehicles in winter. Tubes of plastic fabric or expanding aluminum can be used for protection of young seedlings in lieu of direct control.

**Pocket Gophers** (*Thomomys* sp.)

*Life History Information*

*Preferred Habitat.* Grasslands, meadows, clearcuttings, burns, and open conifer forests, with adequate soil depth for burrowing, are the most desirable sites. Gophers are found in a wide diversity of habitats throughout the region.

*Feeding Habits.* Bulbous roots of forbs and grasses are favorite foods. Aerial parts of grasses and forbs are taken to a lesser extent. The roots and upper parts of small woody species, such as young pine trees and other conifer species, also are eaten readily. Barking and clipping of shrubs and trees above ground occurs, especially under snow in winter.

*Activity.* Gophers spend most of their time below the ground surface. They do come above ground at night, during cloudy days, and when young are leaving the burrow system to establish new homes. When snow cover persists, burrow systems may be extended into the snow. Each adult has its own burrow system. Main tunnels are 2 to 3 inches in diameter, usually several hundred feet in length, and vary from a few inches to several feet below the surface. Feeding tunnels normally are 2 to 8 inches below the surface and are most extensive in areas where vegetation is sparse.

*Reproduction.* Most species in Oregon and Washington normally have only one litter each year. Breeding begins in early spring, and four to eight young are born after a gestation period of 18 to 19 days. The female rears the young, which become solitary as soon as they are weaned.

*Control*

Gophers may be controlled by habitat manipulation and by direct removal. However, use of rodenticides for control of pocket gophers is restricted and the effectiveness of habitat alteration has not been fully demonstrated.

Strychnine-treated grain is federally registered for use on all commercial forest lands for control of pocket gophers. Restrictions have been placed on its use on federal lands as a result of Executive Order No. 11643 and its subsequent interpretation by the U.S. Fish and Wildlife Service. Use of strychnine is not permitted, for example, where there is reasonable doubt as to the hazard of secondary poisoning. State and federal laws regulate its use on private and state lands in Oregon and Washington.

Habitat manipulation is a method in which the vegetation is managed to make living conditions less suitable for gophers. This is usually done by spraying an area with selective herbicides to reduce the availability of gopher foods. Much work still remains before this method can be recommended as a control measure.

Direct removal techniques include hand baiting, machine baiting, and trapping. Choice of method should be based on site characteristics, season, and available manpower. These are discussed under each method.

Gopher control by means of baiting is a difficult job that usually requires one or more annual follow-up treatments. The number of additional years of baiting and time intervals between baiting will vary from area to area. Initial control success, type of habitat, and potential for invasion from untreated areas will be factors controlling variability.

Control effectiveness can be checked readily by marking and opening holes in a number of burrow systems on the treated area. If the systems are still occupied, the opened holes usually will be closed within 48 hours. Mortality checks should not be made until bait has been exposed for about 2 weeks.

*Hand Baiting.* Any site regularly occupied by pocket gophers may be hand baited, but there are several conditions that influence control effectiveness. These conditions are as follows:

- Active mound building must be taking place to allow best selection of spots to bait. Fresh mounds can be identified by their unweathered appearance and loose structure. Recent mounds often will be darker than surrounding soil, because of their greater moisture content.

- Soil moisture should be sufficient to prevent burrow crumbling when probing or excavating tunnels for baiting. Moisture content becomes less critical in soils that are well-structured, fine-textured, or heavily sodded.

- Guidance of experienced baiters is necessary to insure correct bait placement.

The following diagrams illustrate the location of lateral and main runways in relation to earth mounds, mound plugs and main runway plugs. Knowledge of these burrow characteristics is necessary for efficient and accurate bait placement.

Main runways may be located and baited by probing or excavating with a heavy garden trowel.

