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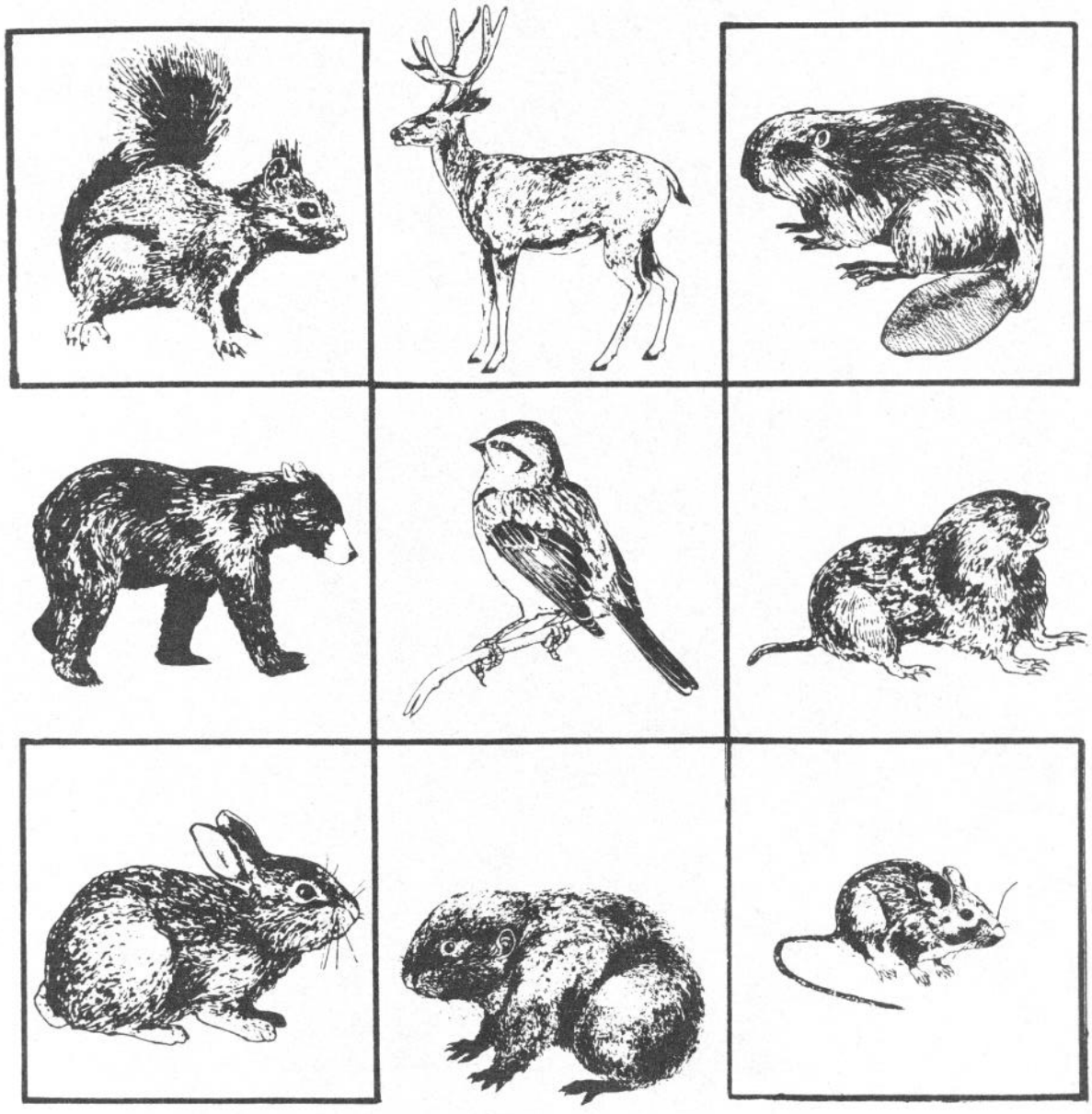
September 1994

Animal Damage Management Handbook



Pesticide Precautionary Statement

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key-out of reach of children and animals-and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary landfill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

Technical Editor

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Animal Damage Management Handbook

Hugh C. Black, Technical Editor

U.S. Department of Agriculture
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Abstract

Black, Hugh C., **tech. ed. 1994.** Animal damage management handbook. Gen. Tech. Rep. PNW-GTR-332. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 236 p.

This handbook treats animal damage mangement (ADM) in the West in relation to forest, range, and recreation resources; predator management is not addressed. It provides a comprehensive reference of safe, effective, and practical methods for managing animal damage on National Forest System lands. Supporting information is included in references after each chapter and in the appendices.

Keywords: Animal damage management, integrated forest protection, wildlife problem species, damage identification.

CAUTION

Before any control actions are undertaken, be sure to determine the effects they will have on Threatened, Endangered, and/or Sensitive species. For example. the use of poison baits for control of pocket gophers in occupied Grizzly Bear habitat is restricted under a Section 7 consultation with the U.S. Fish and Wildlife Service

Several genera listed in this handbook (Sorex, Eutamias, Thomomys, Microtus, Neotoma, and Sylvilagus bachmani) have species listed as federal candiates for review under the Endangered Species Act and may be considered a Sensitive species by the USDA Forest Service.

Foreword

This handbook is adapted from Forest Service Handbook (FSH) 2609.22, Animal Damage Control Handbook, Region 6 (Pacific Northwest Region), Amendment No. 6, September 1988. (FSH 2609.22 was published in 1966, and later revised and updated several times. It was revised and adapted for use in the Pacific Southwest and Pacific Northwest Regions in 1976 and for use in the Northern Region in 1988.)

This publication responds to the need for a comprehensive reference for safe, effective, and practical methods for managing animal damage on National Forest System lands in the West. Emphasis is placed on prevention of damage, preferably by indirect means, rather than on direct control of wildlife or livestock causing damage. Any technique described here, when adapted to fit local and regional situations, should help to improve animal damage management (ADM) on National Forest System lands and on other forest and range lands.

This handbook does not provide guidelines specific to a National Forest System Region or Forest and, thus, may lack the indepth treatment desired by some readers. It is hoped, however, that the user will find the tools necessary to form a good approach to specific animal damage problems.

These procedures are guidelines, not prescriptive directions. Successful ADM requires ingenuity and resourcefulness on the part of the biologist or other resource specialist, who must assess the need for ADM, use available resources, and adapt procedures appropriate to site-specific problems. These guidelines also are consistent with the Forest Service's emphasis on resource coordination; that is, the effort to have wildlife biologists work in close consultation with foresters and other resource specialists to develop approaches to ADM that will successfully limit animal damage and minimize adverse impacts on desired wildlife and their habitats.

Animal damage management is a dynamic process that is constantly being improved and expanded by new techniques and refinements of the old. For these reasons, we encourage users to keep up with the state of the art through the literature and by other means. We also encourage users to become involved, to share their ideas with others, as successful practices used in their area may be adapted and used elsewhere.

Robert D. Nelson
Director of Wildlife, Fish, and Rare Plants

Preface

This handbook focuses on animal damage management (ADM) in relation to forest, range, and recreation resources; predator management is not addressed. Methods for limiting animal damage to seedlings, saplings, and mature trees traditionally have emphasized direct control (baiting, trapping, snaring, and special hunts) of wildlife problem species and use of physical barriers (plastic-mesh tubing and fencing). But these practices are limited in effectiveness, costly, and becoming increasingly restricted by regulations and the public's concerns regarding their use. The potential impact of direct controls on threatened and endangered species and other nontarget species and on animal welfare is also of growing concern. In recent years, the value of indirect methods (based primarily on the modification of silvicultural practices) for avoiding or minimizing animal damage has become increasingly important. Integrating direct and indirect methods, in coordination with silvicultural systems, offers the best approach for managing animal damage. Because silvicultural and range management practices profoundly influence the susceptibility of developing stands to animal damage, an understanding of these practices is critical to sound, cost-effective ADM on forest and range lands.

Management of animal damage on National Forest System (NFS) lands is a significant issue for forest resource managers and may become more so in the future. Resource managers must assess the long-term effects of animal damage, the need for management, the degree of protection needed, if any, and the efficacy and risks associated with specific management practices. Greater emphasis on ecosystem management will require consideration of a broader range of biological and environmental factors in preparing an integrated program of ADM (see chapter 1). Animal damage management also is increasingly affected by the social, political, legal, and ethical environment in the United States (see chapter 1). Societal values must be incorporated in decisionmaking processes for ADM.

"New forestry," which involves new approaches to forest regeneration and stand and landscape management, including practices that increase habitat suitability for problem species and other wildlife, also will have a major impact on ADM. Populations of and damage by mountain beaver and pocket gophers, for example, may increase in shelterwood stands and other stands harvested under new forestry practices. Greater reliance on natural regeneration also may renew concerns over the impact of seed-eating mammals and birds. New forestry is likely to improve habitat conditions and

increase the potential for damage caused by most of the wildlife species treated in this handbook. New resource management objectives with greater emphasis on threatened, endangered, and sensitive species and noncommodity resources, however, may reduce the economic costs assigned to animal damage because of reduced or delayed timber yields.

Extensive references are given in each chapter of this handbook, especially in chapter 5, and provide suggested reading for each wildlife species covered. In addition to these sources of information, users should be alert to problem analyses of key species, such as "Porcupine Control: A Problem Analysis" (see chapter 5) and "Pocket Gophers and Reforestation in the Pacific Northwest: A Problem Analysis" (see chapter 5). Annotated bibliographies on wildlife problem species also are valuable sources of information on ADM. Teipner and others (see chapter 5) published a state-of-the-knowledge report on pocket gopher biology, ecology, damage, and control. The authors reviewed gopher species throughout the United States, and a bibliography containing more than 1,000 literature citations is included (see chapter 5). "Assessment and Management of Animal Damage in Pacific Northwest Forests: An Annotated Bibliography" (see chapter 1) is a comprehensive reference guide to published information on ADM in the Pacfic Northwest and other regions. It includes citations and abstracts from more than 900 papers and is indexed by subject and author.

Supporting information can be found in the references after each chapter and in the glossary of technical terms. In appendix 3 are reprints of four key papers on "Vexar' seedling protectors that estimate cost-effectiveness of animal damage control and give animal damage prediction models and an overview of ADM in the Pacific Northwest. The appendices also include a sample contract for building a deer fence and information on gopher-baiting probes and the forest-land burrow builder.

Possibly the most comprehensive reference on ADM is "Prevention and Control of Wildlife Damage" (see chapter 4). This valuable compendium provides indepth treatment on everything from "armadillos to woodpeckers" and "beavers to weasels." It contains detailed sections on supplies and materials and pesticides, including a listing of all pesticides registered for control of terrestrial vertebrate pests. In addition, it contains the following sections: "Identifying Wildlife Damage," "Procedures for Evaluating Predation on Livestock and Wildlife," and "Wildlife Diseases and Man." It should be on the bookshelf in all Districts and Forests.

Wildlife biologists, silviculturists, and pesticide-use specialists (District, Forest, Region) can provide technical assistance in ADM. Expert assistance is also available from the USDA Animal and Plant Health Inspection Service; see memorandum of understanding between APHIS-ADC and the USDA Forest Service in appendix 2). Extension wildlife specialists with the Cooperative Extension Service, U.S. Department of Agriculture, also can provide technical support in ADM. Biologists with the Fish and Wildlife Service, U.S. Department of the Interior, and those with state wildlife agencies also may be consulted regarding ADM, particularly if sensitive, threatened, or endangered species may be involved.

Although we may expect an increased tolerance of animal damage in the future, resource managers are responsible for using the best knowledge available to solve these problems.

Hugh C. Black
Technical Editor

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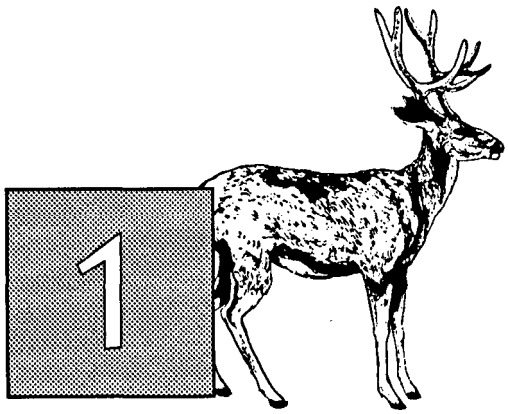


Chapter 1:

Animal Responses to Habitat Changes

Contents

Introduction

To maintain animal use of forest resources within acceptable levels, resource managers must have a basic understanding of the physiological requirements, general behavior, and responses of animals to habitat changes. (See McComb and Hansen [1992] for a comprehensive overview of forest wildlife ecology.) Responses of animals to specific habitat changes are not always well understood. Different animal species often respond differently to similar habitat treatment. Because the system is dynamic, animal damage management must be site specific. No single method of control is universal.

All animals need food, water, shelter, and space. Significant changes in the distribution, relative abundance, or type of food, water, and shelter can influence animal behavior and cause a change in population density or use of an area by a particular species. Some species will find an increase in the type of habitat they prefer and will benefit. Other species will find the habitat they prefer decreased and will be adversely affected. Changes in numbers and distribution of animals and intensities of plant use can be expected when land-management activities alter habitats.

Forest trees and their seeds constitute a portion of the natural diet of many forms of wildlife. For example, feeding on conifers by big game is directly related to animal preference for particular tree species and to the availability of other preferred foods at the time. Indirect control by means of habitat manipulation (based primarily on the modification of silvicultural practices) can be an effective way of limiting animal damage, particularly when combined with other means of animal damage management (ADM). By making the habitat less suitable for wildlife problem species, the impact on plantations and older stands often can be reduced or managed more easily by other means.

One of the best and most comprehensive sources of up-to-date information on the influence of silvicultural practices on animal damage is Black (1992). This book provides a state-of-the-art assessment of ADM as practiced in the forests of the Pacific Northwest. It is a compilation of published information and reports based on operational experience. The book's central focus is the potential of silvicultural practices to minimize animal damage, but it necessarily includes information on the use of chemical repellents, mechanical barriers, and direct control measures to minimize the impact of animal damage.

Work with a Forest silviculturist and other specialists to establish an integrated approach to (ADM) that is applicable to the specific site in question.

Silvicultural Practices

It is beyond the scope of this book to discuss silvicultural practices in detail, but a brief overview of basic silvicultural practices is provided.

Silvicultural systems are divided into two principal categories: even-age and uneven-age management.' Within each system are several regeneration methods. Even-age management includes clearcut, seedtree, and shelterwood regeneration methods. Uneven-age management uses single tree or group selection and coppice methods of regeneration.

'Definitions of terminology are given in the "Glossary" at the end of this book.

Clearcutting removes the canopy and the existing vegetation, thereby allowing succession to begin. Early successional plants occupy the site and change the habitat from one suitable for animal species associated with mature forest stands to one that species associated with new plantations will use. Variations in unit size and rotation length are the principal determinants of the type and extent of wildlife habitat produced. Rodents, hares, rabbits, and other herbivores attracted to the high-quality successional vegetation frequently damage young conifers.

In areas where pocket gophers occur, for example, use of the shelterwood regeneration method, in place of clearcutting, has created less favorable habitats for gophers and reduced damage to the developing stands (Emmingham and others 1992).2

Uneven-age management produces a smaller area of disturbance than even-age management. Forest stand structure remains relatively similar to the preharvest condition. Thus, mature forest wildlife species are favored and damage from such species as deer, elk, or gophers would be expected to be less prevalent.

Small group selection (l/4- to l/2-acre groups of trees) produces significant amounts of edge, which may promote increases in deer or elk populations. Shade-tolerant species, such as western hemlock and grand fir, are favored by group selection in the Douglas-fir region. Both tree species are less desirable forage to browsing animals than Douglas-fir.

Coppice silviculture is not common in the United States, but it may be used with sprouting hardwood species such as California black oak, tanoak, and madrone. This method could alleviate the need for planting (where management objectives favor maintenance of hardwoods) while producing wildlife forage. Because only a few sprouts per clump are needed for the future stand, browsing should not be a problem.

When animals search for food their movements are closely related to the availability and distribution of cover. Small forest openings are usually fully used by big game. Large openings receive their greatest use near the “edge.” Use of the inner portions of large openings differs with the amount of escape cover within the opening or that develops over time.

Big-game carrying capacity increases rapidly as the diversity and volume of low-growing vegetation increases after clearcutting or wildfire. This trend may continue for 10 to 20 years after logging, or until tree canopies close and begin to shade out the understory. Delays in reforestation may extend this period of high forage production. As tree canopies close, the amount, diversity, and nutritional quality of understory vegetation decrease and habitat quality declines (for early successional species). Changes in big-game habitat carrying capacity may be roughly proportional to the changes in habitat resulting from forest management.

Timber management often improves the quality of big-game habitat, particularly on winter ranges. As the quality of browse of the harvested area is reduced by successional trends, new areas can be harvested. To maintain productive big-game habitat, protection from animal damage may be necessary for newly planted young conifers.

‘Scientific names of all species are given in appendix 1

The type and quality of wildlife habitat created by timber management is determined mainly by the systems of timber harvest and fuel management that are used. Clearcutting, and to a lesser extent group-selection cutting, sets back plant succession and usually results in the temporary production of large quantities of forage. Shelterwood cutting produces similar but smaller increases in big-game carrying capacity than does clearcutting or group-selection cutting.

Fuel Management

Fuel management and planting-site-preparation practices can directly affect use by wildlife and livestock of treated areas.

Unburned Fuels

Rabbits, hares, and many species of rodents are secretive and depend on easily accessible cover for protection from predators. Entire home ranges may exist in small areas where food and cover are abundant. This is particularly true in areas with accumulated down and dead material. Under these conditions, population density often is limited only by the space requirements of individual animals.

Established populations of rabbits, hares, and rodents may expand, if favorable habitat is provided by unburned fuels. These animals will use any available food, including tree seeds and seedlings. Unburned fuels may provide some protection for young trees by restricting movement of big game and cattle and by reducing exposure of trees. Most of the low, herbaceous, and shrubby vegetation responds quickly to the increased light and moisture produced by canopy removal. This improved food source attracts big game and may, in turn, reduce browsing pressure on both natural regeneration and planted trees.

Burned Fuels

Broadcast burning of logging slash and other fuels creates changes in the availability of food and cover, which directly affect the composition, distribution, and abundance of small-mammal populations. Burning also may directly kill some small mammals. In the Douglas-fir region of Oregon, prescribed burning temporarily reduced populations of small mammals (Hooven and Black 1976) and, in Washington, populations of mountain beaver, particularly after an intense burn (Motobu 1978). Animals also may be affected by minor changes in the microclimate, such as soil-surface temperature, water penetration, and air movement. In Douglas-fir clearcuttings in Oregon, before and after logging, Gashwiler (1959) found that deer mice increase after fuel burning, but chipmunks, hares, and redbacked voles decrease.

Steen (1966) reports significant differences in the development of vegetation on burned sites compared with unburned sites near Oakridge, Oregon. Plant composition and the rates of development were affected. Predicting the magnitude of change in habitat after burning is difficult, however. Pengelly's (1961) study of broadcast burning in northern Idaho led him to conclude that ". ..fire is a rough and largely unpredictable tool due to the following variables: time and intensity of burn, homogeneity of burn, kind and availability of fuel and seed source, and growing conditions during the first season after the fire."

Hot burns tend to favor herbaceous plants and some shrubs, such as red-stem ceanothus in the Pacific Northwest. Cooler burns tend to favor shrubs present in the understory at the time of harvest. When increased light and nutrients are available, these shrubs undergo rapid growth.

Planting immediately after fuel removal has been one of the best ways of minimizing damage from rabbits, hares, and pocket gophers. Planting larger stock also has reduced rabbit and hare damage problems in many areas.

Fuel Piling

On many areas, especially those with flat or gentle slopes, fuel often is piled with bulldozers before burning. Treatment leaving **20** to 30 tons of fuel per acre generally is the recommendation in the Pacific Northwest. This favors regeneration of conifers and shrubs. Intensive treatments that pile (or remove) all the slash cause plant succession to revert to an early successional stage. In these stages, grasses and herbs usually predominate. Intensive site preparation seems to stimulate pocket gopher and vole activity.

Wildfire

Responses by animal populations to habitat changes after wildfire are similar to those after broadcast burning of slash. During the revegetation period, wildlife species diversity may be greatest in the successional stage with the greatest diversity of plants. The degree to which deer and elk and some other animals use a natural burn is influenced (among other factors) by the size and intensity of the burn, abundance of food, and the proximity of cover.

Animal Use

The basic principles that relate to animal-forage preference may be grouped into five categories. These are palatability; associated forage species; climate, soil, and topography; forage preference; and impacts of use (Heady 1964). Understanding the nature of these factors will help land managers recognize and possibly control some of the complex and interrelated influences governing animal use. A brief summary follows of important elements associated with each of these categories.

Palatability

Palatability has been defined as a plant characteristic stimulating a selective feeding response. Some factors found to affect palatability are chemical composition; portion of leaves, stems, and fruits eaten; plant-growth stage; past grazing use; climate; topography; soil moisture; and soil fertility. Other characteristics possibly related to palatability, such as texture, odor, and external plant form, have received little attention by biologists.

Associated Forage Species

Availability of choice affects preference. Some plant species growing in one community have been found to have different preference factors than the same species growing with other combinations of plants. Thus, certain plant species, such as conifers, may be used heavily when sparsely distributed through an area of preferred forage species.

Climate, Soil, and Topography

These factors have been mentioned as affecting palatability, but they probably have a more important effect by influencing animal behavior. Changes in temperature, rainfall, soil texture, steepness of slope, and moisture content of foliage often change animal preferences.

Forage Preference

Preferences differ among animal species for plants, parts of plants, or plants at certain growth stages. Animal preference has been related to individual animal conditions such as fatness, pregnancy, lactation, and hunger. Senses, such as sight, taste, smell, and touch, coupled with instinct and experience also influence preference. Preferences of individual animals also may differ season to season, day to day, or even within a day.

Impacts of Use

Heavy use of forest lands by browsing animals may increase damage to planted seedlings or natural tree regeneration. The interaction of animals with their habitat has been demonstrated in the Olympic National Forest in Washington where small study plots were fenced to exclude deer and elk. The exclusion of browsing animals allowed low shrubs to develop rapidly. This, in turn, provided excellent cover for rabbits and rodents. Under these conditions, destruction of Douglas-fir seedlings inside the big-game exclosure by rabbits, mice, and mountain beavers exceeded losses on the outside. Trees were 30 percent taller, on average, outside the exclosures where big-game browsing had reduced small-mammal cover and vegetative competition. Deer exclosures in the Allegheny National Forest in Pennsylvania also have demonstrated the deleterious effects of deer browsing on hardwood regeneration (Tilghman 1989). In other areas, damage to seedlings may not occur even though big game may browse native shrubs sufficiently to change shrub forms and sizes. This has been reported by the Umatilla National Forest in Oregon

Moore and Reid (1951) observed that pocket gophers adversely affect plant composition in several ways: favored foods are gradually removed and replaced by those of lower palatability, soil excavated from runways suppresses plants on which it is deposited, soil mounds are occupied quickly by annuals that usually are less desirable than the original perennial vegetation, and unused runways provide refuge for other herbivorous rodents such as deer mice and meadow mice. Gophers also prevent natural improvement of mountain meadows that are in poor condition, but do not limit improvement of meadows in fair or better condition.

Uncontrolled grazing by big game or livestock greatly influences soil compaction and range condition (Graham and others 1992). With time, plant communities may be completely altered. The more obvious effects are changes in plant composition, density, vigor, soil structure, and the rate of soil erosion. All wildlife species are responsive to both subtle and dramatic modifications of their habitat. Thus, the type of land use practiced influences their distribution, density, and diversity.

References

Asherin, D.A. 1976. Changes in elk use and available browse production on north Idaho winter ranges following prescribed burning. In: Proceedings, elk-logging-roads symposium; 1975 December 16-17; Moscow, ID. Moscow, ID: University of Idaho: 122-134.

Black, H., Jr.; Scherzinger, R.J.; Thomas, J.W. 1975. Relationships of Rocky Mountain elk and Rocky Mountain mule deer to timber management in the Blue Mountains of Oregon and Washington. In: Proceedings, elk-logging-roads symposium; 1975 December 16-17; Moscow, ID. Moscow, ID: University of Idaho: 11-31.

Black, H.C., ed. 1969. Proceedings, symposium on wildlife and reforestation in the Pacific Northwest; 1968 September 12-13; Corvallis, OR. Corvallis, OR: Oregon State University, School of Forestry. 92 p.

Black, H.C., ed. 1974. Proceedings, symposium on wildlife and forest management in the Pacific Northwest; 1973 September 11-12; Corvallis, OR. Corvallis, OR: Oregon State University, School of Forestry, 236 p.

Black, H.C., tech. ed. 1992. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. **422** p.

Emmingham, W.H.; Holthausen, R.; Vomocil, M. 1992. Silvicultural systems and stand management. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 123-142. Chapter 6.

Gashwiler, J.S. 1959. Small mammal study in west-central Oregon. Journal of Mammalogy. 40(1): 128-l38.

Graham, R.T.; Kingery, J.L.; Volland, L.A. 1992. Livestock and forest management interactions. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 351-364. Chapter 17.

Hagar, D.C. 1960. The interrelationships of logging, birds, and timber regeneration in the Douglas-fir region of northwestern California. Ecology. 41(1): 116-125.

Hanley, T.A.; Bunnell, F.L.; Starkey, E.E. 1984. Habitat relationships of Cervidae (deer) in old-growth forests. Proceedings, The Society of American Foresters; 1983 October; Portland, OR. [Location of publisher unknown]: [Society of American Foresters]: 361-367.

Heady, H.F. 1964. Palatability of herbage and animal preference. Journal of Range Management. 17(2): 18-20.

Hooven, E.F.; Black, H.C. 1976. Effects of some clearcutting practices on small-animal populations in western Oregon. Northwest Science. 50(4): 189-208.

Irwin, L.L. 1975. Effects of intensive silviculture on big game forage sources in northern Idaho. In: Proceedings, elk-logging-roads symposium; 1975 December 16-17; Moscow, ID. Moscow, ID: University of Idaho: 135-142.

Lawrence, W.H. 1967. Effects of vegetation management on wildlife. In: Proceedings, symposium on herbicides and vegetation management in forests, ranges, and non-crop lands; [dates of meeting unknown]; Corvallis, OR. Corvallis, OR: Oregon State University: 88-93.

Loucks, D.M.; Black, H.C.; Roush, M.L.; Radosevich, S.M., tech. coords. 1990. Assessment and management of animal damage in Pacific Northwest forests: an annotated biobliography. Gen. Tech. Rep. PNW-GTR-262. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 371 p.

McComb, W.C.; Hansen, A.J. 1992. An introduction to wildlife ecology. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 93-122. Chapter 5.

Moore, A.W.; Reid, E.H. 1951. The Dalles pocket gopher and its influence on forage production of Oregon mountain meadows. Circ. 884. Washington, DC: U.S. Department of Agriculture. 36 p.

Motobu, D.A. 1978. Effects of controlled slash burning on the mountain beaver (Aplodontia rufa rufa). Northwest Science. 52(2): 92-99.

Owston, P.W.; Smith, S.P.; Stein, W.I. 1992. Stand establishment. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 143-165. Chapter 7.

Pengelly, W.L. 1961. Ecological effects of slash-disposal fires on the Coeur d'Alene National Forest, Idaho. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region.

Schmidt, R.H.; Brooks, D.L.; Salmon, T.P. 1992. Social, political, legal, and ethical aspects of animal damage management. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 395-404. Chapter 20.

Steen, H.K. 1966. Vegetation following slash fires in one western Oregon locality. Northwest Science. 40(3): 113-120.

Tilghman, N.G. **1989.** Impacts of white-tailed deer on forest regeneration in northwestern Pennsylvania. Journal of Wildlife Management. 53(3): 524-532.

Walstad, J.D.; Norris, L.A. 1992. Animal damage management in the context of integrated forest protection. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 57-66. Chapter 3.

Chapter 2:

Damage Identification and Prediction

Contents

Introduction

Wildlife-caused tree injury, primarily associated with feeding activity, is the result of removal of some portion of a tree, such as foliage, bark, or roots, that can result in growth suppression or destruction of the tree. Every injury does not cause economic loss, and trees may sustain repeated feeding injuries with little or no long-term effect. Excessive feeding by wildlife on seeds, seedlings, or saplings, however, can prevent or delay successful reforestation, or it may degrade or destroy valuable crop trees in maturing stands. Animal damage, in simplest terms, is the result of any kind of animal activity that interferes with management goals or objectives. (In the past, the emphasis was on animal activity that causes economic losses by reducing or delaying forest yield.) Assessing the significance of animal damage, however, depends on the resource management objectives for a particular area.

Correct identification of damage is necessary before sound prescriptions can be made for managing damage. First, determine whether the damage is caused by environmental factors, disease, mammals, birds, insects, or a combination of these agents. If the evidence indicates that an animal is causing the damage, the species must be determined.

Identification of animal damage often requires a thorough search for evidence. The feeding characteristics of some animals are so similar that identification is almost impossible without evidence such as droppings, hair, tracks, trails, or the presence of burrows in the area. For example, ants may girdle stems of seedlings just above the root collar to nurture aphid colonies, grasshopper feeding on needles can be confused with bird clipping, bird perching sometimes breaks terminal leaders, and terminal shoots may be damaged by snow or ice. This damage can be confused with mammal damage unless investigations are thorough. In some instances, it may be necessary to trap animals, build exclosures, or install cages to identify the damage-causing agent. Requisites for proper identification of animal damage include an inquisitive and open mind, a desire to do a thorough job, a knowledge of animals and their habits, and an ability to interpret field observations.

An excellent field guide on this topic for the Pacific Northwest is Lawrence and others (1961); a dichotomous key to wildlife injuries to trees, adapted from this guide, is included at the end of this chapter. Another useful guide applicable to this same region is Harestad and others (1986). A related publication by Byrd (1981) describes and depicts, with excellent color photographs, observable signs and activities of selected wildlife species, including the identification of wildlife feeding injuries.

Training is necessary to ensure accurate identification of animal damage. The Animal Damage Control Program of the USDA Animal and Plant Health Inspection Service (APHIS-ADC) has qualified biologists who can provide this training. Extension wildlife specialists, USDA Cooperative Extension Service, also may assist with this training.

Types of Damage Caused by Wildlife

A wide variety of damage by wildlife occurs on forests, rangelands, and associated areas. Damage can be grouped into categories by the location where it occurs: forest lands, rangelands, and buildings and grounds.

Damage to Trees

Excellent summaries of wildlife damage to forests in the United States and Canada, with extensive bibliographies, are available (Borrecco and Black 1990, Crouch 1977). Animals may damage trees in many ways. They clip and browse foliage and leaders, gnaw and girdle stems and tree boles, inflict trampling injuries, and completely remove tree seedlings. Keys have been developed to identify damage (table 1). Missing trees are a major problem, however. Missing trees near gopher activity logically can be attributed to gophers; however, when elk and deer pull trees, they often leave no evidence. Unless there are staked rows of trees in the area, this type of damage may be missed completely.

To identify damage to trees and shrubs, the characteristic differences between browsing and clipping need to be recognized.

Browsing-Browsing refers to the feeding habits of ungulates, including deer, elk, and livestock. Browsing on woody vegetation during the dormant season leaves a ragged, splintered break (fig. 1), because these animals lack upper incisors.

Clipping-Clipping refers to the feeding habits of rodents and rabbits, which produce a smooth, oblique cut on woody shoots (fig. 1). These animals possess prominent chisellike incisors and must tilt their heads to the side to clip a stem.

Table l-Comparative widths of incisor teeth of some common gnawing mammals[a]

Common name	Average width of incisor
	Inch
Beaver	0.24
Porcupine	.14
Black-tailed jackrabbit	.10
Snowshoe hare	.09
Cottontail rabbit	.09
Pocket gopher	.06
Western gray squirrel	.06
Dusky-footed woodrat	.06
Meadow vole	.04
Red squirrel	.04
Red-backed vole	.03
Deer mouse	.02

[a] Based on measurements of 6 or more adult specimens of each species from the museum of Natural History, Oregon State University, Corvallis.

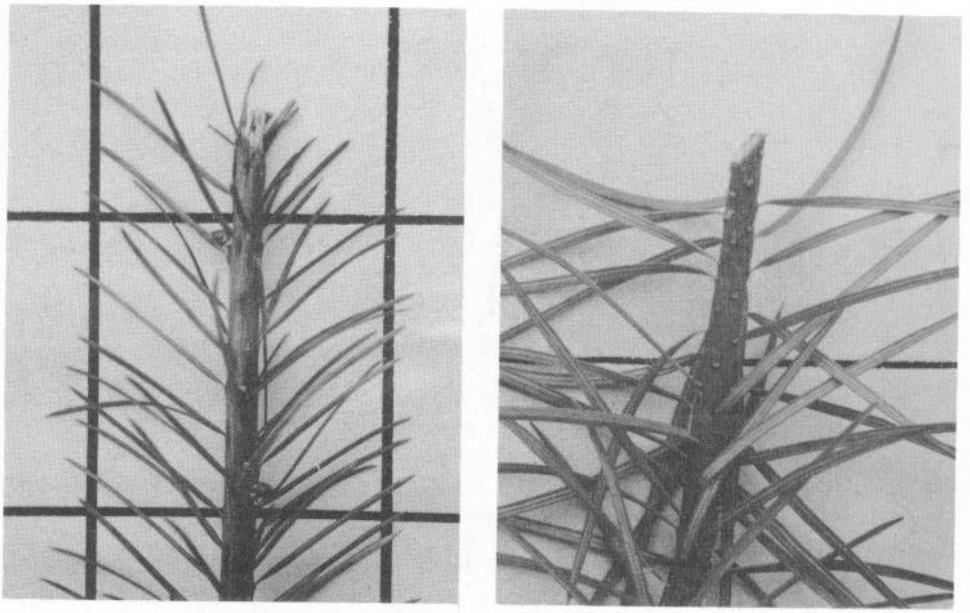


Figure 1—Comparison of twigs browsed by deer (left) and clipped by rabbits (right).

The white-tailed deer skull (fig. 2) lacks upper incisors, which results in the ragged appearance of woody stems browsed by ungulates during the dormant season. The snowshoe hare (fig. 2) has opposed incisors, which permit smooth clipping of stems.

Damage to Rangelands

Grasslands and meadows are subject to three general types of animal damage: plant destruction, soil compaction, and erosion.

Damage to plants—Plant damage occurs in two ways and is caused by both livestock and wildlife. The first is a gradual reduction in plant density and vigor over many years. Livestock, deer, and elk are destructive when the numbers of animals or intensity of use is permitted to increase beyond the carrying capacity of the range. This damage often is difficult to detect because it develops slowly. Changes in range condition can be documented by establishing Parker three-step range transects and by making regular usage checks for several years (USDA Forest Service Manual [FSM] 2210, USDA Forest Service Handbook [FSH] 2209.21). Identification of the species causing damage can be made by direct observation of animals and by animal sign in the area.

The second type of plant damage is the removal or covering of vegetation as a result of feeding and burrow-building activities by certain small mammals. This damage may take place over a very short period. Animals primarily responsible include pocket gophers, moles, meadow mice, and ground squirrels. These animals have small home ranges and can be identified as to group by their burrow-building and food-gathering activities.

Mound building (pocket gophers and moles)—Signs of pocket gopher and mole activity are sometimes confused because both are burrowing animals and spend most of their time underground. Aboveground signs of these animals are distinguishable, however.

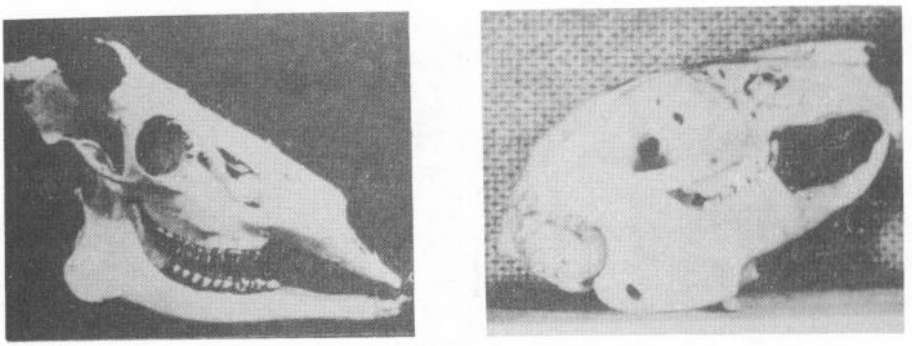


Figure 2—Skull (left) of a white-tailed deer, a browsing animal (an ungulate), compared with the skull of a snowshoe hare (an animal that feeds by clipping or barking).

Pocket gophers—Burrows seldom form a visible ridge on the ground surface. Material excavated from burrows is pushed into fan-shaped mounds or, when under snow, packed in snow tunnels (figs. 3 and 4). When the snow melts, the packed soil remains in cylinders (snow casts). Mounds consist of finely divided soil particles. The burrow entrance usually is near the edge of the mound and is closed by an earthen plug that often leaves a visible depression.

Moles—Much of the burrowing done by moles is close to the surface and often raises a visible ridge (fig. 5). Excavated materials usually are piled in roughly circular mounds, rarely in casts. Mounds often look lumpy (fig. 6). The opening to the burrow usually is near the center of the mound and often lacks a distinct plug.

Meadow voles—Meadow voles require dense cover and seldom are found in sparse cover or openings. Signs of meadow vole activity in grasslands and meadows include vole runway systems that form an intricate network through dense vegetation. When populations are high, these runway complexes are often only inches apart and frequently intersect. Runways can be found by separating matted vegetation or lifting surface litter. Numerous burrow openings are connected by trails. Fresh grass clippings and droppings occur in trails. Burrow openings remain open.

Areas where voles have destroyed perennial vegetation often are invaded by annuals such as cheatgrass and tarweed. Vole depredations frequently can be recognized at a distance by the color patterns of invading or clipped vegetation, which give the area a mottled appearance.

Shrubs or tree seedlings growing in areas of high vole populations often are girdled below the root collar and killed. This damage is easily detected by scraping away the loose duff and soil at the ground line. Girdling also may be found on stems and on branches. Identification of vole species may require capturing them with snaptraps or live-traps.

Ground squirrels—Columbian, Uinta, and other ground squirrels commonly damage grass or meadow areas. Identification is easiest during spring and early summer when they are actively feeding. Specimens can be collected for positive identification by shooting or trapping, if allowed by local regulations.

The presence of open burrows, with little vegetation growing near the entrances, is a good indicator of active dens. Ground squirrels are diurnal and easily seen.

Figure 3--Pocket gopher mound, showing typical fan-shaped appearance, and earthen plug in lower right center.

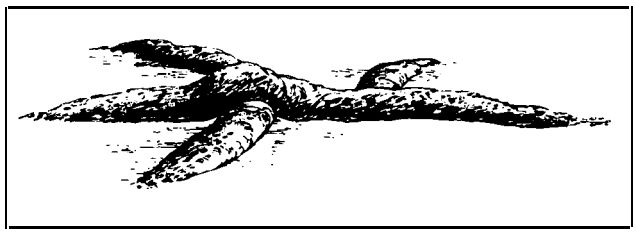


Figure 4-Pocket gopher snow casts, showing typical tubular cylinders of packed soil and occasional overlaying of the casts.

Figure 5-Mole tunnel showing typical shallow ridge formed when feeding occurs near the soil surface.

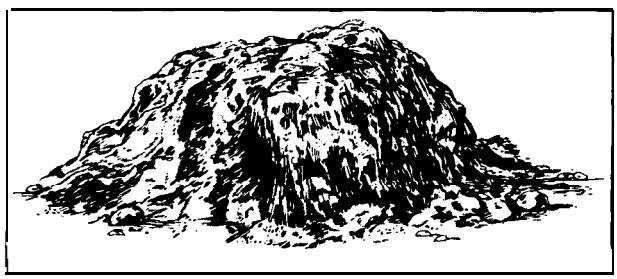


Figure 6-Mole mound, showing lumpy volcanolike appearance.

Rabbits and hares-Signs of rabbits feeding on grasses or forbs are difficult to distinguish from those of rodents, but fecal droppings are distinctive. As with rodents, identification of rabbit and hare damage must rely on indirect signs that indicate the presence or abundance of animals in an area. Pellet group counts are a useful means of determining presence of rabbits and hares.

Soil Compaction

Soil compaction can occur when excessive numbers of big game or domestic livestock use areas of heavy, clay soils saturated with moisture, or as a result of harvest methods.

Areas damaged by compaction look dimpled and animal hoof prints are discernible, if the trampling is recent. When compaction is severe and prolonged, plant density is reduced, perennial plants are replaced by annuals, water infiltration is inhibited, and overland water flow is increased. The area thus is subject to greater wind and water erosion. Areas along waterways and around meadows are particularly susceptible to damage by compaction. Sites used by animals in the early spring that have shallow soils or poor drainage also may be heavily damaged.

Soil Erosion

Soil erosion may be initiated by burrowing animals, including pocket gophers, moles, ground squirrels, badgers, and meadow voles. In some instances, burrows are oriented downslope and serve as small conduits for water from melting snow or heavy rains. This type of damage is observed in the spring when snow is melting. Later in the summer, drying, settling, wind action, and animal use obliterate much of the evidence related to the initial cause of the damage. (Field signs of voles, ground squirrels, gophers, and moles are described in the previous section.)

Damage to Buildings and Grounds

Various birds and mammals may occupy buildings, adjacent grounds, campgrounds, and other areas of human activity where they may be a nuisance or hazard to human health. Animal use of Forest Service buildings and the grounds around them often leads to excessive maintenance costs. Frequently, little actual damage is done, but the nuisance problems may warrant removing or discouraging these animals (see chapter 5).

Birds-Cavity nesters, such as sparrows, starlings, and swallows, often use open air vents, spaces around utility openings, and other spaces for nest-construction sites.

Rodents-Gnawing occurs wherever rodents are present.

Porcupine-Porcupines are the largest gnawing animals found around buildings. They have a definite liking for glue in plywood. Such items as work gloves, saddles and other leather goods, and tool handles are especially attractive. Droppings 1 inch long are characteristic of porcupines.

Woodrats-Sometimes referred to as pack rats, these native species characteristically build large, bulky stick-nests or houses in the crowns of trees and in sheltered sites at ground level. The dusky-footed woodrat is a semiarboreal species, whereas the bushy-tailed woodrat is less arboreal and usually found near abandoned buildings and rocky outcroppings (Lawrence and others 1961). Both species may cause problems in buildings by fouling stored materials and food supplies. (The dusky-footed woodrat may also cause minor damage to young conifer stands.) Droppings about one-third of an inch long are characteristic of woodrat presence.

Mice-Deer mice are abundant on forest lands and frequently move into buildings, particularly during cold weather. Small holes l/2 inch or less in diameter allow mice to enter. Droppings about one-eighth of an inch long, chewed paper, and seed hulls are signs of mouse activity.

Tree squirrels-Tree squirrels, such as red squirrels, occasionally move into buildings or cone-storage facilities. Their presence can be determined by their daytime activity, food-storage habits, and midden piles of pine cone parts that have been discarded as the squirrel removes the seeds from cones during feeding.

Prediction of Animal Damage

In recent years, attempts have been made to predict the occurrence of animal damage in plantations. This reduces treatment costs, because controls are begun only when necessary. Most such efforts have attempted to relate habitat characteristics to animal population dynamics, then use localized experience to predict probable damage to plantations for similar conditions. Results occasionally have been useful, particularly when predictions were based on the combined inputs of interdisciplinary teams composed of foresters, range conservationists, and wildlife biologists. Animal damage prediction models are being used and refined in Pacific Northwest forests (see appendix 3).

McComb (1992) reviews the types of models appropriate for animal damage management and provides a useful list of references on modeling. He outlines the basic steps for developing an "expert" model that relates existing habitat conditions to the habitat preferences of the wildlife problem species. Once these relations are developed and analyzed, appropriate action plans can be formulated for situations identified as being at high risk from animal damage. Sophisticated ADM models can be used to predict the occurrence of animal damage over time.

Districts and Forests should develop ADM models applicable to local conditions; they are a promising new way to avoid unnecessary treatments. Where animal damage is expected or predicted, the cost-effectiveness of controlling the damage should be estimated (see appendix 3).

Key to Wildlife Injuries to Trees

This dichotomous key to wildlife injuries to trees is adapted from Lawrence and others (1961).

INJURIES TO SEEDLINGS AND SAPLINGS.. . . . . A

INJURIES TO MATURE TREES . . . . . B

A. INJURIES TO SEEDLINGS AND SAPLINGS

Key

1A. ROOT CLIPPING 2

1B. STEM BARKING OR STEM BROKEN 3

1C. FOLIAGE CLIPPING AND BROWSING 10

2. Roots gnawed or clipped at root collar...injured seedling may be tipped over or partially pulled underground . . . . . POCKET GOPHER

3. Barking on upper stem of saplings or large seedlings 4

3. Barking basal on saplings or seedlings. 6

4. Bark abraded and shredded on upper stem; small lateral branches broken by antler polishing . . . . . BIG GAME

4. Bark not abraded...lateral branches intact...bark stripped or gnawed from bole or upper branches 5

5. Barking by gnawing...primarily on pines or hemlocks . . PORCUPINE

5. Barking by means other than gnawing...bark stripped from terminal and lateral shoots...branch tips browsed . . . . . BIG GAME

6. Bark stripped from base of saplings...vertical grooves present on exposed sapwood 7

6. Bark not stripped but gnawed from base of saplings or seedlings...lacks vertical grooves, but many tooth marks on exposed sapwood 8

6. Bark stripped or stem broken by trampling; no grooves or gnawing apparent . . . .BIGGAME

7a. Strips of discarded bark at base of tree...vettical grooves on exposedsapwood . . . . . BEAR

7b. Strips of discarded bark absent...irregular vertical claw marks and scattered horizontal or diagonal tooth marks on exposed sapwood...numerous burrow entrances in area . . . . . .MOUNTAIN BEAVER

8. Individual tooth marks less than 1/16 inch wide...gnawed surface of sapwood fuzzy and roughened...grassy areas with numerous surface runways . . . . . MEADOW VOLE

8. Tooth marks distinct, 1/16 inch wide or wider...surface of exposed sapwood not fuzzy 9

9. Tooth marks 1/16 inch wide...sapwood deeply gnawed...above ground damage visible immediately after snow melt...soil mounds, soil casts, and burrow openings . . . . . POCKET GOPHER

9. Tooth marks 1/8 inch wide or wider; sapwood deeply gnawed; 1/2- to l-inch oblong droppings and quills; pieces of outer bark around base of tree . . . . . PORCUPINE

10. Bud and needle clipping on terminal or lateral shoots . . . . . GROUSE, GROSBEAKS

10. No bud or needle clipping, but with cutting or browsing on terminal or lateral shoots 11

11. Clipping or cutting injuries 13

11. No clipping or cutting; browsing injuries only 12

12. Game trails, droppings and tracks . . . . . BIG GAME

12. Browsing-like injury with bud or needle clipping clustered droppings on stumps, logs and rocks . . . . . GROUSE

13. Individual tooth marks distinct...clipped stems usually larger than 1/4 inch in diameter 14

13. Individual tooth marks indistinct...clipped stems 1/4 inch or less in diameter...if on newly germinated seedlings, field signs of rodents are needed to distinguish from bird or insect injury 15

14a. Dams, ponds, and lodges present...cutting areas with distinct trails leading to water..freshly peeled sticks; signs of active beaver pond...wood chips present near stumps . . . . . .BEAVER

14b. On larger seedlings and saplings, cutting of branches leaves short stubs on main stem...piles of fresh leafy cuttings at entrances of numerous burrows . . . . . MOUNTAIN BEAVER

15a. Clipped stems and cotyledons of newly germinated seedlings, in addition to seed eating . . . . . DEER MOUSE

15b. Clipped newly germinated seedlings...in ponderosa pine region and mixed conifer region...numerous burrow openings are signs of ground squirrels . . . . . CHIPMUNKS, GROUND SQUIRRELS

15c. Barked stems of larger seedlings, also clipped lateral and terminal shoots of small seedlings...surface runways in grassy areas . . . . . MEADOW VOLE

15d. Flattened ovoid droppings . . . . . SNOWSHOE HARE OR COTTONTAIL

15e. Clipped seedlings with an oblique cut characteristic of rodents, but it usually can be distinquished from clipping by other animals because of the multiple cuts, which leaves a serrated cut-end. Numerous burrow entrances in area ... limited to coastal Douglas-fir region . . . MOUNTAIN BEAVER

15f. Clipped, small coniferous seedlings . . . . . PORCUPINE

B. INJURIES TO MATURE TREES

16A. TREE CUTTING 17

16B. BOLE BARKING 18

16C. BRANCH AND TWIG CUTTING 24

17. Conical top on stumps, with prominent toothmarks . . . . BEAVER

18. Basal injuries 19

18. Crown injuries 21

19. Long, prominent, vertical grooves on exposed sapwood...large strips of discarded bark at base of tree . . . . . BEAR

19. Vertical grooves and strips of discarded bark lacking...horizontal or diagonal tooth marks. 20

20a. Gnawing, with distinct horizontal or diagonal toothmarks; tooth marks 1/8 inch wide or wider . . . . . PORCUPINE

20b. Gnawing, with tooth marks 1/16 inch wide...Barking occurs in irregular patterns on lower 7 feet of tree . . . . . POCKET GOPHER

20c. Gnawing indistinct...occasional vertical claw marks where bark has been gnawed from bole...numerous burrow entrances in area...limited to coastal Douglas-fir region . . . . . .MOUNTAIN BEAVER

21. Long, prominent, vertical grooves on exposed sapwood of upper bole...large strips of discarded bark at base of tree . . . . . BEAR

21. Vertical grooves and strips of discarded bark lacking...prominent horizontal or diagonal tooth marks or gnawing on sapwood 22

22. Prominent horizontal or diagonal toothmarks on exposed sapwood of upper bole and major branches...oblong droppings up to 1 inch long under tree . . . . . PORCUPINE

22. Prominent tooth marks lacking 23

23. Short strips of discarded bark (1/2 inch wide by 2 to 3 inches long) under injured tree...fine gnawing visible on exposed sapwood . . . . . TREE SQUIRREL

23. Short strips of bark absent...large, bulky, stick nests, either in crowns of trees or on ground in vicinity of injured trees...barking occurs in dense stands of young conifers . . . . . DUSKY-FOOTED WOODRAT

24. Cutting confined to branch tips and twigs...peeled or debudded shoots litter ground under tree . . . . . .TREE SQUIRREL

24. Cutting of moderate-sized branches...no peeled twigs . . . . . PORCUPINE

References

Bailey, V. 1936. The mammals and life zones of Oregon. North American Fauna. 55. 416 p.

Borrecco, J.F.; Black, H.C. 1990. Animal damage problems and control activities on National Forest System lands. In: Davis, L.R.; Marsh, R.E.; Beadle, D.E., eds. Proceedings, 14th vertebrate pest conference; 1990 March 6-8; Sacramento, CA. Davis, CA: University of California: 192-I98.

Burt, W.H.; Grossenheider, R.P. 1964. A field guide to the mammals: field marks of all species found north of the Mexican boundary. 2d ed. Boston, MA: Houghton Mifflin Co. 284 p.

Byrd, N.A. 1981. A forester's guide to observing wildlife use, of forest habitat in the South. For. Rep. SA-FR 15. Atlanta, GA: U.S. Department of Agriculture, Forest Service, State and Private Forestry, Southeastern Area. 36 p.

Crouch, G. **1977.** Wild animal damage to forests in the United States and Canada. In: Proceedings. XVI IUFRO World Congress; 1976; [city unknown], Norway. [Location of publisher unknown]: [Publisher unknown]: 468-475. Reproduced by: U.S. Department of Agriculture, Forest Service, Alaska Region, Juneau, AK.

Dalquest, W.W. 1948. Mammals of Washington. Publication 2. Lawrence, KS: University of Kansas, Museum of Natural History. 444 p.

Harestad, A.S.; Bunnell, F.L.; Sullivan, T.P.; Andrusiak, L. 1986. Key to injury of conifer trees by wildlife in British Columbia. WHR-23. Victoria, BC: Ministry of Forestry, Research Branch. 38 p.

Ingles, L.G. 1955. Mammals of the Pacific States; California, Oregon, and Washington. Palo Alto, CA: Stanford University Press. 605 p.

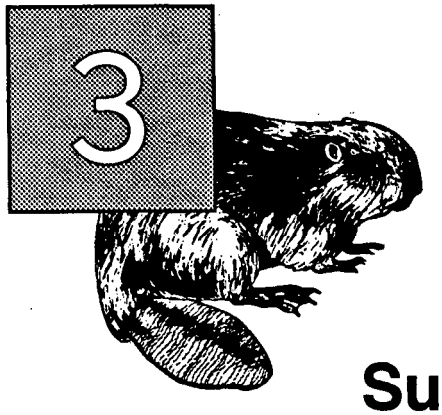
Larrison, E.J. 1970. Washington mammals, their habits, identification, and distribution. Seattle, WA: The Seattle Audubon Society. 243 p.

Lawrence, W-H.; Kverno, N.B.; Hartwell, M.D. 1961. Guide to wildlife feeding injuries on conifers in the Pacific Northwest. Portland, OR: Western Forestry and Conservation Association. 44 p.

Marsh, R.E.; Salmon, T.P.; Howard, W.E. 1981. Integrated management of rodents and other wildlife in campgrounds. San Francisco, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. 126 p.

McComb, W.C. 1992. Modeling systems for prescription development. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 377-393. Chapter 19.

Pank, L.R. 1974. A bibliography on seed-eating mammals and birds that affect forest regeneration. Spec. Sci. Rep., Wildl. 174. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sports Fisheries and Wildlife. 328 p.



Chapter 3:

Surveys

Contents

Introduction

Two principal types of surveys are used to assess animal impacts on forest and range resources. The first measures the extent of the physical use of trees and other plants and is called an "animal-use survey." The second measures animal numbers and is called an "animal population survey." When possible, animal damage surveys should be included as part of other surveys, such as stocking or range surveys. (Techniques for measuring use of forage plants are described in FSM 2210 and **2620.)**

Animal-Use Surveys

Surveys are made on areas scheduled for reforestation, on areas where animal use is delaying or preventing establishment of tree plantations, and on other areas where animal damage is a real or potential problem. These surveys are used to:

- Locate animal use or damage areas.
- Identify animals causing a damage problem.
- Measure animal use.
- Provide data needed for control or prevention of damage.
- Predict in advance of reforestation where animal use or damage is likely to occur.
- Evaluate the impact of animal use on reforested areas.
- Survey predator dependence on rodents, especially raptors that may be impacted by secondary poisoning.

Survey procedures are designed to furnish District Rangers and other resource managers with reliable information to determine where and when animal damage management is needed.

Stocking Surveys

Stocking survey procedures described in Regional reforestation handbooks are designed to evaluate reforestation efforts. These procedures include methods for measuring tree stocking in relation to the influence of weather, vegetation, animals, insects, and diseases. Some forms for reforestation stocking surveys also are designed to allow collection of information on the effects of animal damage. Marking trees with stakes in rows or plots is the best way to determine whether trees are missing and aid in the identification of damage agents.

Examination of staked seedlings provides only an index to survival and growth of seedlings on a unit, however, unless all the seedlings on samplings plots or the entire unit are staked. Staking a small number of trees does not provide precise information on stocking, spacing, distribution of trees, or damage. But it is a useful means of measuring the effects of specific injuries by animals or other factors on growth and survival of seedlings over time.

Examples of potential animal damage areas are south slopes, winter ranges, habitat types particularly favorable to activity by the damaging animal(s), and plantings on established brushfields or grassy areas.

Animal Population Surveys

Two general types of population surveys are counts by direct observation of animals, and indirect estimates of populations by counting pellets, mounds, tracks, or other indicators of animal presence. Variations in terrain, aspect, slope, cover, and animal distribution, abundance, and habits require that techniques be selected to best fit local conditions.

Estimating total populations from sampling surveys is extremely difficult. Population recruitment, mortality, trap shyness, mobility, sex, and age composition are only a few of the many variables that must be identified and interpreted in making accurate estimates of population size. This type of estimation requires good sampling design and ample time to collect data.

Survey procedures must be adequate for obtaining the data needed, but they should be as simple and efficient as possible. Emphasis is placed on measuring one or more of the following parameters:

- Species of animals inhabiting an area.
- Population trends.
- Relative abundance of animals in an area.
- Patterns of animal distribution.
- Effectiveness of control programs.
- Sex and age composition of animal populations.

Direct Population Estimates

Direct population estimates are used most frequently to determine population trends, measure catch per unit of effort, and estimate population size. Big-game populations, for example, often are estimated by trend counts, which survey a given area or route to develop a population index. Trend counts yield an index to estimate population size based on periodic counts, occurrence of damage, or catch per unit of effort. Use care when interpreting trend counts, because weather and other factors frequently influence the number of animals seen.

Trapline Transects

This is an inexpensive method of obtaining useful data on small-mammal populations. Check with local wildlife officials to determine whether restrictions apply.

Kill-trapping-Traplines may be run at any time of the year when animals are active. The periods of inactivity, including hibernation and aestivation, need to be determined locally.