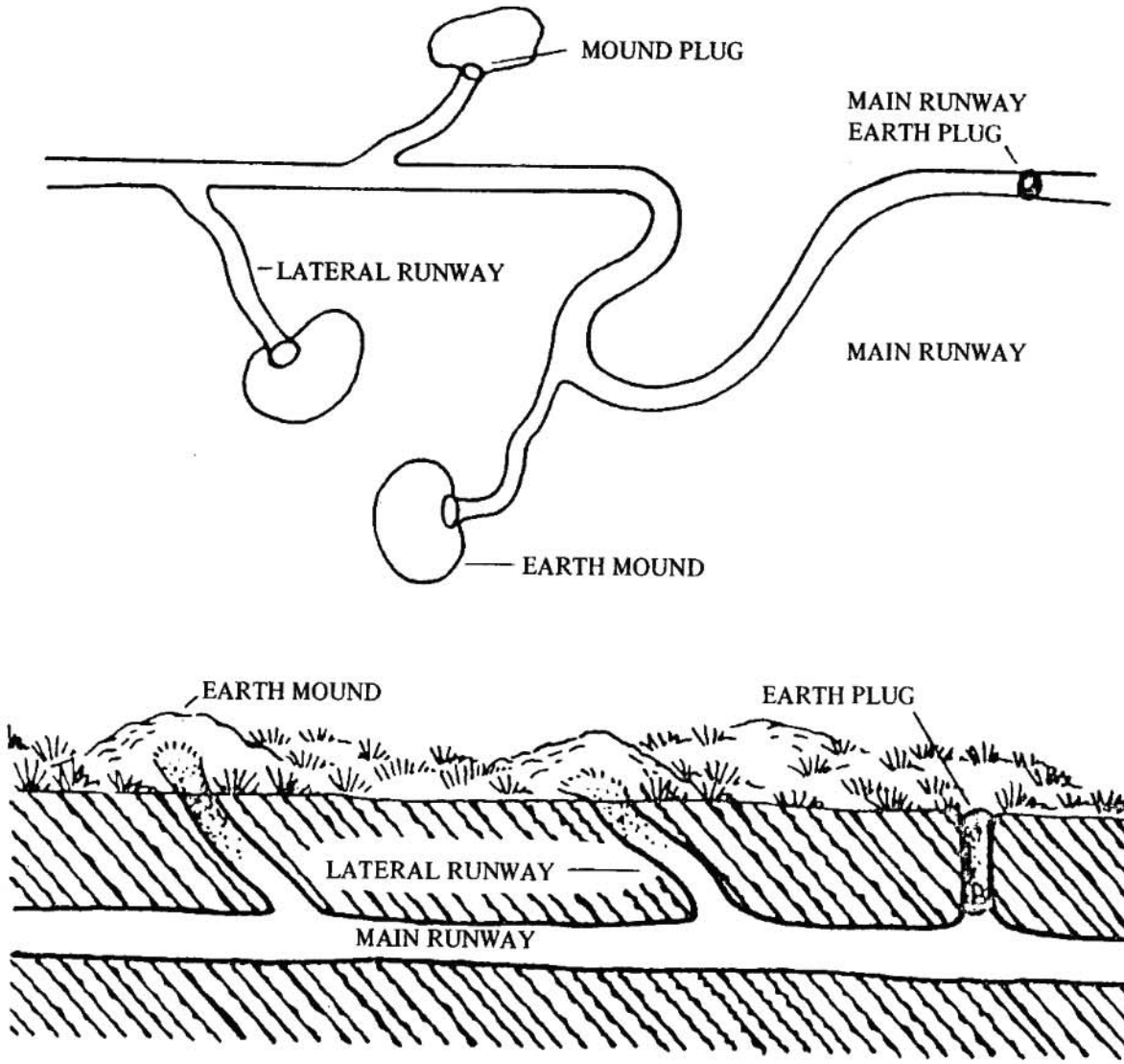


**Figure 43.** *Above,* **pocket gopher burrow showing characteristic location of lateral and main runway.** *Below,* **cross-section of burrow.**