Comparisons of population levels before and after baiting are most reliable when sampling techniques are standardized. Attention to the following details will help achieve uniformity:

- Use the same type and size of traps.
- Maintain consistent spacing between traps.
- Use the same type of bait.
- Tend traps at the same time of day and in the same manner each day.
- Conduct trapping under similar weather conditions, if possible.

Equipment needed--

- Museum special snaptraps, 25 for each trapline. Allow several extra traps for replacement. Ordinary mousetraps may be used, but they are too small to catch chipmunks.
- Bait consisting of equal amounts of peanut butter and whole rolled oats.
- Compass to orient trapline and relocate traps.

- Plastic flagging to mark trap locations.
- Painted stakes to identify trap stations, when permanent locations are needed.
- Forms for recording results (the same form may be used for both snaptrap and live-trap surveys; figs. 7 and 8).

Procedures

- Set traps in a straight line at intervals of either 1/2 or 1 chain (66 feet). One-half chain spacing should be used if mammals having small home ranges, such as voles and shrews, are of primary interest. One-chain spacing should be used for chipmunks and ground squirrels.
- Secure traps to a stake or heavy object by wire or chain. This will prevent poorly caught animals from dragging traps away, or predators from moving the traps.
- Allow a minimum of 5 chains between traplines, when more than one line is needed. In small areas, it may be necessary to locate stations in one direction, offset the line by 5 chains, and continue the line back and forth, as needed, to complete the trapline.

As the size of the area increases, it is impractical to locate trapline transects with the same intensity as for smaller areas; therefore, the following sampling intensity is recommended:

O-100 acres	1 transect/50 acres
100-1,000 acres	1 transect/100 acres
1,OOO-3,000 acres	1 transect/200 acres
3,000-6,000 acres	1 transect/500 acres

- Mark trap locations either by fastening plastic flagging to vegetation or other objects, or by driving painted stakes at each trap station. The latter method will permit accurate trap placement when retrapping.
- Record compass direction of each trapline on a data sheet.
- Sample representative habitat by placing traps next to logs, stumps, shrubs, or grass clumps within 5 feet of each trap station. Prepare a flat spot, 8 inches in diameter, for each trap to ensure that traps rest firmly on the ground and are not tilted. Traps set during rainy weather should be protected from direct rain impact, to prevent bait from washing from the trigger. Protection may be obtained by setting traps under logs, bark, or similar cover; leave enough space above the trap to allow it to spring shut. For voles, set the trap axis perpendicular to the runway, so that the vole trips the trigger when using the runway.
- Bait and set each trap by pressing a pinch of bait firmly onto the trigger. Expose traps on 3 successive nights; check them each day at about the same time as originally set, remove dead animals and record capture location, species, and other pertinent data. Rebait and set traps after each examination. Trapping may be discontinued after the first or second night, if the catch of seed-eating mammals exceeds five per trapline. This would indicate a population high enough to consume most of the untreated seed, if direct seeding were planned.

Small-Mammal Snaptrap Survey

Observer: JJones

Forest: Idaho Panhandle District: Avery Date: 10/1/77

Location: T 26 N; R19E; Sec. 4; NE1/4; Big Burn Line No.: 1

Size of Area: 67 acres Percent Slope: 10-30 Aspect: NE Elevation: 2800'

Weather First Day: Clear calm, High temp 80+ - Low temp approx 45 deg. F

Weather Second Day: Clear 10-20 mph wind - approx, temp high 70, low 40 deg F

Weather Third Day: Partly cloudy, no rain, light breeze, high 70, low 40

Ground Cover: Mainly burned logs, some spots of unburned grass and low shrubs

Area History: Area logged 1978. Wildfire through area on 9/27/68

	Trapping Results								
	First Day			Second Day			Third Day		
Sta. No.	Trap Cond	Bait Cond	Species Caught	Trap Cond	Bait Cond	Species Caught	Trap Cond	Bait Cond	Species Caught
P				D	N	P			
P			P	N			C		
P			P	N	N	P			
P			P	N	N	P			
	D		P	N	N	P			
	D		P	N			C		
P			P	N	N	P			
P				D	N	P			
	C		G	S	S	G			
G			P	N	S	P			
P			P	N	N	P			
P			P	N	N	P			
G							D		
P			P	N	N	P			
	D		P	N	N	P			
P			P	N	N	P			
	GS		P	N	N	P			
P				D	N	P			
G			P	N			D		
	C		P	N	N	P			
	C		P	N	N	P			
P			P	N	N	P			
P				C			GS		
P			P	N	N	P			
	D		G	S	N	P			

Sp. D	No. 4	SP D	No. 3	Sp. D	No. 2	9
sp. c	No. 3	sp. c	No. 1	Sp. C	No. 2	6
Sp. GS	No. 1		No.	Sp. GS	No. 1	2
s p . -	No.	s p . -	No.	Sp.	No.	
s p . -	No.	s p . -	No.	Sp.	No.	
'otal :atch	No. 8 -		N o . 4		No. 5	17

RI-FS-2650-1 (3/87)

Figure 7-Sample small-mammal sample survey form (front).

Instructions

Observer, Forest, District, Date: self-explanatory.

Location: Give legal or local description.

Line number: To identify lines when more than one is used.

Size of area, slope, aspect, elevation: Self-explanatory.

Weather: List approximate high and low temperatures, wind conditions, precipitation, and cloud cover conditions during each trapping day.

Ground cover: List dominant vegetation type and density if vegetation is present in the area. If a recent burn, list as such.

Area history: List management practices or abrupt natural changes that have taken place on the area.

Station number: Be sure to read stations in the same sequence each time, to facilitate comparisons among trapping days and trapping periods.

Trap condition: the following code is used-
N = not sprung; S = sprung; M = trap missing
Bait condition: the following code is used-
P = bait present; G = bait gone
Species caught: the following code is used-

D = deer mouse; C = chipmunk; M = meadow vole; S = shrew;
GS = golden-mantled ground squirrel; and 0 = other (list by species).
If a species is recaptured (live-trapping), place an "R" in the species caught column.

Total catch by species and number for each day.

Total combined catch for each day.

Grand total: species and combined catch for the 3-day period.

Map: Use the space below to show the trapline pattern in relation to the sample area.

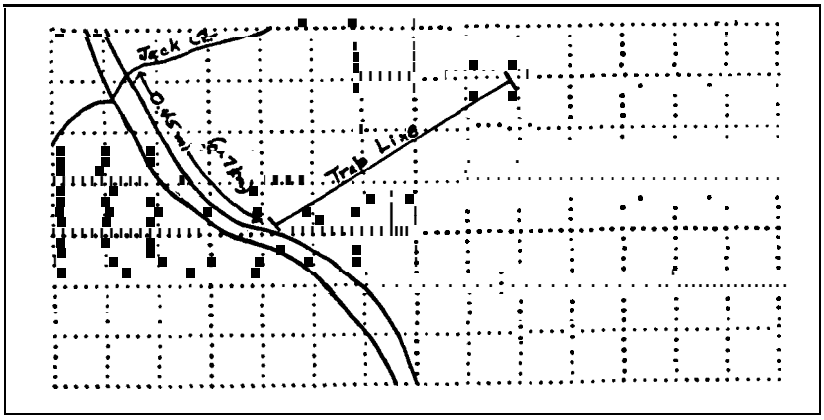


Figure 8-Sample small-mammal census form (back).

- Because snaptraps remove animals from the population, retrapping in the same area may yield misleading data. This source of error can be overcome by either relocating subsequent traplines 5 or more chains away from the original line or waiting 1 year to resample the area.
- Summarize data by expressing the catch as numbers of animals caught per 100 trapnights, so that the results of all surveys can be compared, regardless of the number of traps used. One trapnight is defined as one trap set for 1 night. With two standard traplines, totaling 50 traps, the first night of trapping is equal to 50 trapnights. Three nights of trapping would equal **150** trapnights. The formula for expressing catch per 100 trapnights is:

$$\left[\frac{\text{total catch of small mammals}}{(\text{no. of traps}) \times (\text{no. of trapnights})}\right] \times 100 = \text{small mammals caught per 100 trapnights}$$

If two traplines, with a total of 50 traps, were run for 3 nights, and 15 small mammals were caught, trapping success would be calculated as follows:

$$\left[\frac{15}{(50)(3)}\right] \times 100 = 1{,}500 = 10 \text{ small mammals caught per 100 trapnights.}$$

Many environmental variables influence trapping success. For example, 75 traps placed for 1 night in heavy rain might yield different results than 25 traps set for 3 nights in clear weather, even though the number of trapnights is the same. Lengthening the trapping period tends to minimize daily variations and provides more reliable data.

interpreting results-Many environmental conditions affect the rate and composition of small-mammal catches. Some recognized factors of importance are time of year, weather, and site disturbance.

- Small-mammal populations generally are lowest in the spring because of over-winter mortality. Beginning in the spring, numbers increase owing to the addition of young animals to the population. Populations are highest in fall. Dispersal of animals, primarily young, into unoccupied habitat is greatest during late summer and fall. This is an important consideration when scheduling trapline transects, because such habitat may be quickly occupied by dispersing juveniles.
- Deer mice are active during all kinds of weather, although abrupt weather changes may alter their activity patterns. Sudden cold snaps, snows, or heavy rains after mild weather will inhibit deer mouse (and chipmunk) activity. Nocturnal mice show a reluctance to roam freely on bright nights, which results in generally lower catches under full-moon conditions than on dark nights.
- Most mice and shrews are nocturnal; chipmunks and ground squirrels are diurnal and actively forage during the day. Leaving traps set for a minimum of 24 hours therefore is necessary to get a representative sample of species in the area.

Live trapping-Capturing, marking, and releasing small mammals is a desirable variation of the trapline transect (trapping) techniques described above. The major advantages of live-trapping are:

- Animals are not removed from a population. This prevents other animals from reoccupying an area after removal of trapped animals.

- Retrapping may be done at any time after initial trapping, thereby taking into account variations in conditions caused by factors such as weather changes and seasonal animal activities.
- Retrapping can be done at original trapping sites. This eliminates error caused when a different population is sampled during retrapping.

Many techniques for kill-trapping and directions for analyzing results have been described in previous section "Trapline transects." This section covers modifications that are necessary to apply live-trapping techniques to the trapline transect survey.

Equipment needed

- Twenty-five live-traps.
- Bait made of whole rolled oats or a mixture of whole rolled oats and peanut butter.
- Raw wool for nest material.
- Cloth or plastic bags about 3-1/2 by 5 by 15 inches are recommended for removing small mammals from Sherman-type traps.

Procedure+

- Shade traps from the sun, so that lethal air temperatures will not build up within them.
- Shelter live-traps from direct rain impact, because they are not watertight. Exposure to rain wets trap interiors and their contents, and often leads to exposure and death of captured animals. Rain protection can be provided by constructing bark shelters, or by placing traps under logs or similar cover. Strips of tarpaper can be used effectively to keep traps dry.
- Place wool or cotton at the back of each trap to provide nesting material. This **may help ensure survival of trapped animals in inclement weather. Be sure that** the material does not interfere with the trigger.
- Animals may be removed from traps and handled safely by placing a cloth or plastic bag over the rear of the trap, opening the trap door, and if necessary, shaking the trap to dislodge the trapped animal. Wear gloves. The animal will usually retreat into the bag, which then should be removed from the trap. Hold the bag closed with one hand and grasp the animal by the nape of its neck with the other hand. Invert the bag so the animal can be marked, examined, and released. This method minimizes the chance of an animal escaping or of a handler being **bitten.**
- All animals should be marked for identification, in the event of recapture. Marking may be done in several ways. Toes of squirrels and chipmunks may be clipped, or ears of mice may be notched. Both of these procedures may be used to identify individual animals by marking a combination of toes or positions on the ears. Numbered monel fingerling tags may be attached to the base of the ear. Check with local wildlife officials to determine whether marking restrictions apply in your area.
- Record marked animals by trapsite (see earlier section, "Stocking surveys") where originally marked and time of recapture.

- Summarize data by calculating the catch per 100 trapnights, enumerating only those animals caught for the first time; disregard all recaptures.

Population trends, relative numbers, or amount of time animals used an area can be estimated by counting pellet groups, mounds, runways, nests, evidence of feeding, and similar signs. Indirect population measurements often are more easily obtained than direct census, but require some type of calibration to relate the item counted to the population density. For example, it is necessary to know the number of deer pellet groups dropped per day when calculating deer-days of use by the pellet-group method. Potential damage to natural seed fall, direct seeding, and spot seeding can be predicted by measuring the rate at which small animals remove food from baited spots.

Indirect Population Estimates

Counting Animal Signs

Three types of surveys useful in gathering population information on forest mammals and birds are pellet group counts, mound counts, and seed-spot surveys.

Pellet-group counts-This section deals with procedures for collecting and interpreting pellet group data for big-game population counts. Other pellet sampling techniques have been developed for censuses of small mammals such as mice (Emlen 1957) and hares (Adams 1959).

The following may apply to the use of pellet transects:

- Pellet-group counts can be used effectively where ground cover density does not preclude accurate counting.
- Pellet-group counts provide a useful means of estimating the amount of big-game use of different forest types.
- Population trends on specific areas can be estimated by comparing annual pellet-group counts for 2 or more years.
- Fewer pellet-group plots are needed for determining population trends than for estimating population density (Moore 1949).
- Pellet-group counts can provide useful information for preparing big-game harvest recommendations. Data from a particular sampling area apply only to that area, however, and should not be extrapolated to other areas.

Plot shape-Circular plots are recommended because they are more easily established by one person than are strip plots, and plot boundaries may be quickly and simply located.

Plot size-A 1OO-square-foot plot with a radius of 5.6 feet is recommended.

Number of plots-The number of pellet plots needed will be influenced by the density and distribution of pellet groups and the sampling accuracy desired. Sampling accuracy, suitable for most conditions, requires that the sampling error be within 20 percent of the mean 90 percent of the time. Preliminary sampling is necessary to obtain data needed for computing sample size. After preliminary data are analyzed, it will be possible to adjust plot numbers to obtain desired accuracy.

Sample stratification--More efficient sampling may be obtained by separating different vegetational units or cover types and sampling them separately. This will reduce variation in the sample and the number of sample plots needed.

A restricted random sampling procedure should be followed. The technique requires the random selection of transect lines, which have a predetermined plot spacing.

Equipment needed--Variations in topography and cover on sample plots make standard recommendations of equipment impractical. A small broom and dustpan may be suitable for clearing pellet groups from plots that are open and free of large rocks. A small rake, 8 inches wide, and a small shovel work better in heavy vegetation.

A light chain, 5.6 feet long, is suitable for locating plot boundaries. One end should be looped for attachment to a pivot at the plot center. String or rope should not be used because it may stretch.

Materials needed-The only materials needed for plot installations are pointed stakes (1 by 2 inches by 2 feet) for plot hubs and a box of six-penny nails for pivots.

Procedures--Plots are "read" by slowly walking a circular path midway between the center stake and plot boundary. The chain should be tight so that the plot boundary is readily identified. The initial reading will include old as well as recent pellet groups. All groups should be removed from plots or be marked, and estimates should be made of the number of groups less than 1 year old. When plots are re-examined, all new pellet groups will have been deposited since the last examination. If a pellet group falls on a plot boundary, it is tallied if more than half of the pellets lie within the plot. If more than one-half of the pellets are outside the boundary, the group is not counted.

Frequency ***of*** counts-The type of information needed will determine the frequencies at which plots are read. Monthly counts may be used to construct a use-intensity curve for a given area. Semiannual readings, in spring and fall, are normally sufficient on winter ranges. Summer range transects usually need to be read once a year in a semiarid climate and twice a year in humid climates.

Interpreting results-The number of deer-, elk-, or sheep-days of use per acre can be estimated by dividing the total pellet group count for each species by 13, which approximates the number of defecations per day by these animals. Although defecation rates differ by seasons as animal diets change, they average about 13 per day over a year for deer, elk, and sheep. The estimated rate of cattle defecation is 12 per day. Estimations of game or livestock numbers, per acre, should be related to the amount of damage occurring.

Pocket gopher surveys-Two types of surveys are used to estimate pocket gopher density. Gopher-mound surveys should be conducted when estimating population density to determine whether controls are needed. Open-burrow surveys may be used to evaluate effectiveness of baiting or trapping (see chapter 5, "Pocket Gophers").

Seed-Spot Surveys

Seed-spot surveys can be used as a supplement to the trapline transect to obtain information on the fate of seeds and to determine the damage agent(s). (Trapping may be needed to identify the animals causing the seed loss.) They also provide a way to measure rates of seed destruction or removal. The rate of seed loss, expressed as a percentage of the total seed spots, is easily determined. When seed-spot surveys and trapline transects are used together, they should be spaced at least 5 chains apart to minimize any influence on small-mammal behavior.

Procedures

The following procedures were developed by Moore (1949) for conditions in the Douglas-fir region; the technique applies equally well to the pine region.

Locate 25 seed spots at l-chain intervals in roughly a straight line through the sampling area. Transects should be located to sample representative habitat.

More than one transect may be required to sample large areas; a transect may have to be broken in small areas. Whenever either condition arises, a minimum of 5 chains should be allowed between lines. Spacing requirements should be the same as those described for trapline transects.

Clear a spot about 1 foot in diameter of vegetation and debris to provide a smooth surface that will aid in identifying animals (via tracks) visiting the spot.

Spread about 50 seeds in a line from 3 to 4 inches long on each spot. Cover half of the seeds with a small piece of bark.

Mark the spot with plastic flagging.

Return in the morning after seed placement to record data and interpret results.

Avoid periods of snow or frost.

Materials needed-Conifer seeds and plastic flagging are needed to mark seed-spot locations.

Records-Record results (see fig. 9). Instructions for completing the form are on the back (fig. 10).

Summarizing results-Data are summarized as a percentage of the spots accepted by birds or mammals. For example, if some seeds were eaten at 10 of the 25 spots, this would represent 40 percent seed-spot acceptance.

Interpreting results-The following key is helpful in determining mammal or bird species that have visited a seed spot:

- Seed spot not trampled, seed cover burrowed under: mice, shrews.
  Seed mostly hulled or removed: mice.
  Seed only partly eaten: shrews.
- Seed spot trampled: birds, chipmunks.
  Only exposed seed eaten: birds.
  Seed cover pushed aside: chipmunks.

Chipmunks and ground squirrels usually crack open a seed hull to remove the contents, leaving the two halves largely intact. Deer mice typically open one edge of the seed, remove the endosperm, and leave an empty boat-shaped hull with clean-cut edges at the opening. Shrews shred the seed hulls more completely and leave serrated edges.

Seed Spot Survey

Observer: I D. Jones

Forest: I PNF District: Avery Date: 12/11/77

Location: Line no.: 1

Size of Area: 3 8 a c . Percent Slope: 45 Aspect: NW Elevation: 3,000

Weather: Overcast - calm - approx. temp - High 65, Low 45 F.

Ground cover: Recent Burn.

Area History: Clear cut and broadcast burned in Nov. 1968.

Station Number	Spot Acceptance		Seed Spot Survey Results
	Yes	No	Known or Suspected Animal
1	L		Deer Mouse
2		X	
3		X	
4		X	
5		X	
6	H		Deer Mouse
7		X	
8	M		Birds
9		X	
10		X	
11		X	
12		X	
13		X	
14		X	
15	A		Deer Mouse
16		X	
18		X	
19		X	
20		X	
21		X	
22	A		Deer Mouse and Birds
23		X	
24	H		
25		X	
Total	6	19	

(total acceptance) x (100) / 25 = 24 (%spot acceptance)

Figure 9--Seed spot survey form (front).

Instructions

Observer: Forest, District.

Date: Self-explanatory.

Location: Give legal or local description.

Line number: To identify survey lines when more than one is used.

Size of area, slope, aspect, elevation: Self-explanatory.

Weather: List approximate high and low temperatures, wind conditions, precipitation, and cloud cover conditions.

Ground cover: List dominant vegetation type and density, if vegetation is present on the area. If a recent burn, list as such.

Area history: List management practices or abrupt natural changes that have taken place on the area.

Station number: Be sure to read stations in the same sequence each time, to facilitate comparisons among subsequent surveys.

Seed spot acceptance: If seeds have been removed from the spot, indicate the degree of use with the following legend: L = light; M = medium; H = heavy; A = all.

Known or suspected animal: The following key will aid in identification:

- Seed spot not trampled, seed cover burrowed under: mice, shrews

  Seed all hulled or carried off: mice

  Seed only partly eaten: shrews

- Seed spot trampled: birds, chipmunks

  Only exposed seed eaten: birds

  Seed cover pushed aside: chipmunks

Map: Use the space below to show the seed spot pattern in relation to the sample area.

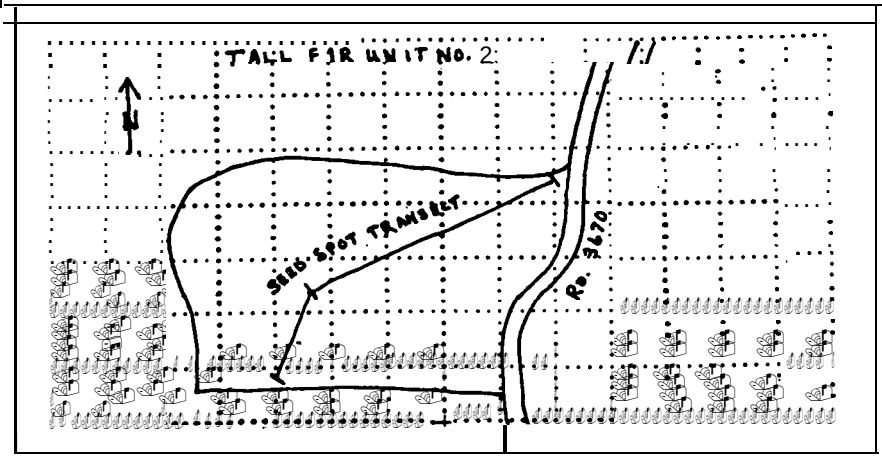


Figure 10-Seed spot survey form (back)

References

Adams, L. 1959. An analysis of population of snowshoe hares in northwestern Montana. Ecological Monographs. 29(2): 141-170.

Emlen, J.T. 1957. Dropping boards for study of small mammals. Journal of Wildlife Management. 21(3): [pages unknown].

Gashwiler, J.S. 1959. Small mammal study in west-central Oregon. Journal of Mammalogy. 40(1): 128-139.

Giles, R.H., Jr., ed. 1969. Wildlife management techniques. 3d ed., rev. Washington, DC: The Wildlife Society. 623 p.

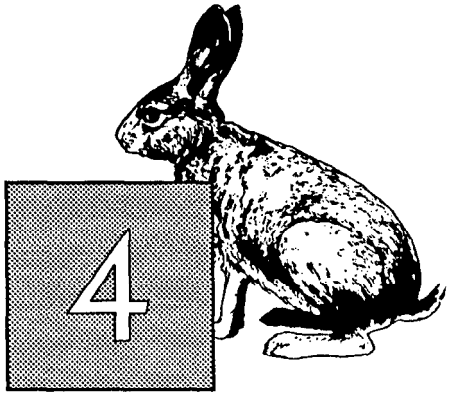
Julander, 0. [and others]. 1963. Measure of animal range use by signs. In: Range research methods. Misc. Publ. 940. Washington, DC: U.S.Department of Agriculture: 102-108.

Moore, A.W. 1949. Forest tree seed eaters and methods used to measure their populations in the Pacific Northwest Douglas-fir region. University of Washington Forest Club Quarterly. 23(1): 1-7.

Neff, **D.J. 1968.** The pellet-group count technique for big-game trend census and distribution: a review. Journal of Wildlife Management. 32(3): 597-614.

Robinette, N.L.; Ferguson, R.B.; Gashwiler, J.S. 1958. Problems involved in the use of pellet group counts. Transactions, 23d North American Wildlife Conference. [Vol. and issue nos. unknown]: 411-425.

Sholl, M.C. 1968. Census methods for seed eaters. In: Proceedings, first reforestation workshop: [dates of meeting unknown]; [Corvalis, OR]. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region: 86-90.



Chapter 4:

Methods for Managing Damage

Contents

Introduction

Animal damage management methods have been developed for most animals of concern in forest and rangeland management. Many of these techniques are only partially successful, however, and are used because more suitable methods are lacking.

No single method is considered completely effective under all circumstances, because the same species may respond differently to changes in habitat or other conditions. It is also common for more than one species to have caused a specific problem. These possibilities should be kept in mind when planning ADM. Depending on the species involved, extent of damage, potential adverse impacts, and cost of management, any one of several techniques or a combination of techniques may be used, including use of toxicants, repellents, hunting, trapping, habitat manipulation, and mechanical protection.

Updated information on ADM methods may be available from your District, Forest, or Regional wildlife biologist or silvicultural specialist, or from APHIS-ADC.

Chemical Toxicants

Reduction of animal populations by use of chemical toxicants can sometimes be achieved with a minimum of adverse effects.

Safety in the Use of Toxicants

When using toxic materials, utmost care must be exercised in handling, storing, applying, and disposing of these compounds. Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers. Follow all label directions, and follow all directions in FSM 2150.

Animals that eat other animals for food may absorb the toxicant loads of their prey and be killed or affected in other ways (this is called secondary poisoning). Changes in behavior in birds and mammals exposed to chemical toxicants, hatching-failure in birds, and reduced reproduction in mammals may occur. The growth and survival rates of the young produced also may be reduced. For mammals, these changes in reproduction may affect both males and females. For birds, reproductive affects usually occur in females. In cage tests with birds, behavioral effects have persisted for three generations, after either the male or female of the first generation was dosed with a pesticide (Caslick 1980). Land managers should recognize that the full effects of toxicant use are difficult to study, even under laboratory conditions, and very difficult to predict under field conditions. Toxicants selected for field use therefore should be used in minimum effective amounts, and the possible secondary effects should be considered.

For further information on using pesticides safely, and for information on the current registration status of chemical toxicants in your area, contact pesticide-use specialists in Districts, Forests, or Regional Offices, or APHIS-ADC.

Regional Foresters may delegate pesticide-use authority to other line officers, except in designated wilderness, wilderness study areas, or designated or candidate research natural areas (FSM 2151.04a).

Characteristics and Uses of Lethal Agents

Strychnine-Strychnine is derived from the seeds of a plant, Strychnine *nux vomica,* grown in southern Asia. It is stable as a powder and relatively insoluble in water. Its salts have a bitter taste and are not absorbed through normal skin contact.

Ingested strychnine is quickly absorbed, mainly in the intestinal tract. The principal symptoms of strychnine poisoning, which may appear 5 to 30 minutes after ingestion, are the result of increased reflex excitability of the spinal cord. The motor reflexes are modified so that smaller stimuli are effective and the response to slight stimulation is maximal and tetanic and tends to spread to all muscles; but tetanus (continuous muscular contraction) depends on an enormous exaggeration of the "startle" reflexes from a sudden stimulus or fright. This involves the simultaneous contraction of all the muscles, which causes several secondary results such as asphyxia, increased metabolism, disturbance of temperature, rise in blood pressure, increased heart rate, and early postmortem rigor. Convulsive seizures may be interspersed by periods of quiescence. Death usually occurs from the tetanic arrest of respiration in the course of a major convulsion.

Strychnine baits may be consumed in sublethal quantities by target species. Animals consuming sublethal doses of bait may develop an aversion to the bait and usually avoid any remaining bait. Any mammal having access to bait may be killed, if sufficient bait is ingested.

Strychnine is not assimilated into tissues or bone. Predatory birds and mammals have been killed by eating field-killed mice and rabbits that had strychnine-treated grain in their guts.

Strychnine baits are restricted-use pesticides. Contact your local APHIS-ADC representative for instructions on ordering such baits from the Pocatello Supply Depot, USDA APHIS-ADC, 238 E. Dillon, Pocatello, ID 83201.

Zinc phosphide-Zinc phosphide is a finely ground powder with a black or grayish-black metallic appearance. The pure compound is 76 percent zinc and 24 percent phosphorus and has a disagreeable phosphorous odor. The chemical is stable when dry and insoluble in water. When zinc phosphide comes in contact with dilute acids, such as occurs in the stomach, phosphide gas **(PH_3)** is released and absorbed into the bloodstream. It takes several hours or occasionally several days for terminal symptoms of convulsions, paralysis, coma, and death from asphyxia.

Zinc phosphide-treated baits have a garliclike odor and deteriorate very slowly; if kept dry, lethal qualities are retained for at least 9 months. When exposed to rain, the bait deteriorates rapidly; for example, up to 50 percent of the toxicant can be lost in 24 hours after exposure to heavy rains. Exposure to prolonged rain and moisture can cause the loss of most of the toxicity in 2 or 3 days.

The risk of secondary poisoning of nontarget, predatory mammals and birds generally is low, because poisoned rodents become sickened and usually seek refuge underground before dying. If raptors or predators were to ingest dead or dying rodents poisoned with zinc phosphide, they likely would become sickened and vomit the toxicant. (Rodents are not able to vomit the bait.)

A risk to seed-eating birds and other rodents is present whenever baits are broadcast or placed aboveground. Pheasants, quail, and waterfowl have been killed, occasionally in large numbers, when bait was broadcast on open ground where it could be found readily.

Use extreme care in handling zinc phosphide-treated baits. Zinc phosphide can be absorbed through the bare skin. (Never distribute baits with bare hands.)

Placement of bait in active runways of meadow voles greatly reduces the chance of birds picking up the bait. Bait also can be placed in bait stations.

A 1.82-percent, zinc phosphide-treated grain bait is registered for use to control field (meadow) voles (Environmental Protection Agency [EPA] registration 6704-6). Zinc phosphide baits also are registered for control of pocket gophers, prairie dogs, ground squirrels, woodrats, and commensal rats. Contact your local APHIS-ADC representative for instructions on ordering such baits from their Pocatello, Idaho, supply depot. Order only the amount that will be used within 2 months.

Anticoagulants-Anticoagulants are chemicals that reduce or prevent the clotting of blood and cause damage to the capillaries. Used as a poison, an anticoagulant causes death by internal bleeding. Most anticoagulant baits seldom cause death in a single feeding, although some new anticoagulants may require only a single feeding. Feeding generally occurs over several days. Feeding does not have to occur on consecutive days but should take place within a 10-day interval, with no longer than 48 hours between feedings. It is important that plenty of bait be available at all times.

Continued feeding on slow-acting anticoagulants, which can be accomplished by broadcast baiting, is necessary to cause death. Bait stations (fig. 11) have been used to facilitate multiple feeding on anticoagulant-treated baits in and around buildings, but this is generally an impractical method for controlling small mammals in forest lands. Second-generation anticoagulants, such as chlorophacinone and diphacinone, are fast acting and require only a few feedings to cause death. With reasonable precautions in using anticoagulants, there is little danger to domestic animals or to raptors and predators. Rodents poisoned with anticoagulants become sickened and generally seek refuge underground before dying.

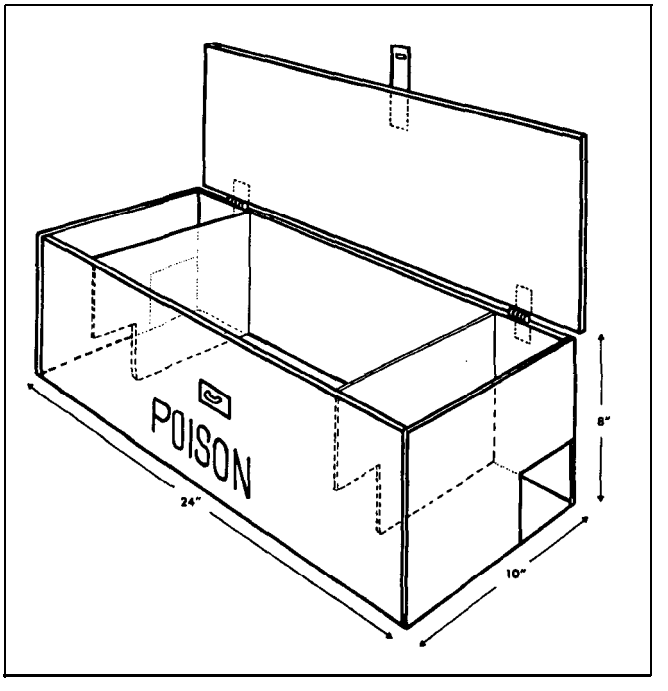


Figure 11-Bait box for use with anticoagulant baits in and around buildings. Baffles reduce spillage and prevent rain, dirt, poultry litter, and so forth, from contaminating the bait.

Several anticoagulants are registered for use in the United States and are marketed under a variety of common and trade names, including Warfarin, prolin, coumafuyl, brodifacoum, bromadiolone, chlorophacinone, diphacinone, pindone, and vapone.[1] Most are not registered by the EPA for field use, but some are registered by California and Oregon for use in seed protection. The use of anticoagulants is recommended by APHIS-ADC and approved by the Forest Service for controlling rats and mice in and around buildings.

Fumigants-Fumigants are used to produce a toxic atmosphere within the tunnels of burrowing rodents or moles (and predators). Many factors, such as soil moisture, composition, and porosity, influence the functioning of fumigants. The effectiveness of fumigants is variable, and it usually requires much time and effort to fumigate each individual burrow.

Aluminum phosphide tablets have been used successfully as a fumigant for control of ground squirrels, Norway rats, and (under some conditions) moles. Fumigants have the advantage over other toxicants of eliminating secondary hazards to nontarget species.

Repellents

Some chemicals have repellent qualities that cause avoidance by animals. Species respond differently to various chemicals, with the result that no single chemical is a universal repellent. Big-game repellent (BGR) and thiram (TMTD) are registered repellents (Rochelle and others 1974). BGR is registered for use on conifer seedlings, ornamental shrubs, and fruit trees. Thiram is registered for use on trees, shrubs, ornamentals, nursery stock, and coniferous seed in combination with other active ingredients.

Big-Game Repellent

Big-game repellent is a putrified protein product derived from whole eggs. This product is registered for foliage application to protect conifers from browsing by big game. It is available in both liquid and powder formulations marketed as Deer-Away. The product generally provides protection for about 60 days in most areas, but evaluate this on a trial basis for your local conditions. Best results are obtained in areas with moderate to heavy browsing pressure (20 to 80 percent of terminals browsed). The use of BGR in these areas may reduce use from 60 to 90 percent for 2 to 3 months. In areas with extreme use (more than 80 percent browsed), the repellent may be less effective and browsing damage may not be reduced significantly.

Three to five acres per staff-day can be treated on rough terrain, and from 6 to 8 acres per day on slash-free areas on gentle terrain. The average treatment cost in 1981 (latest available data), for materials and labor to apply BGR to planted seedlings in the field, ranged from $15 to $30 per acre.

On May 24, 1993, the Regional Forester, Pacific Northwest Region, suspended the use of BGR in Region 6 pending the results of an EPA review of ethyl acrylate, a compound used in the manufacture of the adhesive contained in the repellent formulation. On July 19, 1993, the EPA completed its review of Deer-Away (BGR product produced by IntAgra, Inc.) and reported that it had no human health concerns about the adhesive (specifically, that it had no concerns regarding the use of ethyl acrylate in manufacture of one of the precursor chemicals in the adhesive) and has retained registration for BGR.

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[1]The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Thiram

Thiram (TMTD) has various common and trade names, including Arasan. Thiram is an organic compound, tetramethylthiuram disulfide, which is formulated as a dust, powder, liquid concentrate, or paste. It was developed originally as a fungicide. When used as a foliage spray, it reduces damage by hares and rabbits for up to 60 days but provides inconsistent protection from deer browsing. Thiram is phytotoxic and can cause foliage damage at high concentrations. Some irritation of eyes, nose, and throat have been reported by workers in contact with thiram-treated seedlings.

When a lo-percent suspension is properly applied in the nursery bed at the rate of 1 gallon per 5,000, 2-O conifer seedlings, thiram is nonphytotoxic.

Hunting

Managed hunting is a useful tool that provides recreation and may also help reduce animal damage. Sport hunting is usually the only acceptable method for reducing big-game numbers to levels that will allow plantation establishment or prevent habitat deterioration.

Animals that can be effectively controlled by hunting include deer, elk, bear, and porcupine. Heavy hunting with dogs may locally reduce rabbit populations. Sport hunting also may be a cost-effective means of controlling coyotes.

Deer and Elk

In most states, big game may be controlled over large areas by using an either-sex season, with a specific number of antlerless deer or elk permits issued. If a general either-sex season fails to decrease the population, an early or extended season may be warranted.

General season hunts, especially if restricted to taking males only, usually lack sufficient local intensity to be effective in reducing browsing problems. Controlled hunts in and adjacent to problem areas therefore are more desirable.

Special hunts should not be recommended before the possible results of the hunt are weighed against the high recreational and aesthetic values of the game animals involved. Where the extent of animal damage is unacceptable, special control may be justified. Study state wildlife regulations before attempting to develop recommendations to help solve damage problems caused by big game.

When problems caused by big game are detected, an immediate effort should be made to determine the type and extent of damage and the numbers and species of animals responsible. Careful documentation of problems may aid in securing assistance from state wildlife agencies.

Hunting pressure may be increased in specific areas by providing good road maintenance, adequate signs, maps, and publicity.

Black Bear

To reduce damage to conifers, black bears have been effectively managed in some instances by the regulation of sport hunting. In Oregon and Idaho, for example, special hunts have been scheduled in spring, when bear damage is most prevalent. Sport hunting with the use of hounds is particularly effective where allowed, but taking of bears should be restricted to those areas where significant damage is occurring. In most states, bear hunting is regulated by state wildlife agencies.

Porcupine

Hunting porcupines to reduce damage is most effective after a fresh snowfall in the winter. Trained dogs can greatly increase hunting success. Porcupine control should be done in and adjacent to areas where damage is a problem. Porcupines are inactive during a snowstorm but move around soon after. During the period of activity after a storm, porcupines can be tracked easily and killed. In spring and summer, porcupines can be located by searching meadows and riparian areas in the evening or early morning. Many porcupines can be located in this way, but because porcupines are mobile, it is difficult to determine whether a summer hunting program is effective in reducing subsequent damage.

Trapping

Trapping may serve as a suitable method of controlling animal damage problems in the following situations:

- Removal of ground squirrels remaining after poison baiting.
- Removal of problem beavers.
- Removal of problem bears.
- Control of ground squirrels, pocket gophers, porcupines, and mountain beavers in localized areas.
- Protection of buildings and supplies from wild and commensal rodents (rats and mice).

Consult your Forest wildlife biologist, biologists from the state wildlife agency, or APHIS-ADC for information on trapping techniques specific to your area.

Most animals causing forest or range damage, with the exception of bears, are easily trapped and may be taken with fully exposed traps. The main concern is to select locations frequented by the target animal. Mice and rats prefer to travel under cover of slash or vegetation or along walls in buildings. Ground squirrels and mountain beavers usually stay close to their burrows. Rabbits prefer the protection provided by slash and shrubby vegetation.

If a trap is not set in a natural runway or burrow, an attractant such as bait or scent should be used. Suitable ground squirrel baits include wheat, oats, barley, and apples. A mixture of peanut butter and whole rolled oats is a good bait for small mammals. Nut meats are good baits for woodrats. Fresh cuttings of succulent plants, such as clover, dandelion, or alfalfa, may attract a variety of herbivores.

Current state regulations should be consulted to determine the exact status of an animal in any given area. When game or furbearers are involved, it is necessary to coordinate all proposed trapping with state wildlife agencies. The agency may either take direct responsibility for handling the problem animals or issue special permits allowing their removal.

The Animal Damage Control Program of APHIS-ADC has qualified biologists to consult whenever animal damage control is anticipated. They may either accomplish needed animal control or provide on-the-job training to assist Forest Service personnel in damage control.

Trap Types and Size

Five types of traps are useful for conducting ADM surveys.

Leg-hold trap—A leg-hold trap is a general purpose trap satisfactory for taking small- and medium-sized mammals (fig. 12). The compact structure allows easy placement and concealment. Size 0 traps, with a jaw spread of about 4 inches, are recommended for taking grounds squirrels, woodrats, and Norway rats. Size 1 traps have a 4-1/2-inch jaw spread and can be used for trapping mountain beavers, although Conibear traps are recommended for this purpose. Use no. 2 traps, with a jaw spread of 5-3/4 inches, for trapping porcupines. Use traps with offset jaws to reduce foot injuries and animals pulling out of traps. Traps should be secured to a pin or other solid object with a wire or chain, to prevent an animal from escaping with the trap.

When leg-hold traps are used by Forest Service personnel, traps must be checked at least as frequently as may be required by state regulations. Frequent tending may prevent unnecessary animal suffering and adverse public criticism of control programs.

Conibear trap—The Conibear trap is a body-gripping trap that kills animals quickly, thus preventing them from pulling out of the trap (fig. 13). A special wire trigger permits the trap to be used either aboveground or belowground or in water. Successful sets can be made in runways, burrows, holes, or on rafters or poles. The no. 110 trap has a 4-1/2- by 4-1/2-inch jaw spread and is recommended for trapping rats, squirrels, mountain beavers, and similar small animals. The no. 220 trap with a 7- by 7-inch jaw spread is recommended for rabbits and hares. The no. 330 trap with a 10- by 10-inch jaw spread is recommended for trapping porcupines or beavers.

Pocket gopher trap—The pocket gopher trap is a special-purpose trap designed to fit into a burrow (fig. 14). It is 6 inches long with a jaw spread of 2-3/16 inches. Several companies make similar traps. Figure 15 gives instructions for setting a Victor pocket gopher trap.

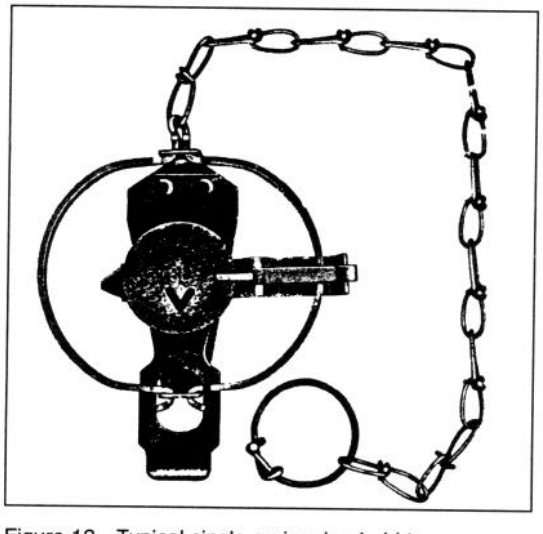


Figure 12—Typical single-spring, leg-hold trap.

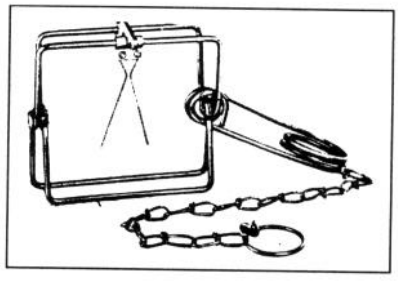


Figure 13—Typical Conibear, quickkill trap.

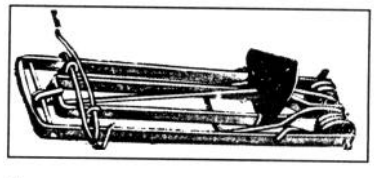


Figure 14—Typical pocket gopher trap used for placement in the burrow systems.

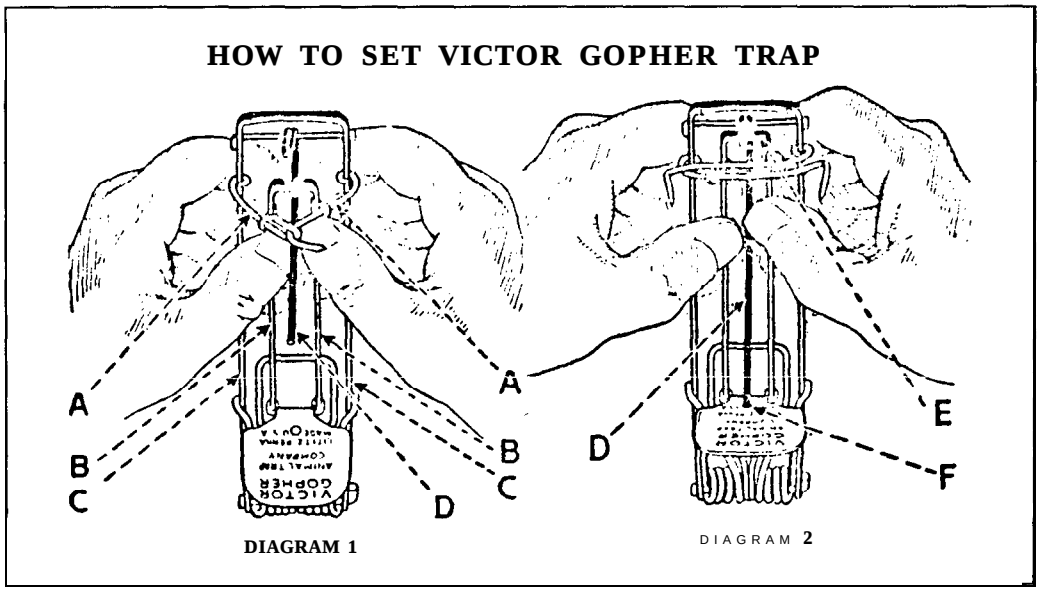


Figure 15-Instructions for setting a Victor pocket gopher trap.

1. Hold the trap in both hands as show in diagram 1.

2. Place thumbs on upper frame (B) back of the jaws (A), with the other fingers underneath the lower frame (C), diagram 1.

3. Lift the trigger (D) with the fingers and press down with the thumbs until the frame members are parallel.

4. Engage hood-end of trigger (D) in diagram 2 over end of upper frame (E); insert long end of trigger in setting hole of pan (F).

5. Place the set trap in a pocket gopher burrow and cover the opening carefully with bark, grass, or other natural materials. The jaws are in position to strike the body of the gopher.

Snaptraps--Simple design and low prices make snaptraps suitable for both surveying and controlling small-mammal populations. Three sizes are available (fig. 16): the small size (mouse trap) is suitable for mice and shrews; the large size (rat trap) is suitable for ground squirrels, woodrats, and Norway rats. The Museum Special is slightly larger than the mouse trap and is recommended for trapping chipmunks and other small mammals of similar size. Traps are usually set on the ground or other flat surface in spots protected from rain and exposure to birds.

Live-traps-Removal of problem animals alive and surveys by mark-recapture methods are best accomplished with live-traps. (Check with local state wildlife officials to determine whether special state regulations apply.) Various sizes are available. The smallest size, 3 by 3 by 10 inches, is suitable for mice, shrews, chipmunks, and golden-mantled ground squirrels. The intermediate size, 5 by 5 by 15 inches, is recommended for rats and squirrels. Larger sizes may be used for snowshoe hares and mountain beavers. The Sherman trap (fig. 17) frequently is used to census small mammals. The two smaller sizes of traps usually are made of sheet metal or aluminum. Larger sizes of live-traps (6 by 6 by 24 inches and 9 by 9 by 30 inches) usually are welded wire. Both types are available in folding and nonfolding models.

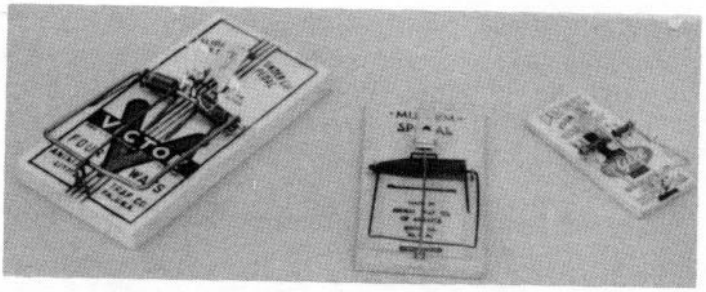


Figure 16—Typical snaptraps for trapping small mammals.

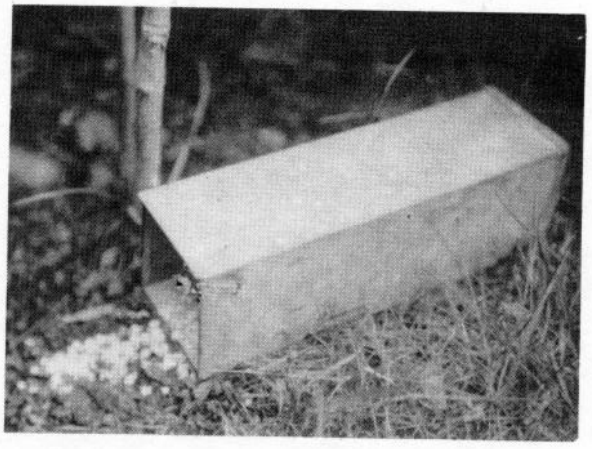


Figure 17—Sherman live-trap for small mammals.

Habitat Manipulation

Habitat manipulation may be used to influence the movements and feeding of wildlife to limit animal damage and for other purposes. Procedures are designed to enrich habitats by selectively favoring preferred herbaceous or shrub species, by seeding or planting preferred species of forbs or grasses, or conversely, by controlling the available forage to make the habitat less favorable to animals. It has been successful in many instances, but results often have not been well documented.

Planning for big-game habitat needs, as a part of forest management, can provide a way to reduce damage to conifer plantations by these animals. Land managers must remember that enhancing habitat temporarily increases carrying capacities of the treated area. Attempts to reduce animal damage by increasing the abundance of preferred grasses, forbs, or shrubs may increase the number of animals in an area and possibly result in increased damage.

Forage Fertilization and Use of Herbicides

Herbicides and fertilizers have been used successfully to alleviate animal damage by modifying animal habitats and increasing seedling survival and growth rates. Under some conditions, however, complete (albeit temporary) removal of herbaceous vegetation and shrubs with herbicides may result in more animal damage to planted seedlings, particularly where animal populations are high or where treated areas are subject to heavy use by transient animals. In some instances, habitat alterations have significantly reduced animal populations, but did not result in reductions of animal damage to seedlings. Use of these methods for ADM has not been sufficiently widespread or well documented for general recommendations to be made.

Supplemental Feeding

In Germany, artificial regeneration has produced forests of parklike stands, where food is the limiting factor for game. Controlling damage while maintaining game populations is a major management goal (Webb 1966).

Establishing game food patches called *"Wildackers'* is a technique practiced in regulated hunting areas of Germany. These *Wildackers* are scattered through the forest, forming chains of feeding areas that encourage animal movement. Food patches are cleared of tree growth, fenced, cultivated, fertilized, and planted to game foods. When supplemental forage is needed, fences are opened for access by deer. It is expected that 3 percent of the forested area in parts of Europe eventually will be devoted to the *Wildackers.*

Attempts have been made to reduce big-game damage to forest reproduction in the Pacific Northwest by seeding and planting foods for big game. Douglas lotus, Dutch white clover, alsike, yellow sweet clover, subclover, red clover, burnet, perennial rye, orchard grass, fall oats, ceanothus, and other species have been sown for this purpose. These plantings generally have been heavily used by deer and elk. Observations indicate that damage to conifers by big game decreases in areas where supplemental browse has been provided (Baron and others 1966) but the practice has not been widely adopted. If grasses are not sufficiently used in grazing, however, high-quality habitat for voles may result in extensive damage to trees by the voles. Grazing by domestic sheep and cattle in clearcuts during spring and summer is being used as a method of preventing excess grass growth in the Pacific Northwest Region of the Forest Service.

During periods of winter stress in the Rocky Mountains, deer and elk use conifer foliage and lichens knocked to the ground by snow and wind or made available by winter logging and thinning operations. Resource managers should consider scheduling thinning operations to attract browsing animals away from damage-susceptible conifer plantations. Management to enhance sprouting of desirable hardwoods in areas adjacent to vulnerable plantations can be used to develop attractive game food. Sprouting can be encouraged by cutting hardwood species that have grown beyond the reach of game. Application of herbicides and prescribed fire also may promote basal sprouting (see earlier section, "Forage Fertilization and Use of Herbicides").

Flowers (1987) tried supplemental feeding of black bears as a possible solution to tree-barking problems in western Washington. (Tree damage by bears occurs shortly after bears emerge from hibernation and when nutritious food is scarce.) He developed a food pellet containing sugar, protein, calcium, and other nutrients attractive to bears. The results of this method for reducing tree damage, however, were inconclusive.

Manipulating Habitat Carrying Capacity

Reducing the attractiveness of habitat for wildlife has been used as a method of reducing animal damage. Broadcast slash burning delays population buildup by brush rabbit and snowshoe hare after logging. Chemical weed and brush control offers many possibilities for controlling animals by reducing available food or cover. A 1974 study showed that complete control of vegetation reduced the abundance of pocket gophers and damage on plantations in southwestern Oregon (Black and Hooven 1974). In Washington, Borrecco (1976) found that the control of vegetation results in a reduction of clipping by snowshoe hares on Douglas-fir seedlings.

Population control through habitat modification should be evaluated carefully, because there is the potential of developing unexpected and possibly unwanted side effects. This type of treatment also can have more impact on the ecosystem than would the temporary population reduction resulting from direct control.

If undesirable browse plants are controlled by herbicide treatments, locally preferred plant species may be released. This may temporarily improve the habitat for some wildlife species, thereby increasing the risk of animal damage. Thinning dense conifer thickets with established understory vegetation, by prolonging the productivity of an area for wildlife, may have the same result.

Silvicultural Practices

Modifications of present timber harvesting, slash disposal, and planting practices may help reduce animal impacts on tree reproduction. Land managers must consider the effects on wildlife and wildlife habitat that may occur after any silvicultural treatment. When modifying silvicultural practices to control animal damage, the side effects of the control measure must be weighed against possible benefits. For example, in certain areas, removing slash to reduce rabbit and rodent cover may increase use by browsing animals.

Animal injuries to forest reproduction are seldom considered, unfortunately, until actual damage to the stand has occurred. The potential impact of animal damage to young trees often can be anticipated well in advance of harvest (see chapter 2). Recognition of potential problem areas during the presale and replanting surveys will allow action to minimize the impact of animal use on reforestation programs. Provision should be made in sale prescriptions for damage control measures (FSM 2472.71).

Animal damage problems should be anticipated during presale surveys when any of the following conditions occur:

- Big-game winter on the site. Areas having south and west slopes, protected valleys and draws, and areas of low elevation often provide suitable wintering grounds for big game. Deer and elk congregate in such areas during severe weather and may use all available browse, including conifers.
- Big-game use is concentrated on areas other than winter ranges. Mixed timber types, river bottoms, old burns, logged sites, game trails, and migration corridors are favored spots.
- Big-game ranges are overpopulated. Excess numbers can occur when hunting is prohibited or harvest is inadequate. Examples are municipal watersheds and areas inaccessible to the public because of distance or because right-of-entry through private property is denied.
- Heavy plant use or numerous tracks, trails, mounds, burrows, or droppings indicate abundant animal activity.
- Use of mechanical tree planters promotes dispersal of pocket gophers and creates conditions favorable for burrowing.
- Trees are planted on sites subjected to severe competition by herbaceous or shrubby vegetation. Thus the trees will be unable to grow rapidly beyond the reach of browsing animals.
- Trees are planted adjacent to older plantations that have a history of animal damage.

When presale surveys indicate that an area has a high probability of animal damage, plans should be made to manage it. Where special silvicultural prescriptions will not provide the desired protection, provisions should be made to provide appropriate physical or chemical protection.

An effort should be made to secure the cooperation and help of the state wildlife agency in alleviating potential problems caused by big game. These efforts, based on accurate and timely data on damage, may lead to special hunts, opening of areas closed to hunting, or issuance of special kill permits.

Timber harvest-Cutting practices that protect existing stocking or control the quality of animal habitat should be considered where animal problems are expected (FSH 2409.26b). Consideration also should be given to the feasibility of leaving corridors for wildlife, moving the unit, or perhaps even deleting the unit.

- Leaving roosting and nesting trees for hawks and owls within or near areas to be reforested may help maintain natural controls on rodent populations (FSM 2470, 5150), although these practices alone may not be sufficient to prevent unacceptable animal damage.

Fuel treatment-The effects of broadcast burning on animal populations and plantation survival must be evaluated carefully. Consider the advantages and disadvantages of burning, as related to the needs and behavior of problem animals.

- Leaving slash from timber harvest and other fuels unburned tends to restrict the movement of deer, elk, and livestock within a plantation. At the same time, unburned fuels provide favorable habitat for maintenance of certain small-mammal populations (see chapter 1).
- Unburned fuels, when used as a barrier to browsing, provide protection to individual conifers.
- Established browse plants remain as buffer food when slash and other fuel is left unburned. This food source will increase rapidly, as shrubs respond to the increased availability of light, moisture, and nutrients (see chapter 1).
- Broadcast burning facilitates access by deer, elk, and livestock to the entire plantation. It also reduces the amount of material, such as light fuel, that can be used to protect individual trees.
- Broadcast burning suppresses existing browse, which increases the vulnerability of planted trees to deer and elk for the first year after burning.
- In some instances, broadcast burning causes direct mortality to lagomorphs and rodents. The reduced protective cover also deters the rapid buildup of rabbit, hare, and most rodent populations during plantation establishment, when small-mammal feeding is most critical (see chapter 1).
- Broadcast burning provides quick release of soil nutrients, which may increase the palatability of recently planted conifers (see chapter 1).

Piling and burning practices should disturb the site as lightly as possible and leave 20 to 30 tons per acre of debris, which can be used to protect tree seedlings. Light disturbance of the site during piling will promote shrubs. Severe disturbance may promote erosion on some soil types and may set a site back to the earliest successional stage, which generally encourages grasses and herbs attractive to rodents and livestock (see chapter 1).

Reforestation practices-The methods followed to reforest denuded areas can greatly influence the intensity of animal damage. If an animal-damage problem is anticipated, reforestation practices can be selected to minimize damage.

Seeding in the late winter or early spring will minimize exposure of seed to seed-eating mammals and birds.

Spring plantings can be made in areas where dormant-season damage is anticipated. This will allow seedlings one growing season to become established, before exposure to severe browsing or clipping damage. Spring-planted seedlings, however, are often more easily pulled out by elk and deer than are seedlings with established root systems.

Planting of less preferred species, where applicable, can help alleviate animal damage. In the Pacific Northwest, Douglas-fir and ponderosa pine are considered preferred browse for deer and elk at certain times of the year. White fir is highly preferred in California. True firs and spruces are among the least preferred conifers. Sitka spruce, for example, is seldom damaged by deer, elk, rabbits, or mountain beaver. Tests of several provenances of ponderosa pine showed that some had natural resistance to pocket gopher damage (Case 1983). In other areas, check with Forest biologists to determine the tree species that local animals are least likely to use.

Animal damage usually is less harmful to large nursery-grown trees than to small trees. Trees with larger stems and more foliage are better able to survive animal-caused injuries than are small seedlings. On suitable sites, the increased cost of planting stock and planting usually is offset by greater seedling survival.

Planting trees under shrub canopies or slash may protect them from damage caused by deer, elk, livestock, and porcupines. The shading also may be beneficial in some areas.

Trees planted along well-used game trails or livestock trails often suffer heavy browsing and trampling damage. To avoid such losses, trees should not be planted within 8 feet of such trails.

On steep slopes, deer and elk generally feed uphill. Thus, trees planted on the uphill side of stumps, logs, and rocks will receive some protection from browsing. Planting close to large pieces of debris may provide protection from trampling.

In some instances, if significant animal damage is anticipated, this loss can be compensated for by increasing the numbers of trees planted. Reduced spacing is often enough to compensate for moderate browsing of big game or the incidental damage by pocket gophers and other rodents that occurs on many sites. It will not, however, compensate for severe damage on sites exposed to repeated damage, where most trees are being damaged or lost.

Mechanical Protection of Seeds, Seedlings, and Trees

Many techniques have been developed to physically protect seeds, seedlings, and trees. Direct protection prevents access, or excludes animals from individual trees or entire plantations. Its application is limited, however, because it usually is the most expensive type of protection available.

Physical protection of plantations usually is not needed on extensive areas but is limited to sites where severe damage has occurred or has been predicted. For example, on plantations with several aspects, only the south slopes may need protection. Protection of only those areas normally free of snow may be sufficient in plantations ranging several hundred feet in elevation. Although the cost of physical protection is comparatively high, such treatment may ensure higher survival, thereby resulting in fewer trees being planted to obtain desired stocking (see the section below, "Individual Tree Protection").

Area Protection

Deer fences-Areas of high damage potential can be fenced to exclude deer. Fencing is one of the most common methods of game-damage control in Germany. In areas where about 10 percent of forest land is fenced at all times, the fences are maintained for about 10 years. As part of the program, deer and elk are provided supplemental feed to compensate for their exclusion from more desirable wildlife feeding areas.

Because fencing excludes deer from prime habitat, it should be used only when it is apparent that reforestation cannot be accomplished by other means. Before fencing, consider all ramifications of this practice.

Fence construction and maintenance costs are high, especially in rough terrain; however, costs per acre decrease rapidly as the size of the enclosed area increases. Also, fewer materials are required per unit area to fence regularly shaped areas.

Excluding wildlife from large National Forest areas is not desirable from a multiple-use standpoint, but it may be necessary temporarily for successful reforestation or necessary to protect seed orchards.

On large areas, it is difficult to avoid fencing in game animals. Enclosed deer and elk are usually difficult and costly to remove, even by shooting or by providing escape gates, Removal of trapped animals must be considered as a cost of protection, as enclosing even a few animals may result in severe damage. To minimize possibilities of fencing in game animals, fences should be constructed before vegetative cover develops.

Deer are persistent in trying to gain access to preferred areas. Thus, fences must be carefully designed, constructed and maintained to exclude deer. Regular maintenance is necessary to prevent animals from penetrating fenced areas. If they gain access but have difficulty leaving, damage may be heavier than if no fence existed.

Fencing one area may increase deer browsing in adjacent areas. Also, deer fencing will not protect trees from rodent or hare damage, and it may increase brush competition.

Electric fences-Electric fences, with the upper wire about 2 feet above the lower, have been used to exclude deer from plantations but are ineffective for elk and moose, which break through the fence on contact.

In addition, electric fences are ineffective in deep snow and may be grounded when in contact with green vegetation. Power failures make them unreliable. Depending on local conditions, high-tensile fences and slanted fences may provide protection. Check with biologists from the state, the Cooperative Extension Service, or the APHIS-ADC for local recommendations.

Woven wire fences-A properly constructed 8-foot-high woven wire fence usually will exclude deer and elk (fig. 18). Woven wire fencing is available in 4-foot widths that can be fastened together with hog rings to produce an 8-foot-high fence. Fencing should not have openings larger than 6 inches. A 7-foot-high woven wire fence may be used, if it is topped with two strands of wire. Fencing may be attached to posts of wood or steel. If there is a possibility of timber blowdown, fences should be built away from the timber edge to avoid excessive maintenance. A travelway adjacent to the fence will facilitate maintenance.

Failure of woven wire fencing usually is a result of poor construction or lack of maintenance. Game animals frequently try to go under a high fence before attempting to jump over it. Deer can work their way under a 4-inch space between the ground and bottom wire, if the wire is slack. Spaces under fences should be filled with stones, logs, or other debris. If the wire between posts cannot be pulled snugly to the ground, it should be fastened to logs or stones that are large enough to hold the wire down. If large logs or stones are not available, two stakes may be crossed over the bottom wire and driven into the ground to close openings. Fences built along contours of steep slopes must be higher than 8 feet or have outrigger attachments to prevent animals from jumping over them.

Woven wire fences must be inspected periodically for damage by animal penetration, snow, frost heaving, fallen trees, slides, and “washouts” under the bottom wire. Restretch loose wire annually.

Cost of woven wire exclosures in the Pacific Northwest ranged from $2.40 to $4.85 per foot in 1984 (newer data not available). Maintenance for 5 to 7 years and removal costs will about equal the original installation expenses.

Nylon net fence-Six-inch (diagonally stretched) mesh nylon netting has been used in Oregon to exclude deer from plantations. An 8-foot-high fence is constructed around a plantation by attaching the netting to steel fence posts (fig. 19). The netting can be stretched and easily pegged down to conform to irregularities in the ground surface. Netting should not be stretched tight, because this reduces its resistance to impact.

When first used, nylon-net fencing was attached directly to trees surrounding cutting units, but fence maintenance was high because of falling limbs and trees. Maintenance problems were reduced by moving fences away from standing trees and attaching the netting to fence posts.

Nylon netting has not been in use long enough or in enough situations to permit thorough evaluation of its effectiveness for protecting plantations. Nylon fencing will exclude deer; it conforms to irregular surfaces, and construction and maintenance costs are less than for woven-wire fences, but nylon fences are more susceptible to vandalism. The anticipated life of the material is 5 to 7 years.

Figure 18—Woven wire deer fence.

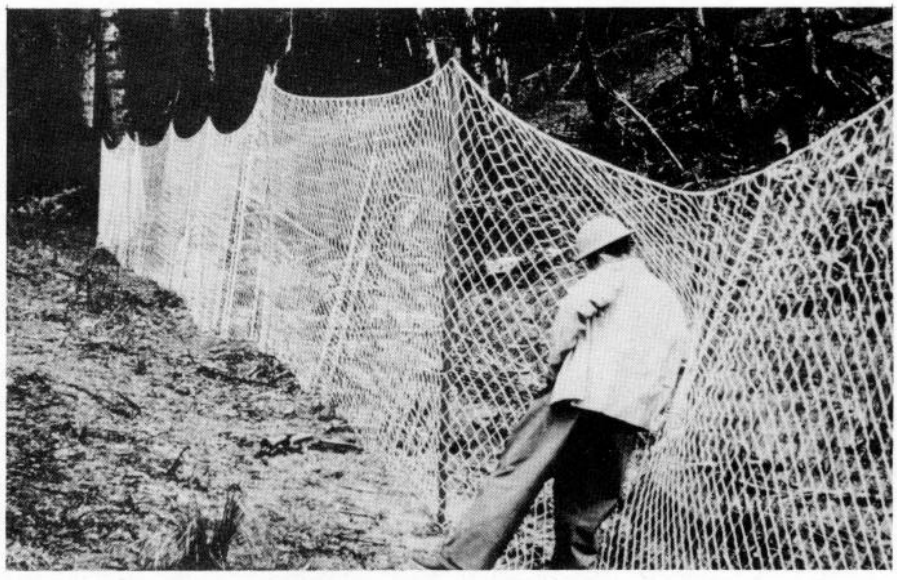


Figure 19—Eight-foot-high nylon netting attached to steel fence posts to exclude deer from a plantation.

"Beaver baffler" fence-The "beaver baffler" fence (fig. 20) was developed by the Washington Department of Game. The use of the this fence to prevent beavers from plugging culverts has been very successful (Fisher 1986, Guenther 1956).

The beaver baffler consists of a narrow lane of woven wire constructed around the head of a culvert or through a dam and extended out into the stream or pond (fig. 21). This lane should be at least 2-1/2 to 3 feet wide and extend 30 to 40 feet above the culvert. Where a beaver dam is continually rebuilt, a fenced lane may be constructed 30 or 40 feet below the dam and extended through the dam out into the pond for 15 to 20 feet. This extension is built in 1 to 3 feet of water and may follow the shoreline, if the lake or pond is deep. Posts must be placed closely enough to hold the wire to the bottom of the pond. If the fence is properly installed, the beaver would have to build a dam completely around the fence to hold water, but such behavior has never been observed. Instead, they concentrate on pushing mud through the fence, crawling over, or digging under the wire at the culvert or dam site.

Early experiments with fenced lanes 1-1/2 feet wide were not always successful, because beavers were able to push the wire together with mud and sticks. A persistent beaver can dig under the fence, but its work is halted when the fenced lane has several cross sections of woven wire located near the beavers accustomed working area. This prevents the beaver from carrying material inside the lane.

Fences are normally built 3 feet high. If it is necessary to build the lane in 3 feet or more of water, higher wire must be used. The cost of new material to install a 30-foot lane of fencing is usually less than the cost of making repeated trips to trap the beaver. Problem areas with heavy snow packs may require a top rail around the fence, to support the wire when buried by deep snow.

Lane fences will save labor, expense, and time wherever they can be used to discourage an occasional unwanted beaver. Streams subject to flooding have not been successfully fenced.

Alarm devices-Electronic noise makers, propane guns, whistles, horns, scarecrows, flashing lights, and various other alarm devices have been used in attempts to protect forest and agricultural crops from animals. Where short-term protection is necessary, alarm devices are sometimes effective. Animals soon become accustomed to these devices, however, and resume use of the area. Alarm devices have not proven effective for continuous protection of forest plantations or nurseries.

Seed Protection

Conical seed protectors-Individual seed spots can be protected from ground squirrels, tree squirrels, chipmunks, and mice by covering them with wire screens. About 750 protective screens can be made from a roll of no. 3 mesh hardware cloth, 100 feet long and 3 feet wide. Using tin snips, the 3-foot rolls should be cut into five strips 7-1/4 inches wide and 100 feet long. The protectors are cut from the narrow strips with the aid of a parallelogram-shaped pattern made of plywood. Pattern dimensions are 7-1/4 inches high by 8 inches wide, the interior angles of 60 and 120 degrees. Large quantities of screen can be stamped out by machine. Screens can be packed flat in boxes or bags for use in the field.

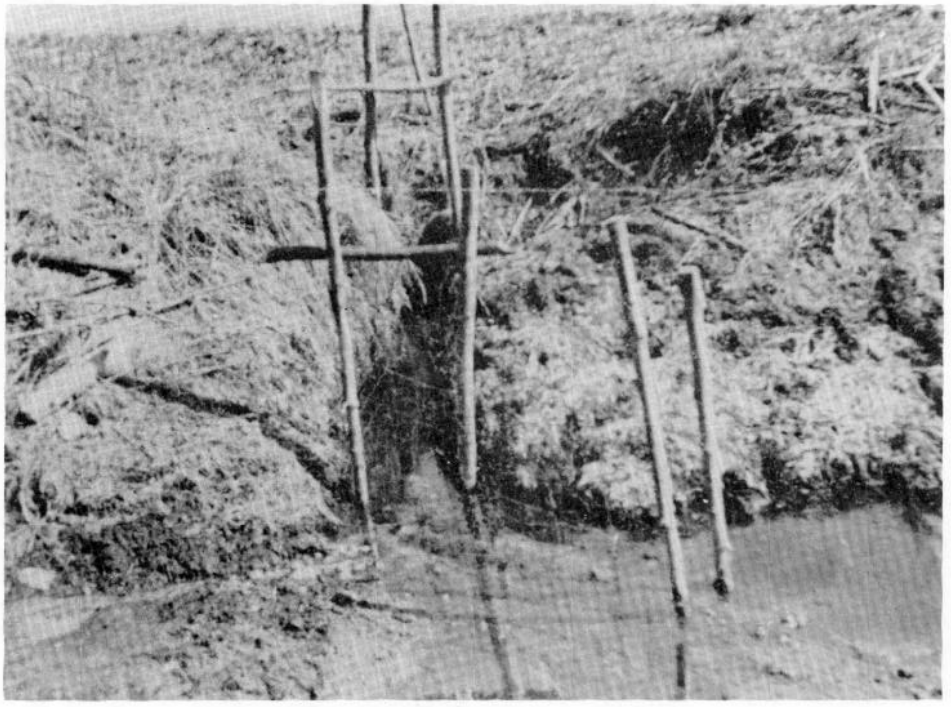
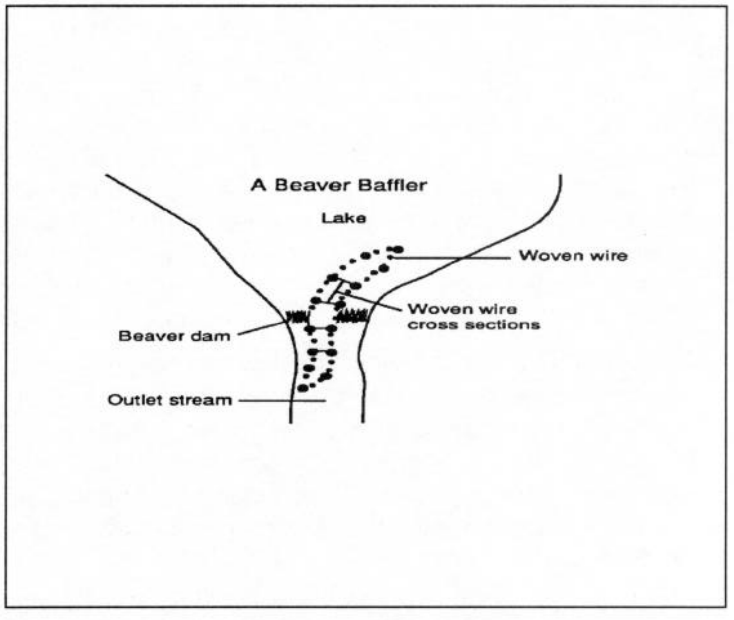


Figure 20—"Beaver baffler" fence, showing placement after a portion of the dam has been removed.



Figre 21—"Beaver baffler" fence, showing fence built through dam and extending up and downstream in 2 to 3 feet of water.

In the field, the screen is rolled into a cone and held in this shape by folding the cut-wire ends into the body of the screen. The protector is set by forcing the base about 2 inches into the ground. When set, this protector has a basal diameter of about 4-1/2 inches and a height of 5 inches. This type of screen provides at least 90 percent protection against small mammals during the first season. The screens should be left in place through the growing season to keep rodents from destroying the young seedlings, and then removed. Protectors can be reused several times.

Netting-Netting has been used successfully to protect a variety of agricultural crops from depredating birds. The cost of netting and installation is generally quite expensive ($500 to $800 per acre in 1984) and can be justified only to protect high-value crops such as berries, fruits, or tree seeds in nurseries. When used, care must be taken to obtain netting with a small enough mesh to exclude undesirable birds. The netting needs to be installed such that feeding through the net or gaining entrance under the edges is eliminated.

Several companies produce various netting materials suitable for excluding birds from high-value crops. Contact your local Cooperative Extension Service agent or APHIS-ADC for current sources.

Individual Tree Protection

Plastic-mesh tubing-Enclosing individual trees with plastic-mesh tubing will protect them from damage by mountain beavers, hares, rabbits, deer, and elk (Campbell and Evans 1975a) and, to a lesser extent, pocket gophers. Where intensive protective measures such as tubing or fencing are necessary for successful reforestation, tubing has an advantage over fencing because it does not exclude wildlife from prime habitat. Tubes should be used only when extra planting of 30 or 40 percent will not yield sufficient stocking, and they should be used only where they are cost effective. Extensive use of plastic tubing to protect plantations is expensive, and costs increase rapidly as terrain becomes steeper and rougher. In addition, cost per unit area for a specific number of tubes is fixed; it does not decrease with additional area as does the cost of fencing. (Larson and others [1979] is an excellent reference for tube installation.) It is very important not only to install the tube correctly, but also to use a tube diameter large enough to allow the tree to develop and grow as normally as possible. Four- to five-inch-diameter tubes should be used for pines. For Douglas-fir and western larch, 3-1/4-inch-diameter tubes are recommended. Diamond twill pattern is recommended as it is the most rigid. Other patterns are more flexible and tend to bend over more. A 3/8-inch mesh opening is recommended.

There will be some growth distortion of tubed trees, due to tube bending or new growth being caught in the mesh opening. The large diameter (recommended above) will help alleviate distortion. Annual maintenance of the tubes should be included in tubing operations. Tubes can be ordered with different breakdown rates. For Rocky Mountain sites, tubes should be ordered that have 30- to 40-month photobreakdown rates. For other areas, local experience and local management guidelines should be followed.

The number of trees to be tubed should be governed by the stocking required in a specific area. The presence and condition of “natural” seedlings as well as those trees seeded or planted always should be considered when assessing stocking adequacy. For additional details see Campbell and Evans (1975; also in appendix 3 of this handbook).

Obstructions-Constructing barriers over and around young trees may effectively protect them from big game and domestic livestock and partially protect them from other wildlife (fig. 22). Materials such as tree limbs and other debris normally are available after logging, site preparation in brush fields, or fires. It may be necessary to cut small, fire-killed trees or shrubs for additional material. Protection costs using this technique differ relative to the availability of materials and the number of trees protected per acre.

Tree guards-Tree squirrels can be discouraged from climbing individual trees, such as in a tree-seed orchard, by placing a 2-foot-wide metal band around the trunk of the tree, about 6 feet above the ground. Because tree squirrels are excellent jumpers, the bands are ineffective if branches of unprotected trees are near enough to permit jumping between trees.

Beavers can be discouraged from cutting individual trees by encircling the lower 3 feet of the tree with l-inch mesh wire fencing. Allow room for tree growth, and replace as needed.

Bud caps-Bud caps are effective against browsing by big game, particularly in winter and early spring. Caps should be used on stock strong enough to support a cap without bending over. Generally, stems 114 inch in diameter at the point of installation will support a cap. Bud caps are effective for one growing season and may need to be replaced annually for 3 years before seedlings are free to grow. Areas without protection being browsed at 50- to 70-percent rates should expect to have damage reduced to about 10 percent of terminals browsed.

Many types of bud caps have been tried; the style shown in figure 23 has proven very effective. This cap uses a piece of 8-1/2- by 5-1/2-inch waterproof paper and five staples. One staple is used to hold the top of the cap together. The other staples are used in pairs on each side of the stem just below the bud, to hold the cap firmly in place. The terminal bud should be positioned in about the center of the tube, with 4 inches of the tube above the bud and 4 inches of stem in the tube below the bud. No more than 25 percent of the foliage should be stapled inside a cap. Some Districts in Region 6 have reported heat damage to the leader from using this type of cap. Bud caps made of polypropylene netting are now available; they may reduce or eliminate this heat damage. Bud caps should be tried first on a small scale to determine their usefulness under local conditions. Although bud capping is not widely used for animal damage reduction, it may be useful in some situations.

Figure 22—Hand-piled brush provides effective protection of planted ponderosa pine seedlings.

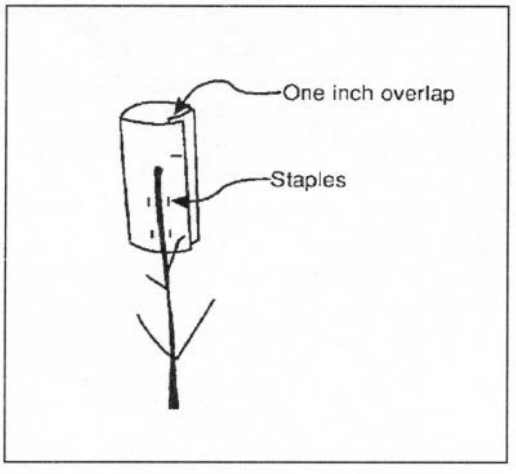


Figure 23—Bud cap, showing placement of staples in relation to the terminal bud.

References

Baron, F.J.; Nord, E.C.; Evanko, A.B.; Makel, W.J. 1966. Seeding conifers and buffer crops to reduce deer depredation. Res. Note PSW-100. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 8 p.

Bartik, M.; Piskac, A., eds. 1961. Veterinary toxicology. Amsterdam, Oxford, New York: Elsevier Scientific Publishing Co. 346 p.

Black, H.C., ed. 1969. Proceedings, symposium on wildlife and reforestation in the Pacific Northwest; 1968 September 12-13; Corvallis, OR. Corvallis, OR: Oregon State University, School of Forestry. 92 p.

Black, H.C.; Hooven, E.F. 1974. Response of small-mammal communities to habitat changes in western Oregon. In: Black, H.C., ed. Proceedings, symposium on wildlife and forest management in the Pacific Northwest; 1973 September 11-12; Corvallis, OR. Corvallis, OR: Oregon State University: 177-186.

Borrecco, J.E. 1976. Controlling damage by forest rodents and lagomorphs through habitat manipulation. In: Siebe, C.C., ed. Proceedings, 7th vertebrate pest conference; 1976 March 9-l 1; Monterey, CA. Davis, CA: University of California: 203-210.

Boyd, R.J. 1967. Vegetation management and animal damage. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, workshop on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: **55-58**

Brown, E.R.; Mandery, J.H. 1962. Planting and fertilizing as a possible means of controlling distribution of big game animals. Journal of Forestry. 60 (1): [pages unknown].

Campbell, D.L.; Evans, J. 1975a. "Vexar" seedling protectors to reduce wildlife damage to Douglas-fir. Wildl. Leafl. 508. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 11 p.

Campbell, D-L.; Evans, J.A. 1975b. Improving wildlife habitat in young Douglas-fir plantations. In: Sabol, K. H., ed. Transactions, 40th North American wildlife and natural resources conference; 1975 March 16-19; Pittsburg, PA. Washington, DC: Wildlife Management Institute: 202-208.

Case, R.M. 1983. Pocket gophers. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska: B-13 to B-17.

Caslick, J.W. 1980. Effects of insecticides on birds and mammals Misc. Bull. 109. Ithaca, NY: Cornell University. 14 p.

Caslick, J.W.; Decker, D.J. 1979. Economic feasibility of a deer-proof fence for apple orchards. Wildlife Society Bulletin. 7(3): 173-175.

Fisher, P.H. 1986. Keeping beavers from plugging culvert inlets. In: Engineering Field Notes. Washington, DC: U.S. Department of Agriculture, Forest Service; 18: 9-13.

Flowers, R.H. 1987. Supplemental feeding of black bear in tree damage areas of western Washington. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, workshop on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 149-153.

Giles, R.H., ed. 1969. Wildlife management techniques. 3d. ed. Washington, DC: The Wildlife Society. 623 p.

Grisez, T.J. 1960. Slash helps protect seedlings from deer browsing. Journal of Forestry. 58: 385-387.

Guenther, S.E. 1956. Beaver baffler. Olympia, WA: Washington State Game Bulletin. 8(3): 3-6.

Keyes, J.; Smith, C.F. 1943. Pine seed-spot protection with screens in California. Journal of Forestry. 41: 259-264.

Larson, J.E.; Campbell, D.L.; Evans, J.; Lindsey, G.D. 1979. Plastic tubes for protecting seedlings from browsing wildlife. ED&T 2217. Missoula, MT: U.S. Department of Agriculture, Forest Service, Equipment Development Center. 19 p.

Longhurst W.M.; Jones, M.B.; Parks, R.R. [and others]. 1962. Fences for controlling deer damage. Circ. 514. Davis, CA: University of California, Division of Agricultural Sciences. 19 p.

McCabe, R.A. 1970. Vertebrate pests: problems and control. Principles of plant and animal pest control. Washington, DC: National Academy of Sciences, National Research Council, Subcommittee on Vertebrate Pests. 153 p. Vol. 5.

McCracken, H.; Van Cleave, H. 1947. Trapping: the craft and science of catching fur-bearing animals. New York: A.S. Barnes. 196 p.

Radwan, M.A. 1963. Protecting forest trees and their seeds from wild mammals: a review of the literature. Res. Pap. PNW6. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 28 p.

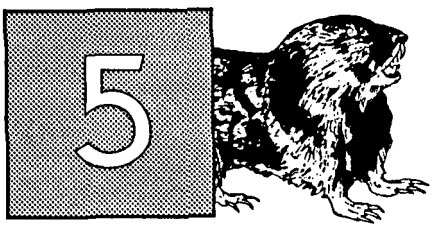
Radwan, M.A. 1970. Destruction of conifer seed and methods of protection. In: Dana, R.H., ed. Proceedings, 4th vertebrate pest conference; 1970 March 3-5; West Sacramento, CA. Davis, CA: University of California: 77-82.

Rochelle, J-A.; Gauditz, I.; Oita, K.; Oh, J.H.K. 1974. New developments in big-game repellents. In: Black, H.C., ed. Proceedings, symposium on wildlife and forest management in the Pacific Northwest; 1973 September 11-12; Corvallis, OR. Corvallis, OR: Oregon State University, School of Forestry: 103-112.

Thompson, W.T. 1981. Agricultural chemicals. Book III: Fumigants, growth regulators, repellents, and rodenticides. Fresno, CA: Thompson Publications. 182 p.

Timm, R.M., ed. 1963. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension Service; Great Plains Agricultural Council.

Webb, W.L. 1966. Forest wildlife management in Germany. Journal of Wildlife Management. 24(2): [pages unknown].



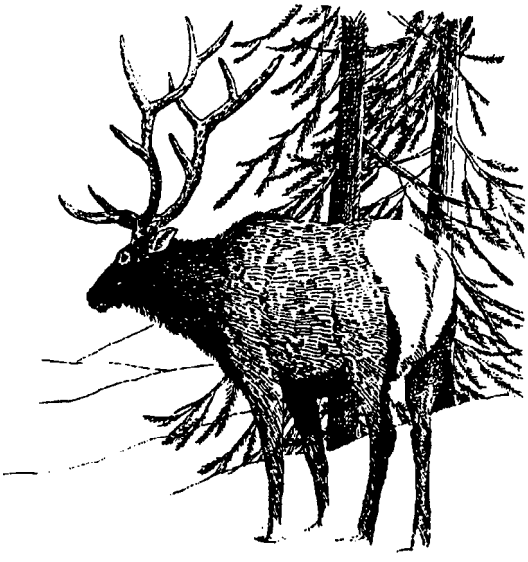
Chapter 5

Wildlife Problem Species and Their Management

Contents

Large Mammals

Rocky Mountain Elk, Wapiti
(Cervus elaphus nelsonl)



Description-A large member of the deer family with a pale yellow rump patch, small tail, and reddish brown body. Elk can weigh up to 1,000 pounds. Males have huge spreading antlers. Cows are much smaller, rarely weighing more than 600 pounds.

Economic significance-The Rocky Mountain elk is one of the most prized game animals. Money spent in its pursuit provides a substantial source of income to local communities that furnish services and supplies.

Overgrazing by elk in localized areas may cause range and watershed problems when populations are allowed to exceed carrying capacity. Rocky Mountain elk also may cause serious problems in forest regeneration, and in some areas, elk depredations cause serious economic losses to ranchers. When forced by hunger, elk will use orchards and haystacks to supplement their diets.

Life history information-

Preferred habitat--Rocky Mountain elk are found in timbered mountainous areas. Favored habitats include meadows and grasslands for feeding and dense timber for cover. Optimum habitat has gentle terrain and free-running water available during summer. Areas disturbed by fire or logging usually support a diversity of vegetation and are attractive to elk. A good distribution of escape cover is needed to make these areas more desirable.

Feeding habit-shrubs, forbs, grasses, and sedges form the basic diet, but significant quantities of forbs and browse are used seasonally. During spring and early summer, succulent grasses, sedges, and forbs make up the major portion of the diet of Rocky Mountain elk. As grasses and sedges mature during late summer and early fall, the diet shifts to shrub species, which stay succulent longer. Wintering can occur on open bunchgrass or shrub ranges, as the highly adaptable elk will use whatever food source is most readily available. The two daily feeding periods are in the morning-from just before to several hours after daylight-and in the early evening. Winter feeding periods are more frequent and erratic.

Acfivity--Elk normally cover several miles a day as they feed during spring, summer, and fall. In winter, they are more sedentary and feed heavily in one area before moving to another. Migration from summer to winter range usually takes place in late November and December. Some routes are more than 100 miles, but they usually are much shorter.

Elk are gregarious and travel in herds most of the year. Herd size is greatest from late summer through winter. Older bulls are more solitary, are often found alone, and tend to winter at higher elevations.

Elk make well-defined trails. They usually bed on gentle slopes, benches, or ridgetops.

Reproduction--Rocky Mountain elk are polygamous. Their main breeding period is from late August through September. The gestation period is 249 to 262 days, with the calf drop occurring from late May to mid-June. Breeding age of cows normally begins at 2-1/2 years, although 1-1/2 year-old cows may breed. Bulls 1-1/2 years old are capable of breeding and are significant breeders in many heavily hunted populations. Many Rocky Mountain elk herds have high calf production rates, with a 35 to 50-percent annual rate of population increase possible.

Damage problems and their management-

Browsing-Elk, possessing lower incisors only, leave a splintered break on browsed, dormant woody stems (see fig. 1). Spring browsing may cause the bark to slip from the browsed twig, resulting in a stripped stem below the break. Small, newly planted seedlings may be pulled out by elk, especially on wet or loose, sandy soils. Where large numbers of planted seedlings are missing completely and elk are numerous, elk may be responsible. Elk also bark shrubs and small deciduous trees, particularly willow and cottonwoods. Elk may seriously damage plantations by trampling, particularly along trails and in loafing and bedding areas.

Grazing--Grazing use is difficult to differentiate from that of livestock. The best way to identify the impact of elk use on rangelands is by a combination of surveys. A range survey (FSH 2209.21) can be used to evaluate total forage use, and a series of pellet-group-count transects (see chapter 3), which can be read once or twice a year, can be used to separate big-game use from domestic stock use.

Deferming the need for damage **management-Browsing** on conifers is frequently highest immediately after planting in new clearcuttings. When forage plants become well established in a harvest unit, the amount of conifer use declines. A survey, such as the reforestation stocking survey, should be made to gather information to evaluate degree of use by elk. Browsing of 20 percent or less of the terminal shoots is usually not sufficient to warrant control, because a plantation may sustain the effects of such browsing without serious growth loss. Elk prefer to feed near bedding areas, and damage may be concentrated near them. Some plantations can be adequately protected by treating only those areas on gentle to moderate slopes. Overuse by grazing is frequently the result of excessive use by both big game and domestic livestock. The type of control depends on the land-management objectives for the particular area and the ability to implement control practices.

As in most damage situations, the best predictive information can be found by evaluating adjacent areas having similar conditions and history.

Management methods-

Hunting--increased elk damage to plantations or forage areas may be related to habitat deterioration. Downward trends in the condition of big-game habitat must be brought to the attention of the state wildlife agency and the public that does the hunting.

Silviculfural **modifications-leave** sufficient debris on the site after site preparation to provide seedling protection and forage for elk. When planting on wintering areas, plant as late in the spring as is consistent with other reforestation practices, use large 2-O planting stock, plant seedlings in spots protected by debris or other obstructions, and plant seedlings a minimum of 8 feet from well-used elk trails. On steep hillsides, plant in or above debris piles.

Habitat manipulation-Consider forage fertilization, supplemental food development, or improvement of forage species composition to lessen impacts on planted trees (see chapter 4).

Area protection-Properly constructed, 8-foot high, woven-wire fences will exclude elk, but this procedure is costly and seldom used other than for very high-value plantations. Resource managers must weigh the advantages and disadvantages involved in fencing portions of National Forest System lands.

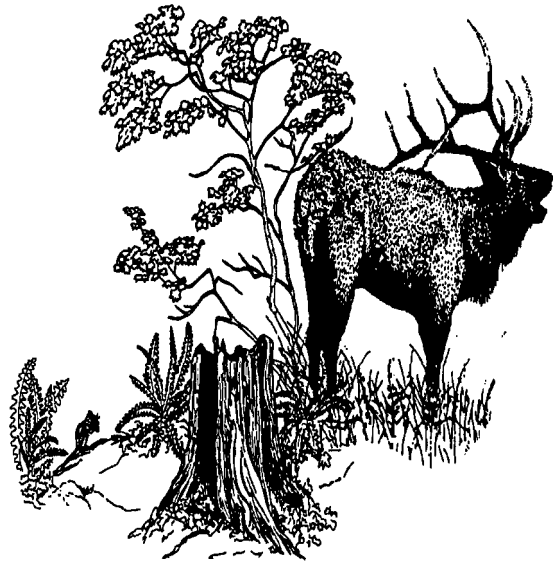
Individual tree protection--Tubing or bud caps on individual trees will protect them from elk damage (see chapter 4). For additional details see Campbell and Evans (1975; also reprinted in appendix 3).

Repellents-Big game repellent can be used to provide short-term protection to seedlings (see chapter 4 and section on black-tailed deer).

References--References for Rocky Mountain elk are combined with those for Roosevelt elk and are found at the end of that section (below).

Roosevelt Elk, Wapiti (Cervus *elaphus rooselvelti)*

Description-The Roosevelt elk is the largest subspecies of North American elk. Mature bulls weigh 700-1,000 pounds and mature cows 400-700 pounds. The antlers of the Roosevelt elk are generally shorter, less symmetrical, more massive, and have a narrower spread than those of the Rocky Mountain elk. The wintercoat is heavy with dark brown coloring on head, neck, and legs. The sides are a much lighter grayish-brown, and a large rump patch is whitish-yellow in color. The summer coat is more reddish brown.



Economic significance--Roosevelt elk of the Pacific slopes of Washington, Oregon, and northern California are highly valued by both outdoor enthusiasts and those who wish only to observe and photograph the animals. (About 8,000 Roosevelt elk are harvested annually in Washington and Oregon.)

In some areas, feeding damage constitutes an important loss in forest plantations. Plantation damage also may occur when elk trample young trees.

Life history information-

Preferred **habitat-Roosevelt** elk generally range west of the Cascade Crest in Oregon and Washington. They favor forest ranges that provide a mosaic of young and mature stands interspersed with grassy openings and narrow streamside meadows. During summer, elk in the Olympic Mountains and on the western slopes of the Cascade Range in Oregon and Washington may migrate to high mountain meadows.

Optimum habitat includes about 60 percent cover, gentle southerly or flat exposures, and a free-running water source, all in close proximity.

Feeding habits-shrubs, forbs, grasses, and sedges are all eaten readily at some period of the year. Elk use of Douglas-fir differs with season and availability of other food materials. Succulent new growth on Douglas-fir is frequently eaten, even when there is an abundance of other food. Western hemlock occasionally constitutes a major food in winter. Elk generally feed upslope in steep country. Roosevelt elk seldom feed more than 200 yards from suitable hiding or escape cover.

Activity--Roosevelt elk are most active just before dawn and again in late afternoon. Daytime activity increases during winter, when food is less abundant. Home ranges average about 2 to 4 square miles for nonmigratory populations. Migratory populations follow the receding snow to summer ranges at higher elevations. Most elk return each year to the same wintering area. Roosevelt elk normally feed over a large circular route, moving slowly through each feeding area and then moving on. A typical small band of elk makes a complete circuit of its feeding area in about 2 or 3 weeks.

Reproduction--Roosevelt elk are polygamous. Most breeding takes place between September 15 and October 15. Most yearling bulls are capable of breeding. Preseason populations have 2 to 10 percent antlered bulls. On good range, females usually breed during the second fall after birth. The gestation period is from 8 to 8-1/2 months, and calves are dropped from mid-May through June. Less than 1 percent of births are twins. Cows in the wild are believed to be capable of bearing young for at least 20 years. Lactating cows are frequently in such poor condition that fewer than half become pregnant. Most cows with calves are still lactating during the breeding season. Studies have shown that 75 to 85 percent of dry cows and all cows in areas with high-quality forage are capable of conceiving.

The mean annual population increase depends on many factors, with quality of forage, herd density, and age structure being most important. Herds are capable of increasing at a rate of 25 to 40 percent per year.

Damage problems and their management-

Identification-Elk, possessing lower incisors only, leave a splintered break on browsed, dormant woody stems. Spring browsing may cause the bark to slip from the browsed twig, resulting in a stripped stem below the break. Small, newly planted seedlings occasionally are pulled up by elk, especially in loose, sandy, or pumice soils. Elk also bark shrubs and small deciduous trees, particularly willows and cottonwoods. Areas damaged by elk often are related to movement patterns. Elk usually travel in small bands, making well-defined trails. They bed most often on gentle slopes, benches, or ridgetops.

Determining the need for damage **management-Although** use of clearcuttings by Roosevelt elk is heaviest 6 to 8 years after logging, severe damage to coniferous seedlings may occur immediately after planting. Moderate to heavy browsing damage may occur throughout stand establishment and continue until terminal shoots of Douglas-fir and other conifer saplings are out of reach of the elk. Rubbing the antlers on trees may cause serious injuries, but it seldom kills the trees.

A survey should be made to gather information to evaluate degree of use by elk. Browsing of 20 percent or less on the terminal shoots usually is not significant enough to warrant control, because the plantation may sustain the effects of such browsing without serious growth loss. Some plantations can be adequately protected by treating only those areas preferred by elk that are on gentle to moderate slopes.

As in most damage situations, the best predictive information can be found by evaluating adjacent areas with similar conditions and history.

Management methods-

Hunting--lncreased elk damage to plantations may be related to habitat deterioration. Downward trends in the condition of big-game habitat should be brought to the attention of the state wildlife agency, so that hunting pressure may be increased.

Silvicultural modifications-Plant on elk wintering areas as late in spring as is consistent with other reforestation practices; use large planting stock (24 to 30 inches high), plant seedlings in spots protected by slash or other obstructions, and plant seedlings a minimum of 8 feet from well-used elk trails. On steep hillsides, plant in or above debris piles.

Habitat **manipulation-Consider** forage, fertilization, supplemental food development, or improvement of forage species composition to lessen impact of elk damage to planted trees.

Area protection--Properly constructed, 8-foot high, woven-wire fences will exclude elk. Resource managers must weigh the advantages and disadvantages involved in fencing portions of National Forest System lands, however.

Individual plant profection--Use plastic tubing or bud caps on the minimum number of trees desired for the site. Treat only those areas likely to be exposed to heavy elk browsing. For additional details see Campbell and Evans (1975) in appendix 3 of this handbook.

Repellents-Big-game repellent can be used to provide short-term protection (see chapter 4 and section on black-tailed deer in this chapter).

Reference-

Becker, J.M. 1989. Forage enhancement in the Pacific Northwest: improving elk habitat and forest regeneration. Seattle, WA: University of Washington, College of Forest Resources. 55 p. M.S. thesis.

Black, H.C.; Dimock, E.J., II; Evans, J.; Rochelle, J.A. 1979. Animal damage to coniferous plantations in Oregon and Washington. Part 1: a survey, 1963-1973. Res. Bull. 25. Corvallis, OR: Oregon State University, School of Forestry, Forest Research Laboratory. 45 p.

Borrecco, J.F.; Black, H.C. 1990. Animal damage problems and control activities on National Forest System lands. In: Davis, L.R.; Marsh, R.E.; Beadle, D.E., eds. Proceedings, 14th vertebrate pest conference; 1990 March 6-8; Sacramento, CA. Davis, CA: University of California: 192-198.

Campbell, D.L.; Evans, J.A. 1978. Improving wildlife habitat in young Douglas-fir plantations. In: Sabol, K., ed. Transactions, 40th North American wildlife and natural resources conference; 1975 March 16-19; Pittsburg, PA. Washington, DC: Wildlife Management Institute: 202-208.

decalesta, D.S. 1983. Elk. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension Service: D-35 to D-43.

Harper, J.A.; Harn, J.H.; Bentley, W.W.; Yocum, CF. 1967. The status and ecology of the Roosevelt elk in California. Wildlife Monograph 16. Washington, DC: The Wildlife Society. 49 p.

Harper, J.S. 1971. Ecology of Roosevelt elk. [Location of publisher unknown]: [Publisher unknown]; Federal Aid Project W-59-R Oregon State Game Commission. 44 p.

Rochelle, J.A. 1979. Effects of forest fertilization on wildlife. In: Gessel, S.P.; Kenady, R.M.; Atkinson, W.A., eds. Proceedings, forest fertilization conference; 1979 September 25-27; Seattle, WA. Inst. For. Resour. Contrib. 40. Seattle, WA: University of Washington, College of Forest Resources: 163-168.

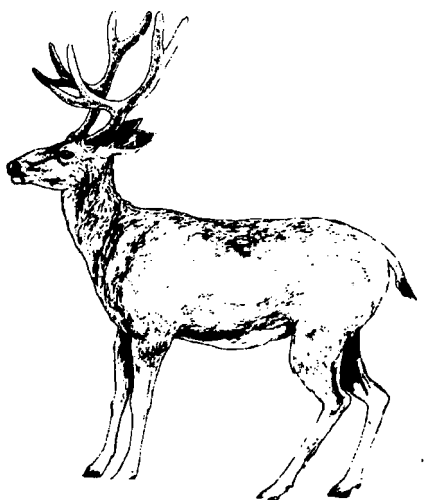
Rochelle, J.A. 1992. Deer and elk. In: Black. H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 333-349. Chapter 16.

Swanson, D.O. 1970. Roosevelt elk-forest relationships in the Douglas-fir region of the southern Oregon Coast Range. Ann Arbor, Ml: University of Michigan. 173 p. Ph.D. dissertation.

Thomas, J.W.; Toweill, D.E., eds. 1982. Elk of North America: ecology and management. Harrisburg, PA: Stackpole Books. 698 p.

Witmer, G.W.; Wisdom, M.; Harshman, E.P. [and others]. 1985. Deer and elk. In: Brown, E.R., ed. Management of wildlife and fish habitats in forests of western Oregon and Washington. Part 1: Chapter narratives. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region: 231-258. Chapter 11.

Mule Deer
(Odocoileus hemionus)



Description-Mule deer differ considerably in size; bucks may weigh more than 300 pounds live weight. Pelage is dark gray during fall and winter months, reddish brown in summer. Large ears, white rump, and a short, round tail with a black tip and hairless undersurface are typical mule deer characteristics. Antlers branch in a dichotomous manner.

Economic significance-The mule deer is an important big-game animal, in both total kill and hunter days of effort. For example, during the 1982 hunting season, more than 60,000 mule deer were harvested in northern Idaho and Montana, 21,000 of which were taken from National Forest System lands. Serious reforestation problems can occur in plantations within or adjacent to deer winter range. Most damage occurs from mid-fall through spring.

Life history information-

***Preferred* habitat-Mule** deer use nearly all habitat types that provide suitable food, cover, and water. Preferred topography includes open forests and broken brushlands on steep and rugged terrain.

Foods and feeding-Mule deer are primarily browsers and consume woody forage throughout the year. In fall and early spring, however, grasses make up a significant part of their diet. Forbs are used extensively during late spring and summer.

Acfivity--Daily movements are from 1 to 2 miles on summer range. On winter range, daily movement is much more restricted, generally about 1/4 mile, if undisturbed.

Most feeding is done in late evening and early morning; however, in winter it takes place throughout the day. Mule deer tend to be gregarious. This is particularly true during winter, when they often form groups of 10 or more.

Reproduction-Mule deer are polygamous. Breeding takes place from late October through early December. The gestation period is 196 to 210 days, with the fawn drop occurring in June. Most deer breed at 16 to 18 months of age. During the first two pregnancies, single fawns are normal; thereafter, twin births are common. The average number of fawns per doe is 1.5. Potential productivity is 50 to 60 percent annual increase, but net productivity seldom exceeds 20 to 40 percent in most herds.

Damage problems and their management-

Barking-Antler polishing by mule deer leaves tree bark in a shredded condition, with long frayed strips of bark hanging at the top and bottom of the barked area. Antler polishing is generally restricted to an area between 1 -1/2 and 3-1/2 feet above the ground. Preferred targets are small, live, open-growth saplings 3/4 to 1-1/2 inches in diameter, generally restricted to an area between 1-1/2 and 3-1/2 feet above the ground.

Browsing-Deer feeding on woody vegetation leave a ragged splintered edge during the dormant season, although early spring browsing may result in the bark slipping, thereby leaving a stripped stem some distance below the break. Browsing of new growth usually leaves a clean, blunt stem-end, where the tender shoots were broken off. Browsing seldom occurs more than 4 feet above the ground, except in deep snow situations (see chapter 2).

Grazing--Deer use of grass and forbs is best differentiated from use by domestic livestock and other ungulates by the use of pellet transects (see chapter 3).

***Need for* management-Antler** polishing occurs sporadically and control is generally impractical. Browsing of less than 20 percent of the terminals is generally not a serious problem on established plantations.

The amount of deer use on rangelands that is required to constitute damage will depend in part on the objectives set for the area. If a combined deer-livestock overuse situation occurs, and if reduction in deer or livestock use is anticipated, pellet transects can help document the amount of deer use.

Management methods-

Hunting-Controlling mule deer damage by hunting is often feasible because the animals occupy open habitat and form groups in late fall. Hunting should not be considered a panacea, however, because in preferred habitats with large deer populations, tree damage may occur even though large herd reductions are made. Roads into the problem areas should be kept open and maintained during the hunting season to promote increased deer harvest.

Silvicultural modifications-Leave 20 to 30 tons per acre of debris on the site after site preparation. When planting on or near deer winter range, plant as late in the spring as is consistent with other reforestation practices. Do not plant trees within 8 feet of well-used deer trails. Practice obstruction planting (see chapter 4).

Habitat **manipulation--Consider** forage fertilization, supplemental food development, or improvement of forage species composition to lessen impacts on planted trees (see chapter 4).

Area **protection-An** 8-foot fence will effectively protect most plantations. If plantations are in deer migration routes or are subject to extremely heavy deer pressure, a woven wire fence should be used. Area protection has a number of disadvantages and should not be used if other protective measures will be equally effective (see chapter 4). Managers must determine the feasibility of this based on local conditions and current costs.

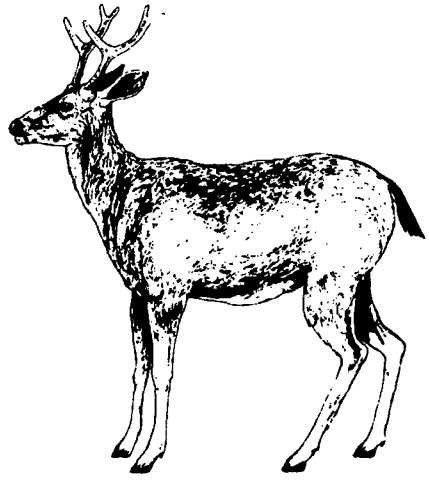
Individual tree protection--Tubing or bud caps on individual trees will protect them from deer damage (see chapter 4). For additional details see Campbell and Evans (1975; also reprinted in appendix 3).

Repel/en&-Big-game repelllent may be applied to seedlings to provide protection (see chapter 4 and black-tailed deer). Thiram can be used as a brush-on during the dormant season.

References-References for mule deer are combined with those for black-tailed deer and are found at the end of that section (below).

Black-Tailed Deer
(Odocoileus hemionus columbienus)

Description-The black-tailed deer is smaller than the mule deer, its closest relative. Adult black-tailed does average **110 to 130** pounds live weight, with an occasional doe weighing up to 145 pounds. Adult bucks average 120 to 160 pounds, although an occasional buck may exceed 200 pounds live weight. The summer pelage is typically reddish brown, in contrast to the winter coat, which is predominately brown to gray-brown. The tail is broad at the base and narrows gradually to a rounded tip. The outer surface of the tail is dark brown to black, with a white undersurface. The rump patch is not as pronounced as in the typical mule deer. When startled, black-tailed deer often raise their tail as a flag, similar to the behavior of white-tailed deer.



Antlers of black-tailed deer branch in a dichotomous manner, typical of mule deer. Antlers begin growth in April and are dropped from mid-December to March. Antlers of most yearling black-tailed deer and many 2 year olds develop as spikes. Branched antlers are rare for yearlings but are most common for 2 and 3 year olds.

Economic significance-The black-tailed deer is the most important game animal west of the Cascade crest, with about 90,000 harvested annually in Washington and Oregon.

Black-tailed deer usually are able to meet their year-long habitat needs within a limited area, and as a result they exert a steady pressure on forest crops. Conifer plantations often are set back as much as 5 years because of heavy deer feeding.

Life history information-

Preferred habitat-Black-tailed deer range west of the crest of the Cascade Range in Oregon and Washington. They occupy a wide range of habitats and thrive in areas of subclimax vegetation that develop after fire or logging.

Feeding habits--Black-tailed deer are primarily browsing animals, but they also consume a wide variety of herbaceous plants. As grasses and forbs become available, the volume of browse in the diet decreases. Use of conifers differs as a result of abundance, location, time of year, availability of other foods, and deer population density. The feeding pattern on steep slopes is generally uphill. Black-tailed deer seldom venture more than 200 yards from escape cover while feeding.

Activity-Daily movements are usually only a few hundred yards in extent. Many black-tailed deer are nonmigratory and spend most of their lives within an area of 1 to 2 square miles. In the more mountainous portions of their range, black-tailed deer may seasonally move to higher elevations. Migrations seldom exceed 1 mile. Deer moving into the Cascade Range migrate several miles to spend summer at upper elevations and return in fall to winter ranges that are usually below 2,000 feet.

Reproduction-Black-tailed deer are polygamous. Breeding takes place from late October to early December, with the peak occurring in mid-November. They usually breed as yearlings, but the greatest productivity is in the 3-1/2- to 6-1/2-year age group. The gestation period is about 208 days. The average fawn-per-doe ratio in good habitat is about 1.2 and in poor habitat is about 0.8. Black-tailed deer have reproductive rates of 35 to 65 percent per year, with habitat conditions being the principal control on population growth rate.

Damage problems and their management-

Barking-Antler polishing by black-tailed deer leaves the bark in a shredded condition with long frayed strips of bark hanging at the top and bottom of the barked area. Antler polishing is generally restricted to an area between 1-1/2 and 3-1/2 feet above the ground. Preferred targets are small live saplings 3/4 to 1-1/2 inches in diameter.

Browsing-Deer feeding on woody vegetation leave a ragged, splintered stem during the dormant season, although early spring browsing may cause the bark to slip, which leaves a stripped stem some distance below the break. Browsing of new growth usually leaves a clean, blunt end where the tender shoots were broken off. Browsing seldom occurs more than 4 feet above the ground, except in deep snow situations.

Winter and summer browsing damage to Douglas-fir and other conifers is a widespread problem in the Pacific Northwest (Borrecco and Black 1990). Summer browsing is common in many areas; it starts soon after spring bud burst and continues into the summer.

Determining the *need for* damage management-Antler polishing occurs sporadically and in such a manner that control is generally impractical. Browsing of less than 30 percent of the terminals is generally not a serious problem on established plantations.

Management methods-

Hunting-Sport hunting to regulate black-tailed deer numbers is the most desirable, although not always the most effective, method of controlling browsing damage to plantations. Deer population levels that can be maintained in this way without causing damage to other forest resources must be determined from a knowledge of local habitat conditions and deer use patterns. Obtaining a harvest that will produce a desired population level is primarily the result of coordination with the state wildlife agency and the hunting public. Roads into the problem areas should be kept open and maintained during the hunting season to promote increased deer harvest.

Silvicultural modifications-Leave logged areas unburned to restrict deer access to trees and to preserve existing food. When planting on deer winter range, plant as late in the spring as is consistent with other reforestation requirements. Mix tree species and include those that local experience has indicated are of low preference. Plant stock 24 to 30 inches tall with leader diameters of 3/8 inch or larger. Plant seedlings in spots protected by slash or other obstructions and a minimum of 8 feet from well-used deer trails. Plant on the uphill side of logs, stumps, rocks, and other obstructions when on steep hillsides.

Habitat **manipulation-Consider** possibilities for reducing browsing pressure on conifers by improving quantity and quality of food in areas away from damage-susceptible plantations.

Area protection-Gameproof fencing is an effective method of controlling deer use in plantations, if it is economically feasible. It restricts other uses on the area, however, and should be used only after other protection alternatives have been evaluated and judged inappropriate.

/individua/ tree Protection--Plastic-mesh tubing or bud caps on individual trees are effective in protecting trees from deer damage. Tubing should not be used on steep slopes where deep snow cover normally occurs. For additional details see Campbell and Evans (1975; also reprinted in appendix 3).

Repellents--Big-game repellent, a putrified protein product derived from whole eggs, is available in both liquid and powder formulations. It is registered for the protection of conifer seedlings (Douglas-fir, noble fir, grand fir, and ponderosa pine) from black-tailed deer and Roosevelt elk in the Pacific Northwest (see chapter 4). These repellents may be applied to seedlings in the nursery bed or by backpack sprayer to newly planted or established seedlings in the field. The recommended use during the growing season is to apply deer repellents to new growth immediately after bud burst.

References-

Black, H.C.; Dimock, E.J., II; Evans, J.; Rochelle, J.A. 1979. Animal damage to coniferous plantations in Oregon and Washington. Part 1: a survey, 1963-1973. Res. Bull. 25. Corvallis, OR: Oregon State University, School of Forestry, Forest Research Laboratory. 45 p.

Borrecco, J.E.; Black, H.C. 1990. Animal damage problems and control activities on National Forest System lands. In: Davis, L.R.; Marsh, R.E.; Beadle, D.E., eds. Proceedings of the 14th vertebrate pest conference; 1990 March 6-8; Sacramento, CA. Davis, CA: University of California: 192-198.

Brown, E.R. 1961. The black-tailed deer of western Washington. Biol. Bull. 13. Olympia, WA: Washington State Game Department. 124 p.

Campbell, D.L.; Evans, J. 1978. Establishing native forbs to reduce black-tailed deer browsing damage to Douglas-fir. In: Howard, W.E., ed. Proceedings, 8th vertebrate pest conference; 1978 March 7-9; Sacramento, CA. Davis, CA: University of California: 145-151.

Craven, S.R. **1983.** Deer. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska: D-23 to D-33.

Crouch, G.L. 1966. Preferences of black-tailed deer for native forage and Douglas-fir seedlings. Journal of Wildlife Management. 30(3): 471-475.

Crouch, G.L. 1980. Post-season hunting to reduce deer damage to Douglas-fir in western Oregon. Res. Note PNW-349. Portland, OR: U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station. 6 p.

Gourley, M.; Vomocil, M.; Newton, M. 1987. Mitigating deer browse damage-protection or competition control? In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension Service: 113.

Hines, W.W. 1973. Black-tailed deer populations and Douglas-fir reforestation in the Tillamook Burn, Oregon. Game Rep. 3. Corvallis, OR: Oregon Department of Fish and Wildlife, Research Division. 59 p.

Longhurst, W.M.; Leopold, AS.; Dasmann, D.F. 1952. A survey of California deer herds, their ranges and management problems. Bull. 6. Sacramento, CA: California Department of Fish and Game. 136 p.

Mackie, R.J.; Hamlin, K.L.; Pat, D.F. 1982. Mule deer *(Odocoileus hemionus).* In: Chapman, J.A.; Feldhamer, G.A., eds. Wild mammals of North America: biology, management, and economics. Baltimore, MD: Johns Hopkins University Press: **862-877.**

Radwan, M.A. 1972. Differences between Douglas-fir genotypes in relation to browsing preference by black-tailed deer. Canadian Journal of Forest Research. **2(3): 250-255.**

Rochelle, J.A. 1992. Deer and elk. In: Black. H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 333-349. Chapter 16.

State of Oregon. 1980. The Oregon interagency guide for conservation and forage plantings. Portland, OR: State of Oregon, Oregon State University and Oregon Department of Fish and Game; U.S. Department of Agriculture, Forest Service and Soil Conservation Service; U.S. Department of the Interior, Bonneville Power Administration and Bureau of Land Management. 84 p.

Taber, R.D.; Dasmann, R.F. 1958. The black-failed deer of the chaparral, ifs life history and management in the north Coast Range of California. Game Bull. 8. Sacramento, CA: California Department of Fish and Game. 163 p.

Taylor, R.H.; Johnson, R.L. 1976. Big game habitat improvement project in western Washington. Olympia, WA: Washington State Department of Game; job completion report; project W74-R-4. 220 p.

Wolertz, W.C. 1987. Evaluating deer damage control in ponderosa pine plantations on the Paisley Ranger District. Lakeview, OR: U.S. Department of Agriculture, Forest Service, Fremont National Forest. 83 p.

White-Tailed Deer
(Odocoileus viginianus)

Description-The white-tailed deer is smaller than the mule deer and black-tailed deer, although the species differs widely in size throughout ifs range. Pelage is gray-brown during fall and winter, reddish brown in summer. Large fail, white beneath; antlers (males only) branch from main beam.

Economic significance-The white-tailed deer is the most common and widely distributed deer in North America and is the most important big-game animal in the Nation, in both kill and hunter days.

There is direct competition between white-tailed deer and domestic livestock, particularly on deer winter ranges. Much of this range is privately owned and is used by ranchers as spring and fall range. When forage competition becomes keen, the ranchers may be faced with downward adjustments in stocking or supplemental feeding. In either case, they may suffer a financial loss.

Serious reforestation problems can occur in plantations within or next to deer winter range. Most damage occurs from mid-fall through spring. In hardwood forests, browsing on understory vegetation may cause extensive damage to young tree seedlings. The estimated cost of this damage to hardwood forest landowners in Pennsylvania was estimated at $13 per acre per year if control measures (including fencing, fertilizing and herbiciding) were not used (Tilghman 1984). In Eastern forests, deer have seriously damaged oak and aspen regeneration. They also have inflicted browsing damage on planted white pines.

For some areas, guidelines are available for integrating deer management and timber management (Pruitt and Pruitt 1986). Consult with your National Forest wildlife biologist for updates on this topic.

Life history information-

Preferred habitat-White-tailed deer use various habitat types. Topography does not appear to be a constraint to use; however, preference for mesic sites, such as flood plains, marshes, and stream bottoms, does exist.

Feeding habit-White-tailed deer are primarily browsers and consume woody forage throughout the year. In spring, grasses make up a significant part of the diet. Forbs make up a substantial part of the diet during spring and summer months. The winter diet consists primarily of browse species, with conifers being a locally significant component, where available.

Activity--In northern climates, daily movements are from 1 to 2 miles on summer range. On winter ranges, daily movement is much more restricted, generally about 1/4 mile if undisturbed. Most feeding activity is in late evening and early morning; however, if may fake place throughout the day in winter.

White-tailed deer tend to be gregarious during the rut and particularly during the winter.

Reproduction-White-tailed deer are polygamous. Breeding fakes place from mid-November through early January. The gestation period is 185 to 200 days. Most female white-tailed deer breed at 18 months of age.

Damage problems and their management-

Barking-Antler polishing by white-tailed deer leaves the bark in a shredded condition, with long-frayed shreds of bark hanging at the fop and bottom of the barked area. Antler polishing is generally restricted to an area between 1-1/2 and 3-1/2 feet above the ground. Preferred targets are small, open-grown saplings 3/4 to 1-1/2 inches in diameter.

Browsing-Deer feeding on woody vegetation leaves a ragged splintered edge during the dormant season, although early spring browsing may result in the bark slipping, which leaves a stripped stem some distance below the break. Browsing of new growth usually leaves a clean, blunt stem end where the tender shoots were broken off. Browsing seldom occurs more than 4 feet above the ground, except in deep snow situations (see chapter 2).

Grazing--Deer use of grass and forbs is best differentiated from use by domestic livestock and other ungulates by the use of pellet transects (see chapter 3).

Need for management-Antler polishing occurs sporadically and control is generally impractical. Browsing of less than 20 percent of the terminals is generally not a serious problem on established plantations.

The amount of deer use on rangelands that is required to constitute damage will depend in part on the objectives set for the area. If a combined deer-livestock overuse situation occurs, and if reduction in deer or livestock use is anticipated, pellet transects can help document the amount of deer use.

Management methods-

Hunting--Managing deer damage by sport hunting is often feasible where animals occupy open habitat and form into groups in late fall. Hunting should not be considered a panacea, however, because in preferred habitats with large deer populations, free damage may occur even though large herd reductions are made. Keep roads open to encourage hunting.

Silvicultural modifications-Similar to mule deer (see previous section on mule deer). In addition, fertilization to promote rapid seedling growth or use of fencing to temporarily exclude deer from recently harvested areas has proven very successful in achieving successful reforestation on the Allegeheny National Forest in Pennsylvania (Tilghman 1984).

Habitat **manipulation--Consider** forage fertilization, supplemental food development, or improvement of forage species composition, to lessen impacts on planted trees (see chapter 4). Opening the overstory to discourage deer browsing during the regeneration period has been helpful in trials at the Ottawa National Forest in Michigan.

Area **protection-An** 8-foot fence will effectively protect most plantations. If plantations are located in deer migration routes or are subject to extremely heavy deer pressure, a woven wire fence should be used. Area protection has a number of disadvantages and should not be used if other protective measures will be equally effective (see chapter 4).

Where nurseries experience high levels of deer damage, a permanently installed woven wire fence will likely prove to be effective. Several designs have been used successfully by orchard owners; an 8-foot-high mesh fence topped with two strands of wire (about 1 and 2 feet above the woven wire) has generally been cost-effective (Caslick and Decker 1979).

A 1985 survey of 55 users of high-tensile electric fencing for controlling deer damage to orchards and field crops in the Northeast indicated that fence performance was excellent, although a majority reported that deer penetration did occur (Ellingwood and others 1985). A study of 12 randomly selected fences showed that most were in poor operating condition and needed better maintenance.

Several fence designs to exclude deer from hardwood regeneration cuts have been fried over the last 30 years at the Allegheny National Forest in Pennsylvania. An 8-foot woven wire fence has proven effective (1980 cost: $0.81/lineal ft). In their trial of plastic mesh fencing, initial construction costs were less, but increased maintenance costs more than made up for initial savings, when compared with the woven wire fence (Tilghman 1984).

A recent evaluation of an electronic device that emitted auditory and visual stimuli showed no effectiveness in protecting hardwood seedlings in Alabama from deer (Roper and Hill 1985). In this test, the AV-ALARM electronic scare device produced the sound and strobe light.

Individual tree protection-Tubing or bud caps on individual frees will protect them from deer damage (see chapter 4). For additional details see Campbell and Evans (1975; also reprinted in appendix 3).

Repellents--Big-game repellent may be applied to provide protection (see chapter 4). Thiram can be used as a brush-on during the dormant season.

Many compounds have been investigated for their potential use as systemic deer repellents. Because they would be absorbed by the plant, they would have the advantages of not being washed off and protecting new growth. Only the naturally occurring element selenium has shown potential for this use. In studies with penned white-tailed deer at Pennsylvania State University, selenium provided some protection for white ash and black cherry seedlings, but further research is needed with free-ranging deer to evaluate repellency of systemic selenium (Angradi and Tzilkowski 1987). Field tests in Washington, in 1984, failed to confirm adequate repellency of selenium-treated seedlings to black-tailed deer (Black and Lawrence 1992).

Reference-

Angradi, T.R.; Tzilkowski, W.M. 1987. Preliminary testing of selenium-based systemic deer browse repellent. In: Holler, N.E., ed. Proceedings, 3d Eastern wildlife damage conference; 1987 October 18-21; Gulf Shores, AL. Auburn, AL: Auburn University, Cooperative Extension: 102-107.

Black, H.C.; Lawrence, W.H. 1992. Animal damage management in Pacific Northwest forests: 1901-90. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S Department of Agriculture, Forest Service, Pacific Northwest Research Station: 23-55.

Caslick, J.W.; Decker, D.J. 1979. Economic feasibility of a deer-proof fence for apple orchards. Wildlife Society Bulletin. 7(3): 173-175.

Craven, S.R. 1983. Deer. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension: D-23 to D-33.

Ellingwood, M.R.; McAninch, J.B.; Farigone, M.J. 1985. Current status of deer fencing in the Northeast. In: Bromley, P.T., ed. Proceedings, 2d Eastern wildlife damage conference; 1985 September 22-25; Raleigh, NC. Raleigh, NC: North Carolina State University, Cooperative Extension: 180-185.

Jagman, H. 1984. White-tailed deer habitat in north Idaho. Moscow, ID: University of Idaho. 36 p. M.S. thesis.

Martinka, C.J. 1968. Habitat relationships of white-tailed and mule deer in northern Montana. Journal of Wildlife Management. 32(3): 558-565.

Mundinger, J.G. 1980. Population ecology and habitat relationships of white-tailed deer in coniferous forest habitat of northwestern Montana. [Location of publisher unknown]: Montana Department of Fish and Game, Federal Aid Project; W-122-R; progress report, July 1, 1979-June 30, 1980: 8-92.

Owens, T.S. 1981. Movement patterns and determinants of habitat use of white-tailed deer in northern Idaho. Moscow, ID: University of Idaho. M.S. thesis.

Palmer, W.I.; Wingard, R.J. 1982. Electric deer fencing. College Park, PA: Pennsylvania State University, School of Forest Resources. 11 p.

Pengelly, W.C. 1961. Factors influencing production of white-tailed deer on the Coeur d'Alene National Forest, Idaho. [Location of publisher unknown]: U.S. Department of Agriculture, Forest Service. 190 p.

Pruitt, L.R.; Pruitt, S.E. 1986. Effects of northern hardwood management on deer and other large mammal populations. In: Proceedings of a symposium: managing northern hardwoods: [dates of meeting unknown]; [location of meeting unknown]. Syracuse, NY: Syracuse University, College of Environmental Science and Forestry: 363-380.

Roper, R.B.; Hill, E.P. 1985. An evaluation of visual and auditory electronic devices to repel deer. In: Bromley, P.T., ed. Proceedings, 2d Eastern wildlife damage conference; 1985 September 22-25; Raleigh, NC. Raleigh, NC; North Carolina State University: 186-191.

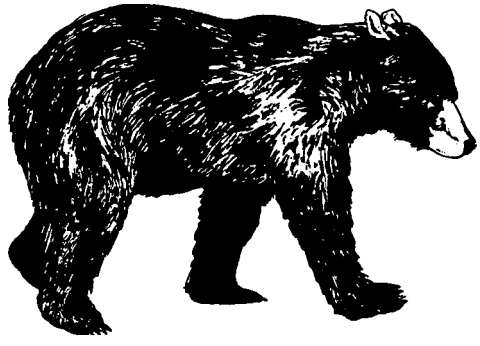
Shaw, H.G. 1962. Seasonal habitat use by white-tailed deer in the Halter Creek enclosure. Moscow, ID: University of Idaho. 36 p. M.S. thesis.

Tilghman, N.G. **1984.** Deer densities and forest regeneration. In: Decker, D.J., ed. Proceedings, 1st Eastern wildlife damage control conference; 1983 September 27-30; Ithaca, NY. Ithaca, NY: Cornell University, Cooperative Extension Service: [pages unknown].

Tilghman, N.G. **1986.** Deer populations and their impact on regenerating northern hardwoods. In: Proceedings, managing northern hardwoods; [dates of meeting unknown]; Syracuse, NY. Syracuse, NY: Syracuse University, College of Environmental Science and Forestry: 286-297.

United States Steel Company. 1980. How to build fences with USS Max-10, 200 high-tensile fence wire. Pittsburgh, PA: U.S. Steel. 75 p.

Black Bear
(Ursus americanus)



Description-Black bears may weigh 200 to 500 pounds and reach a height of 2 to 3 feet at the shoulders. Their color ranges from cinnamon or black to a light brown, and usually a small patch of white is on the breast.

Economic significance-Black bears are game animals in most states. Most black bears are shot incidentally by people hunting deer and elk. There also is considerable sport hunting with hounds in local areas where bears are abundant.

Bear pelts are of only minor importance in the U.S. fur market. The largest outlet is in England where the furs are used in making hats. Poaching of bears to obtain body parts, such as gall bladders, for an illicit foreign trade has become a serious problem in all regions, particularly in the Southeast United States.

Bear damage in forests is localized; however, this damage is expected to increase as more plantations reach pole size. Bear damage was found to be three times higher in thinned versus unthinned blocks in Montana (Schmidt 1987). There, the 6- to 8-inch diameter at breast height (d.b.h.) class had 63 percent of the bear damage. Thinned blocks with moderate damage may still yield significantly more board feet per acre than unthinned stands with less damage. Supplemental feeding of bears may result in hazards to humans and is not recommended.

Life history information-

Preferred habitat-Dense forests with scattered mountain meadows and areas of berry-producing shrubs provide ideal habitat. Bears seldom venture far from escape cover.

Feeding habits--Succulent herbs, roofs, grasses, nuts, fruits, insects, and animal flesh are readily eaten, with vegetable matter making up the bulk of their diet. In many areas, bears do considerable damage to young conifers during May, June, and July by stripping off bark to feed on the sap and inner tissue. They prefer fast-growing, smooth-barked frees 5 to 15 inches d.b.h. They bite the bark off or peel if downward and then scrape the sapwood with upward movements of their lower incisors.

Activity--The size of the home ranges of bears differs considerably by habitat type. In western Washington, for example, the home range of female black bears is about 1 square mile and about 30 square miles for males (Poelker and Hartwell 1973). In Montana, the home range of female and male black bears is 207 acres and 1,233 acres, respectively (Jonkel and Cowan 1971). Information has been tabulated on translocation distances of live-trapped black bears to determine how far they must be moved to minimize their chances of returning (Rogers 1986).

Reproduction-Black bears are polygamous. Most breeding takes place during June and July, and females usually breed every other year. Breeding begins when the animals are 3-1/2 years old. The gestation period is from 7 to 7-1/2 months. Cubs are born in January or February while the mother is still in the den. Twins are normal; singles and triplets are not uncommon. The average annual population increase is about 5 to 12 percent.

Damage problems and their management-

Identification-Black bears leave large strips of bark around the bases of trees they peel. Long vertical grooves in the sapwood are left by the incisors as the bear strips off the outer layers of sapwood (fig. 24), in contrast to rodents that leave short horizontal or diagonal grooves in barked stems.

Determining the need for damage **management-Before** a bear removal program or other bear management practice is begun, stand exam information needs to be reviewed closely to determine whether impacted stands are being reduced below acceptable stocking levels or are only being thinned. Frequently, individual bears can be removed to alleviate a serious damage problem.

Management methods-

Hunting and snaring are the most effective management methods now available. The effectiveness of these methods in reducing damage to young trees is not fully known, but population reduction usually will reduce damage to an acceptable level. There are no current data to support supplemental feeding as a method for reducing bear damage to trees. It is not recommended by the U.S. Department of Agriculture, APHIS-ADC.

Hunting-In damage areas, sport hunting for bears should be encouraged, because it is a desirable use of the resource and can help reduce damage (see chapter 4). Local newspaper and radio releases can be helpful in directing hunters to critical areas. Maps showing damaged areas and the road system should be available to inquiring hunters.

Figure 24—Basal barking on Douglas-fir by a black bear. Long vertical grooves on the exposed sapwood and large strips of bark at the base of damaged trees are identifying characteristics.

Snaring—Taking bears with a steel cable foot-snare is a common practice in many damage areas (see chapter 4). Snaring has the advantage of restricting control to specific problem areas. Consult with APHIS-ADC and the state wildlife agency regarding snaring procedures and pertinent regulations before beginning any bear removal program involving foot snares.

Piling slash against the bases of crop trees at precommercial thinning—Although the initial trials were inconclusive and the practice is labor intensive, piling slash against croptrees may offer a practical and environmentally acceptable way to alleviate bear damage to young stands.

References—

Beecham, J. 1980. Some population characteristics of two black bear populations in Idaho. In: Martinka, C.J.; McArthur, K.L., eds. Bears—their biology and management; papers from the 4th international conference on bear research and management; 1977 February; Kalispell, MT. [Location of publisher unknown]: [Publisher unknown]: Bear Biology Association Conference Series; 3: 201-204.

Borrecco, J.E.; Black, H.C. 1990. Animal damage problems and control activities on National Forest System lands. In: Davis, L.R.; Marsh, R.E.; Beadle, D.E., eds. Proceedings of the 14th vertebrate pest conference; 1990 March 6-8; Sacramento, CA. Davis, CA: University of California: 192-198.

Boddicker, M. 1983. Bears. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension: C-17 to C-24.

Childs, T.W.; Worthington, N.P. 1955. Bear damage to young Douglas-fir. Note 113. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 3 p.

Erickson, A.W.; Nellor, J.; Petrides, G.A. 1964. The black bear in Michigan. Res. Bull. 4. East Lansing, Ml: Michigan State University, Agricultural Experiment Station. 102 p.

Flowers, R.H. 1987. Supplemental feeding of black bear in tree damage areas of western Washington. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 149-153.

Glover, F.A. 1955. Black bear damage to redwood reproduction. Journal of Wildlife Management. 19: 437-443.

Gourley, M.; Vomocil, M. 1987. Public involvement in a black bear damage control program on private land. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 149-153.

Jonkel, C.J.; Cowan, I.M. 1971. The black bear in the spruce-fir forest. Wildl. Monogr. 27. Washington, DC: The Wildlife Society. 57 p.

Kanaskie, A.; Chetcock, J.; Irwin, G; Overhulser, D. 1990. Black bear damage to forest trees in northwest Oregon 1988-1989. Pest Management Report 90-1. Salem, OR: Oregon Department of Forestry. 34 p.

Lindzey, F-G.; Meslow, E.C. 1976. Population characteristics of black bears on an island in Washington. Journal of Wildlife Management. 41(3): 408-412.

Maser, C. **1968.** Black bear damage in Oregon. Murrelet. 48(2): 34-38.

Mason, A.; Adams, D.L. 1987. Black bear damage to thinned timber stands in northwestern Montana. Western Journal of Applied Forestry. 4(1): 10-13.

Nelson, E.E. 1989. Black bears prefer urea fertilized trees. Western Journal of Appplied Forestry. 4(1): 13-15.

Piekielek, W. 1975. A black bear population study in northern California. California Fish and Game. 61: 4-25.

Poelker, R.J.; Hartwell, H.D. 1973. Black bear of Washington. Biol. Bull. 14. Olympia, WA: Washington State Game Department. 180 p.

Resner, O-L. 1953. Damage to conifers by bear. In: Proceedings, 33d annual conference, Western Association of State Game and Fish Commissioners; 1953 June 1-3; Long Beach, CA. [Location of publisher unknown]: [Publisher unknown]: 109.

Rogers, L.L. 1986. Effects of translocation distance on frequency of return by adult black bears. Wildlife Society Bulletin. 14: 76-80.

Rogers, L.L. 1987. Effects of food supply and kinship on social behavior, movements, and population growth of black bears in northeastern Minnesota. Wildlife Monographs. 97: 1-72.

Scheffer, T.H. 1952. Spring incidence of damage to forest trees. Murrelet. 33(3): 38-41.

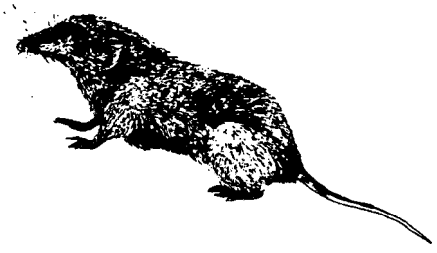
Schmidt, W.C. 1987. Bear damage-a function of stand density in young larch forests. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 145.

Schmidt, W.C.; Gourley, M. 1992. Black bear. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 309-331. Chapter 15.

Small Mammals

Shrews (*Sorex* spp.)

Description-Shrews are mouse-sized insectivores with dark beady eyes. Ears are concealed or nearly concealed by soft, thick fur. Shrews differ from mice, with which they often are confused, by having five toes on each foot. Mice have only four toes on each front foot. Field identification among species is difficult.



Economic significance-Shrews are among the many small forest mammals that eat conifer tree seeds. Shrews destroyed up to 10 percent of white spruce seed over a 6-year period in Alberta (Radvanyi 1970). Shrews also ate lodgepole pine seeds there (Radvanyi 1977). More studies are needed to determine the effects of shrews on reforestation.

Life History Information-

Preferred **habitat-Several** species of shrews occur on Forest Service lands. They prefer moist sites with an abundant food source and dense cover and are most abundant in mesic forested regions.

Feeding **habits-Shrews** feed primarily on the adults and larvae of insects, other small forms of animal life, and carrion when available, although seeds and other plant parts also are eaten. They have both a voracious appetite and a rapid rate of metabolism; they will starve if deprived of food for more than a few hours.

Activity--Shrews are active throughout the year. They spend most of their time under cover and may be active either day or night.

Reproduction--Shrews do not breed until their second year. They usually have two litters of four or five young each per year.

Damage problems and their management-

Identification-Damage by shrews has not been studied extensively. A trapline survey is the best way of determining shrew occurrence.

Determining the need for damage management-Shrews should be considered as potential seed eaters and included with the small rodents when considering the need to protect seed.

Management methods-None known. Snap traps baited with peanut butter may be used to collect shrews. Pit traps (large cans sunk into the ground until the lip of the can is level with the ground) usually are more effective.

References-

Hooven, E.F.; Hoyer, R.F.; Storm, R.M. 1975. Notes on the vagrant shrew, Sorex *vagrans,* in the Willamette Valley of western Oregon. Northwest Science. 49(3): 163-173.

Ingles, L.G. 1961. Home range and habitats of the wandering shrew. Journal of Mammalogy. 42(4): 455-462.

Jameson, E.W., Jr. 1955. Observations on the biology of Sorex *trowbridgii* in the Sierra Nevada, California. Journal of Mammalogy. 36(3): 339-345.

Kangur, R. 1954. Shrews as tree-seed eaters in the Douglas-fir region. Res. Note 17. Salem, OR: Oregon State Board of Forestry. 23 p.

Moore, A.W. 1940. Wild animal damage to seed and seedlings on cut-over Douglas-fir lands of Oregon and Washington. Tech. Bull. 706. Washington, DC: U.S. Department of Agriculture, Bureau of Biological Survey. 28 p.

Radvanyi, A. 1970. Small mammals and regeneration of white spruce forests in western Alberta. Ecology. 51: 1102-1105.

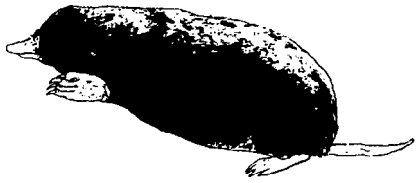
Radvanyi, A. 1977. Lodgepole pine seed depredation by small mammals in western Alberta. Forest Science. 17: 213-217.

Schmidt, R.W. 1984. Shrew damage and control. In: Decker, D.J., ed. Proceedings, 1st Eastern wildlife damage conference; 1983 September 27-30; Ithaca, NY. Ithaca, NY: Cornell University, Cooperative Extension Service: [pages unknown].

West, S.D. 1992. Seed-eating mammals and birds. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 167-186. Chapter 8.

Moles *(Scapanus* spp)

Description-Moles live most of their lives underground. Their small, pinhead-size eyes are adapted to poor light. Broad front feet, with palms usually facing outward, aid moles in burrowing through the soil. Ear openings are completely covered by thick, soft fur.



Economic significance-Moles often are more of a nuisance than an economic liability. The most serious problems occur in nursery beds, home yards, gardens, and golf courses where they do extensive burrowing and mound building in their search for earthworms and grubs. They may directly damage tree roots, their burrowing activities may result in root desiccation, or their mounds may cover small seedlings.

Life history-

***Preferred* habitat-Moist** soils, lawns, fields, and forest areas where soil can be easily worked.

***Feeding* habits--The** major items in the diet of moles are earthworms, grubs, beetles, and other insects. Small amounts of plant material, including rootlets, are occasionally consumed.

Activity--Moles are active day and night, year-round. Peak periods of mound building occur in late winter and early spring, and also in the fall, when young disperse and establish new burrow systems.

Reproduction--Breeding occurs in February to March, with young born in March and April. One litter is raised yearly, with two to six young per litter.

Damage problems and their management-

Identification-The mounds and shallow tunnels of moles are readily noticeable whenever they are present. The mole creates a rounded soil mound by shoving excavated dirt up through the center of the mound. See chapter 2 for the key features differentiating mole hills and gopher mounds.

Determining the need for management-Control of problem individuals is the best approach. Preventive management is generally not recommended, as it can be time consuming and expensive, whereas individuals can be removed with minimal effort.

Management methods-

Baiting-No baits are registered for use in the control of moles on National Forest System lands.

Trapping-Trapping is the most reliable method of control. Several types of mole traps are available at hardware stores and nurseries. Most mole traps are designed to be activated by a mole pushing aside an obstruction in a main runway of its burrow system. Trap sites should be selected by locating areas of recent activity, then stamping down short sections of the runway to determine if it is still being actively used. Main tunnels probably will be repaired within a day. The shallow feeding tunnels that branch from the deeper main tunnel frequently are not reused and should not be used for trap locations. Best results are obtained by setting traps only in actively used main tunnels (see fig. 25).

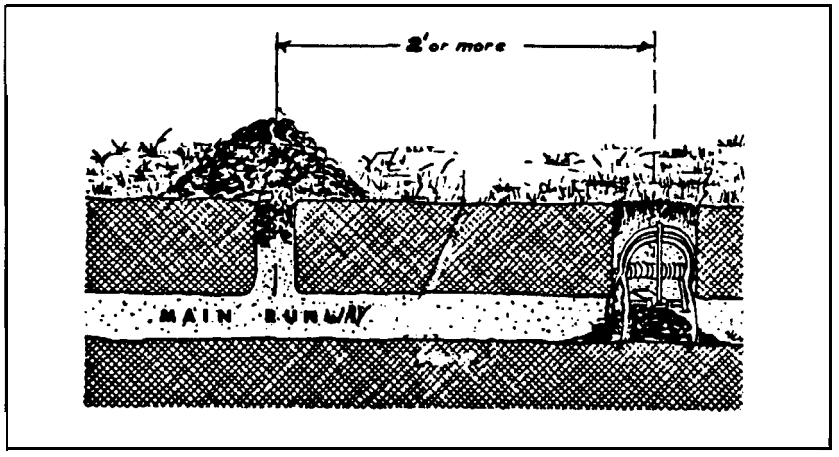


Figure 25--Scissors-jaw trap set in a main mole runway. The position of the jaws and the dirt plug under the trigger are shown.

Fumigants-There are several fumigants registered for use in controlling moles (see chapter 4). In general, the use of fumigants has given undependable results. The variability of soils, soil moisture, burrow depth, and burrow length combine to make the use of fumigants difficult and questionable.

References-

Caslick, J.W.; Decker, D.J. **1981.** Controlling wildlife damage in homes and gardens. Info. Bull. 176. Ithaca, NY: New York State College of Agriculture and Life Sciences, Cornell University. 28 p.

Giger, RD. 1965. Home range, dispersal, homing and density of the Townsend mole Scapanus townsendii (Bachman) near Tillamook, Oregon. Corvallis, OR: Oregon State University. 63 p. M.S. thesis.

Kuhn, L.W. 1970. Mole control. In: Dana, R. H., ed. Proceedings, 4th vertebrate pest control conference; 1970 March 3-5; Sacramento, CA. Davis, CA: University of California, Cooperative Extension: 71-76

Pedersen, R.J. 1963. The life history and ecology of Townsend's mole, *Scapanus* townsendii (Bachman), in Tillamook County, Oregon. Corvallis, OR: Oregon State University. 60 p. M.S. thesis.

Quilliam, T.A., ed. 1966. The mole; its adaptation to an underground environment. Journal of Zoology. 149(1): 31-114.

Schaefer, V.H. 1982. Movements and diet activity of the coast mole *Scapanus orarius.* Canadian Journal of Zoology. 60(3): 480-492.

Yates, T.L.; Pedersen, R.J. **1982.** Moles. In: Wild mammals of North America: biology, management, and economics. Baltimore, MD: Johns Hopkins University Press: 37-51.

Rodents in Campgrounds

An excellent reference on the problems that rodents and other kinds of wildlife may create in campgrounds, diseases that may be involved (primarily plague), and practical control measures is Marsh and others (1981). It deals mainly with California species, but has an extensive list of general references. As pointed out in the report, the establishment of campgrounds may result in high densities of rodents through provision of extra water, food, and burrowing sites. When rodent densities are high, the stage may be set for epizootic disease (a disease attacking a large number of animals simultaneously). The integrated management plan proposed includes sanitation, changes in the design of facilities, and other suggestions. Rodent population-reduction methods and ectoparasite control methods also are discussed.

Managers should remain current on wildlife diseases and epizootics specific to their areas. Consult with public health officials and local veterinarians for updated local information. Wild birds are reservoirs for viral encephalitis; rodents and lagomorphs for plague and tularemia (their ticks are carriers for Rocky Mountain spotted fever). Beavers are suspect in spreading human giardiasis; woodchucks and deer spread parasites pathogenic to domestic livestock; waterfowl contaminate bathing beaches with "swimmers' itch," and *Cuterebra* bots (larvae of bot flies) of- pets are normally parasites of rodents and rabbits (Georgi 1983). Lyme disease, carried by deer ticks, is now a concern nationwide.

References-

Georgi, J.R. 1983. Parasites of wildlife transmissible to domestic animals and man. In: Decker, D.J., ed. Proceedings, 1st Eastern wildlife damage conference; 1983 September 27-30; Ithaca, NY. Ithaca, NY: Cornell University, Cooperative Extension Service: 97.

Marsh, R.E.; Salmon, T.P.; Howard, W.E. 1981. Integrated management of rodents and other wildlife in campgrounds. Rep. 81-39. San Francisco, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, Forest Pest Management. 126 p. [Available from: Cashier, State of California, Department of Food and Agriculture, 1220 N. Street, Sacramento, CA 95814. Ask for Sale Publication 521 and remit $5.00 for each copy.]

Salmon, T.P.; Gorenzel, W.P. 1981. Plague, what you should know about it. Leafl. 21233. Berkeley, CA: University of California, Division of Agricultural Science. 14 p.

Uinta Ground Squirrel
(Spermophilus richarsonl)

Description--Uinta ground squirrels are medium-sized rodents. The middle of the back is brownish. The tail is black mixed with buffy white above and below; belly hairs are tipped with pale buff.

Economic significance--Uinta ground squirrels are usually of only minor concern in reforestation programs, but they feed on emerging pine seedlings and young trees when other food becomes scarce.

Life history information-

Preferred habitat-Meadows, grasslands, and forest openings are the most suitable habitats.

Feeding habit-spring and early summer foods consist mainly of roots, grasses, legumes, and a wide variety of succulent plants. Some insects also are taken. In late summer, ripening seeds and grains are taken in abundance. Food is not stored.

Activity--These ground squirrels normally enter hibernation in late summer or early fall, as soon as they have accumulated sufficient body fat. Older males enter hibernation between late July and early August. Young animals require much of their food for growth, and some may be found aboveground as late as mid-September. Emergence takes place in February and March, after from 5 to 7 months of hibernation. Ground squirrels are relatively short-ranging animals and may spend their entire life in a very small area.

Reproduction-Breeding takes place shortly after spring emergence from hibernation. Young are born in 24 to 30 days and leave the nest in 2 to 3 weeks. Litters average from five to seven young.

Damage problems and their management-

Identification-Uinta ground squirrels are active during daylight hours. Their burrow entrances and adjacent soil mounds are readily apparent.

Determining the need for damage management-Squirrel control may be needed to protect new grass seedlings, if an old meadow area is heavily populated. Ground squirrels are seldom a problem on forest land, unless it has been deforested for several years and squirrels are common where trees are planted.

Management methods-

Baiting-Aboveground uses of strychnine-treated baits are no longer registered for ground squirrel control on National Forest System lands. Contact pesticide-use specialists in District, Forest, or Regional offices, or APHIS-ADC, for the current status of aboveground uses of strychnine and other toxicants for use in ground squirrel control.

Habitat manipulation-There is a direct relation between ground squirrel numbers and range condition. Poor vegetative conditions usually provide more desirable squirrel habitat because of decreased plant density and a greater variety of plant species available. Improving poor range conditions through management often will reduce the density of ground squirrels.

Trapping--Use no. 0 jump traps, live-traps, or no. 120 Conibear traps (see chapter 4). Trapping of individuals is effective and highly selective. Trapping should be used only for localized problems, because it is time consuming and costly.

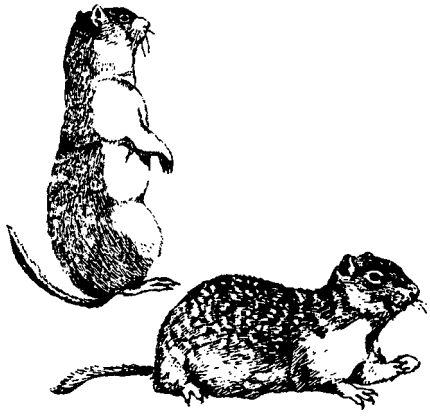
Hunting--Where it can be used safely, a .22 caliber rifle is suitable for shooting ground squirrels, and it may be used effectively as a control measure within localized areas.

Fumigants-Fumigants may be effective in reducing ground squirrel populations (see chapter 4).

References-

Record, C.R. 1983. Franklin, Richardson and Columbian ground squirrels. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension Service: B-133 to B-139.

Belding (Oregon) Ground Squirrel *(Spermophilus be/ding)* **and Columbian Ground Squirrel** *(Spermophilus columbianus)*



Description-Belding ground squirrels (left in the illustration) are medium-sized and have grayish upper parts mixed with buffy white. A brownish streak may run down the back. The tail is reddish beneath, tipped with black and bordered with buff or white and is small and relatively flat.

The larger Columbian ground squirrel (right) may be distinguished from all other species within its home range by its mottled, gray upperparts and dark rufous feet and legs.

Economic significance-Belding and Columbian ground squirrels are usually of only minor concern in reforestation programs, but they do feed on emerging pine seedlings and young trees when other food is scarce.

Life history information-

Preferred habitat-Belding ground squirrels range east of the Cascade Range in Oregon. Columbian ground squirrels are found in eastern Washington and northeastern Oregon. Meadows, grasslands, and openings in or along the edges of ponderosa pine, Douglas-fir, and larch stands are the most suitable habitats.

Feeding habits-spring and early summer foods consist mainly of green vegetation, including grasses, legumes, and a wide variety of succulent plants. Some insects also are taken. In late summer, ripening seeds and grains are taken in abundance. Food is not stored.

Activity--These ground squirrels begin hibernation in mid-summer to early fall. Older males enter hibernation between late July and early August. Young animals may be found aboveground as late as mid-September. Emergence takes place in February and March. Ground squirrels are short-ranging animals and may spend their entire lives in small areas.

Reproduction--Breeding takes place shortly after spring emergence. Young are born in 24 to 30 days and leave the nest in 2 to 3 weeks. Litter sizes range from five to seven.

Damage problems and their management-

Identification-These ground squirrels are active during daylight hours. Their burrow entrances and adjacent soil mounds are readily apparent.

Determining the need for damage **management-Squirrel** control may be needed to protect new grass seedlings if an old meadow area is heavily populated. Ground squirrels are seldom a problem on forest land, unless it has been deforested for several years and squirrels are numerous where trees are planted.

Management methods-

Baiting-Aboveground uses of strychnine-treated baits are no longer registered for ground squirrel control on National Forest System lands. Contact pesticide-use specialists in District, Forest, or Regional offices, or APHIS-ADC, for the current status of aboveground uses of strychnine and other toxicants for use in control of ground squirrels.

***Habitat* manipulation-There** is a direct relation between squirrel numbers and range condition. Poor vegetative conditions usually provide more desirable squirrel habitat, because of decreased plant density and the greater variety of forbs available. Improving poor range conditions through management often will reduce destructive concentrations of ground squirrels.

Trapping-Use no. 0 jump traps, live traps, or no. 120 Conibear traps. Trapping of individuals is an effective and highly selective control method. Trapping should be used only for localized problems because it is time consuming and costly.

Hunting-Where it can be used safely, a .22 caliber rifle is suitable for shooting squirrels, and it can be used effectively as a control measure within localized areas.

Fumigants--Fumigants may be effective in reducing ground squirrel populations in localized areas.

References-

Boag, D.A.; Murie, J.O. 1981. Population ecology of the Columbian ground squirrel in southwestern Alberta. Canadian Journal of Zoology. 59(12): 2230-2240.

Manville, R.H. 1959. The Columbian ground squirrel in northwestern Montana. Journal of Mammalogy. **40(1): 24-45.**

Record, CR. 1983. Franklin, Richardson and Columbian ground squirrels. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension Service: B-133 to B-139.

Turner, L.W. 1972. Habitat differences between *Spermophilus belding* and *Spermophilus columbianus* in Oregon. Journal of Mammalogy. 53: 914-917.

Golden-Mantled Ground Squirrel
(Spermophilus lateralis)

Description-The golden-mantled ground squirrel, which looks something like a chipmunk, has a relatively short, straight tail. The head is copper colored, and white stripes bordered with black are on each side of the back. The lack of stripes on the sides of the face and its much larger size distinguishes it from the chipmunks.

Economic significance-Golden-mantled ground squirrels consume large quantities of both coniferous seed and emerging seedlings. They do the most destruction to forest regeneration in some areas of any of the ground squirrels.

These ground squirrels behave much like chipmunks, adapting easily to human presence and becoming quite tame. Their appearance and mannerisms also make them a very attractive part of the natural environment.

Life history information—

Preferred habitat—Forest lands containing rocky areas for nesting provide ideal habitat.

Feeding habits—The golden-mantled ground squirrel is omnivorous, eating green vegetation, roots, bulbs, seeds, grain, nuts, berries, mushrooms, and meat. Diets differ with the seasonal availability of different plants and plant parts. Carrion apparently is eaten whenever available.

Activity—Golden-mantled ground squirrels are active during daylight hours. They rarely climb trees. Nesting is in underground burrows, usually located in rocky areas. Hibernation starts about the middle of September and usually lasts until May. Variations in the hibernating period are caused by location, elevation, weather, age, sex, and physical condition.

Reproduction—Breeding occurs once a year, shortly after emergence from hibernation. Four to six young are born in late June or early July.

Damage problems and their management—

Identification—The golden-mantled ground squirrel often opens pine seeds while on a rock or log used as an exposed feeding perch; the empty hulls are left nearly intact (fig. 26). Clipping of needles and newly emerged seedlings also occurs, but it is difficult to identify which species did the damage.

Determing the need for damage management—The golden-mantled ground squirrel should be considered a potential seed-eater if broadcast seeding is planned. Clipping damage is erratic, but if found to be a persistent problem in an area, a temporary reduction of ground squirrels should be considered.

Management methods—

Baiting—Aboveground uses of strychnine-treated baits are no longer registered for ground squirrel control on National Forest System lands. Contact pesticide-use specialists in District, Forest, or Regional offices, or APHIS-ADC, for the current status of aboveground uses of strychnine and other toxicants for use in ground squirrel control. Anticoagulants are registered for use in controlling golden-mantled ground squirrels in California and are effective (see chapter 4).

Other methods—No definitive studies have been done on the impact of habitat manipulation on golden-mantled ground squirrel populations. Trapping, hunting, fumigation, and habitat manipulation likely would be effective in controlling golden-mantled ground squirrels within localized areas, but no data on the efficacy of these methods are available.

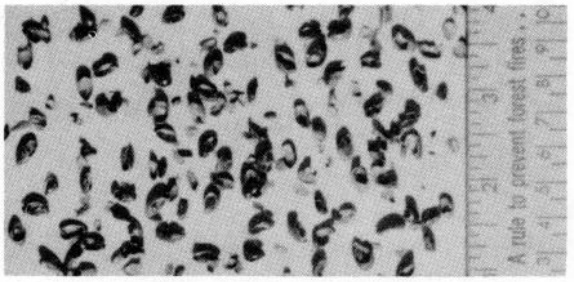


Figure 26—Ponderosa pine seeds opened by golden-mantled ground squirrels.

References-

Gordon, K.L. 1943. The natural history and behavior of the western chipmunk and the mantled ground squirrel. Studies in Zoology 5, Monographs. Corvallis, OR: Oregon State University. 104 p.

Hooven, E.F. 1966. Pine regeneration in Oregon, habits and control of seed-eating mammals. Res. Pap. 5. Corvallis, OR: Oregon State University, Forest Research Laboratory. 24 p.

McKeaver, S. **1964.** The biology of the golden-mantled ground squirrel. Ecological Monographs. 34(4): 383-401.

Mullally, D.P. 1953. Hibernation in the golden-mantled ground squirrel, *Citellus lateralis bernardinus.* Journal of Mammalogy. 34(1): 65-73.

Salmon, T.P.; Lickliter, R.E. 1984. Wildlife pest control around gardens and homes. Pub. 21385. Berkeley, CA: University of California, Cooperative Extension. 90 p.

Storer, T.I.; Evans, F.C.; Palmer, F.G. 1944. Some rodent populations in the Sierra Nevada of California. Ecological Monographs. 14(2): 165-192.

Tevis, L., Jr. 1955. Observation on chipmunks and mantled squirrels in northeastern California. American Midland Naturalist. 53(1): 71-78.

Wirtz, J.H. 1961. The golden-mantled ground squirrel *Citellus lateralis chrysodeirus* (Merriam): its social and community interactions. Corvallis, OR: Oregon State University. 134 p. Ph.D. dissertation.

Black-Tailed Prairie Dog
(Cynomys ludovicianus)

Description-These squirrellike rodents have short legs and tails. Hair color is sandy brown to cinnamon, with lighter hair on the belly. Tail tips are black. Weights are up to 3 pounds. These rodents get their name from their barklike calls.

Economic significance-prairie dogs cause extensive losses on National Grasslands by destroying high percentages of annual forage production. They may cause an unwanted change in plant composition of pastures by removing favored grasses. Their burrowing activities may create problems for mechanical cultivation and harvesting and vehicle operation, and pose hazards for horses and other livestock. Irrigated fields may be drained by burrowing activity. These animals may serve as a reservoir for bubonic plague.

Life history information-

Preferred habitat-prairie dogs prefer open areas of low vegetation (grasses or shrubs) and may be especially numerous near water sources in arid areas.

Feeding habits--Prairie dogs eat the seeds, succulent leaves, stems, and roots of grasses, sedges, and forbs. Grasshoppers and a variety of other insects are eaten during summer.

Acfivity--These animals are active year-round.

Reproduction-One litter of four to eight young is produced each year.

Damage problems and their management-prairie dogs clip vegetation for food and apparently to maintain open areas around their burrows. This may result in a change in forage species composition. Managers should note, however, that these changes may be beneficial to other wildlife species. Isolated or small colonies generally can be tolerated. When colonies cover several acres or more, particularly where they adjoin managed private lands, controls may be necessary. Before controls are planned, check the legal status of this animal in your area by consulting with local state wildlife officials or APHIS-ADC personnel. Because the black-footed ferret is listed as an endangered species and may occur within prairie dog range, special attention must be given to its possible occurrence.

Management methods-

Baiting-Aboveground uses of strychnine are currently prohibited in most situations. Contact pesticide-use specialists (District, Forest, or Region) or APHIS-ADC for the current registration status of chemical toxicants for use in prairie dog control.

Habitat **manipulation-Plow** and leave lands fallow for 2 years, then plant tall grain crops. Rest-rotation and light grazing can delay prairie dog reinvasion. Restoration of degraded rangelands now occupied by high populations of prairie dogs offers the optimum long-term solution to managing prairie dog "problems."

Trapping-For small areas, up to 5 acres, trapping with leg-hold traps, live-traps, or no. 120 Conibear traps may be effective; trapping on larger areas seldom is practical.

Hunting-Persistent shooting may reduce localized populations of prairie dogs by up to 75 percent. Managed sport shooting is a potentially effective method of managing prairie dog populations over wide areas.

Fumigation-Gas cartridges can be used for prairie dog control in some states. Check with APHIS-ADC for restrictions, recommendations, and ordering information.

References-

Boddicker, M.L. 1983. Prairie dogs. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension Service: B-75 to B-84.

Clark, T.W. 1973. Prairie dogs and black-footed ferret in Wyoming. In: Proceedings, black-footed ferret and prairie dog workshop; [dates of meeting unknown]; [location of meeting unknown]. Brookings, SD: South Dakota State University: 88-101.

Gold, I.K. 1976. Effects of blacktail prairie dog mounds on shortgrass vegetation. Fort Collins, CO: Colorado State University. 40 p. M.S. thesis.

Uresk, D.; Bjugstad, A. 1980. Effects of prairie dogs and cattle on vegetation of the northern high plains-executive summary. In: Proceedings, 7th North American prairie dog conference: [dates of meeting unknown]; [location of meeting unknown]. Springfield, MO: Missouri State University: [pages unknown].

U.S. Department of Agriculture. 1981. USDA summary report-strychnine, RPAR DD 2/3. Washington, DC. 47 p.

Chipmunks
(Eutamias **spp.)**

Description-The chipmunk probably is the most popular and well known squirrel species. It can be identified easily by facial stripes, which distinguish it from all other mammals over most of its range. Side and back stripes end at its reddish-colored rump.

Economic significance-Coniferous tree seeds are a favorite food of chipmunks. These seeds are eagerly sought after and stored for winter use. Studies have shown that chipmunks can consume more than 200 ponderosa pine seeds in one day of feeding. When these animals are abundant, they have a deleterious effect on both natural and artificial seeding. Most seed stored by chipmunks is in deep caches and, even if uneaten, few seeds will grow.

Life history information-

Preferred habitat-Chipmunks occupy nearly all forest and range lands.

Feeding habit-Principal foods are flowering plant and tree seeds, grasses, berries, roots, and insects. Large quantities of seeds are stored in deep underground burrows to provide food during winter.

Activity--Chipmunks are terrestrial but climb readily when alarmed or when searching for food. Activities are confined to daylight hours. Nests are usually underground, near the base of a stump or beside a rock or log. These animals are most active during spring, summer, and fall. They hibernate in winter but wake occasionally to eat from stored food and to make short excursions from their dens.

Reproduction-Breeding occurs once a year, usually in March or April. The gestation period is 28 to 30 days, and litters range from four to six.

Damage problems and their management-

Identification--Trapline surveys and general observations give a good indication of chipmunk occurrence (fig. 27).

Determining the need for damage **managmement-Chipmunks** should be considered with deer mice when determining rodent control or repellency needs for seed protection. Clipping of emergent seedlings occurs but has not been shown to be a serious problem.

Management methods-Control may be needed when populations are high in reforestation project areas scheduled for seeding. Control is most effective in spring and early fall. Spring control primarily protects emerging seedlings. Early fall control will help protect the seed during the period when it is normally collected and stored by chipmunks.

Baiting--Anticoagulants (chlorophacinone, diphacinone, Pival, and Warfarin) are registered only in California for control of chipmunks (and golden-mantled ground squirrels).

Trapping--Trapping with Sherman-type live-traps or leg-hold traps is an effective means of controlling chipmunks within a localized area.

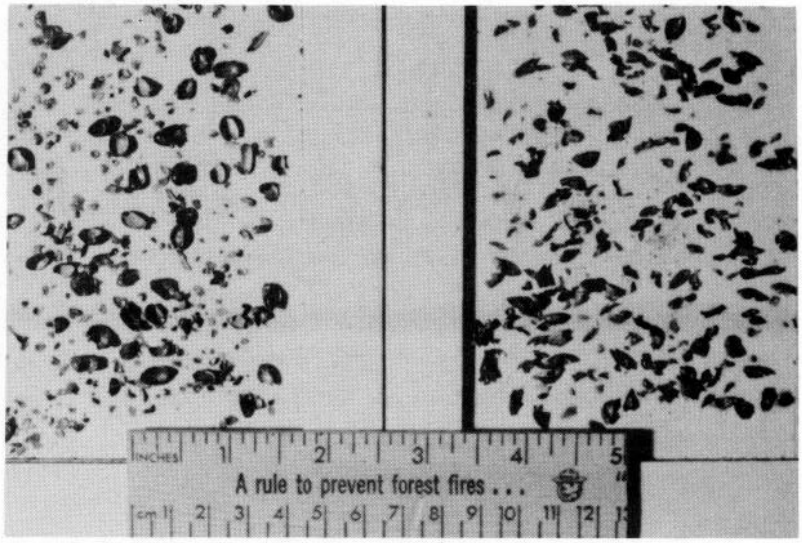


Figure 27—Seed-coat fragments after feeding by chipmunks; ponderosa pine seed on left and Douglas-fir seed on right.

Other methods—No definitive studies have been made of the impact of habitat manipulation on chipmunk populations. No data are available regarding the use of shooting or fumigation to control chipmunk populations.

References—

Broadbooks, H.E. 1970. Home ranges and territorial behavior of the yellow-pine chipmunk, *Eutamias amoenus.* Journal of Mammalogy. 31(2): 310-326.

Garrison, F.J. 1957. Notes on chipmunks of west-central Washington. Murrelet. 28(2): 23-30.

Gashwiler, J.S. 1976. Biology of Townsend's chipmunks in western Oregon. Murrelet. 57: 26-31.

Gordon, K.L. 1943. The natural history and behavior of the western chipmunk and the mantled ground squirrel. Studies in Zoology 5, Monographs. Corvallis, OR: Oregon State University. 104 p.

Martinsen, D. L. 1968. Temporal patterns in the home ranges of chipmunks (*Eutamias*). Journal of Mammalogy. 49(1): 83-91.

McKeever, S. 1961. Relative populations of small mammals in three forest types of northeastern California. Ecology. 42(2): 399-402.

Tevis, L., Jr. 1955. Observations on chipmunks and mantled squirrels in northern California. American Midland Naturalist. 53: 71-78.

West, S.D. 1992. Seed-eating mammals and birds. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 167-186. Chapter 8.

Tree Squirrels: Douglas Squirrel or Chickaree *(Tamiasciurus douglasii),* **Western Gray Squirrel** *(Sciurus griseus),* **and Red Squirrel** *(Tamiasciurus hudsonicus)*

Description-Douglas squirrels and red squirrels are also known as "pine squirrels." The Douglas squirrel (pictured) is slightly smaller than the red squirrel; head and body length of the Douglas squirrel is 6 to 7 inches. The vocal Douglas squirrel is a dark, reddish-olive color, with a yellowish or rusty belly. Distinct black lines along each side, which develop during the summer, help distinguish it from the western gray squirrel. The western gray squirrel is silvery gray in color with white underparts and has a very bushy tail edged with white.

The bushy-tailed red squirrel is widespread throughout most of the pine, spruce, and mixed hardwood forests of North America. It usually is heard before it is seen, because of its noisy, ratchetlike call. Its color is uniformly yellowish or reddish with seasonal variations, including a paler back color during winter and a black line running down each side in summer. It is the smallest tree squirrel in its range; head and body length is 7 to 8 inches.

The western gray squirrel is found along both sides of the Cascade Range in western Washington and western Oregon, in the Coast Range, and along the Sierra Nevada in California. This species commonly inhabits oak groves of the interior valleys. It is much larger (about 22 inches long, including tail) than the Douglas squirrel or red squirrel. It may cause minor, localized damage to mast crops in mixed coniferous-deciduous forests. Bark stripping in the upper boles of conifers is a much greater problem, however.

Economic significance-squirrels may be serious nuisances in seed orchards, seed production areas, cone storage facilities, trees with artificially pollinated cones, or conifer stands designated for cone collection because tree squirrels cut immature cones. However, cone cutting and caching also provides a source of seed that may be readily collected by humans. Squirrels also may place considerable stress on ponderosa pine through defoliation (Soderquist 1987). They eat conifer buds and inner bark from shoots; they also may clip terminal and upper lateral shoots and may strip bark from the upper boles of trees to feed on exposed sapwood.

Life history information-

Preferred habitat-Tree squirrels occupy all coniferous forest types throughout their ranges. The western gray squirrel also commonly inhabits oak groves of the interior valleys.

Feeding habits-seeds, berries, nuts, buds, mushrooms, and insects are eaten when available. Large quantities of food are stored, and single caches may contain up to 10 bushels of cones. When feeding on cones, tree squirrels habitually return to a favorite log or low limb, eventually creating a large "midden" pile of discarded cone scales.

Activity—Squirrels are diurnal (active during daylight hours). They are agile climbers, but also spend much time on the ground. Nests are usually in hollow trees, logs, or old woodpecker holes. One squirrel may have several nests. Home range is normally from 1/2 to 1 acre. Squirrels do not hibernate, but are inactive during cold or wet weather.

Reproduction—One or two litters may occur. Females breed during their second year, in March and April. The gestation period is about 40 days, and litters range from three to six. The young are weaned in about 5 weeks.

Damage problems and their management—

Identification—The occurrence of green, unopened cones scattered on the ground under mature trees and an accumulation of cone scales in a midden pile indicate the occurrence of these tree squirrels, if their chattering has not already caught your attention. The tips of branches are often cut and peeled during winter (fig. 28). Occasionally, only the buds are eaten from the twigs.

All three species of squirrels strip bark from the boles of conifers to feed on the exposed sapwood. (Bark stripping by the western gray squirrel often forms a barberpole pattern in the upper crown of conifers, which is an identifying characteristic for this species.) The sapwood and short strips of discarded bark that accumulate on the ground under the injured tree, characteristically, lack tooth marks. These bark strips readily distinquish squirrel work from similar crown-girdling injuries by the porcupine and woodrat (Sullivan 1992).

Determining the need for damage management—Management is generally needed only on an individual basis to protect seed trees or to keep squirrels out of buildings.

Management methods—Tree squirrels often are classified as game animals and can be taken only as provided by hunting regulations or under authority of a depredation permit. When local problems arise, the following protective measures should be followed.

Figure 28—Field sign of tree squirrels showing (A) opened Douglas-fir cone, with scales cut and removed, and (B) branch tips of pine cut and peeled during winter.

Individual free **protection--Bands** of sheet metal flashing will prevent squirrels from climbing trees. The bands should be at least 2 feet wide and should be placed 6 feet above the ground. Branches of protected trees should not be adjacent to unprotected trees.

Trapping-Individual squirrels can be readily trapped with a live-trap, size 0 jump trap, or a Conibear size 110 trap, using walnut meats for bait. Trapping requires skill, experience and considerable time for baiting, setting, and checking traps. Trapping is practical only where a few squirrels are to be removed.

Baiting--No poison baits are registered for control of tree squirrels.

Hunting-Where legal and safe, using a .22 rifle or shotgun is a practical method of population reduction.

References-

Adams, L. 1955. Pine squirrels reduce future crops of ponderosa pine cones. Journal of Forestry. 53: 35.

Baldwin, R.J.; Howard, W.E.; Marsh, R.E. 1987. Debarking of conifers by the western gray squirrel *(Sciurus griseus).* In: Richards, C.G.J.; Ku, T.Y., eds. Control of mammal pests. London: Taylor and Francis Ltd: 45-54.

Finley, R.B., Jr. 1969. Cone caches and middens of *Tamiasciurus* in the Rocky Mountain region. Misc. Publ. 51. Lawrence, KS: University of Kansas, Museum of Natural History: 233-273.

Fisch, G.; Dimock, E., Il. 1978. Shoot clipping by Douglas squirrels in regenerating Douglas-fir. Journal of Wildlife Management. 42(2): 415-418.

Jackson, J.J. 1983. Tree squirrels. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Great Plains Agricultural Council and Cooperative Extension Service: B-141 to B-146.

McKeever, S. **1961.** Relative population of small mammals in three forest types of northeastern California. Ecology. 42(2): 399-402.

McKeever, S. **1964.** Food habits of the pine squirrel in northeastern California. Journal of Wildlife Management. 28(2): 402-404.

Shaw, W.T. 1936. Moisture and its relation to the cone-storing habit of the western pine squirrel. Journal of Mammalogy. 17(4): 337-349.

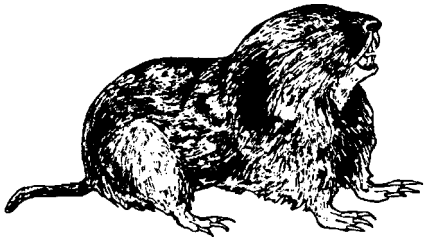
Soderquist, T.R. 1987. The impact of tassel-eared squirrel defoliation on ecotonal ponderosa pine. Journal of Mammalogy. 68(2): 398-401.

Sullivan, T.P. 1992. Tree squirrels, woodrats, and beaver. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 271-287. Chapter 13.

Timm, R.M., ed. 1983. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension Service and Great Plains Agricultural Council.

Walters, J.; Soos, J. 1961. Douglas squirrel damage to Douglas-fir. Res. Note 32. Vancouver, BC: University of British Columbia, Faculty of Forestry. 2 p.

Pocket Gophers
(Thomomys spp.)



Description-There are three genera of pocket gophers in the United States. The distinguishing characteristics of all pocket gophers are the external cheek pouches that open on either side of the mouth, and lips that close behind large yellow incisors. Consistent with a burrowing mode of life, they have long, curved front claws. Size is extremely variable in pocket gophers with combined head and body length ranging from 5 to 9 inches. The size of pocket gophers seems related to the vegetative community, locality, altitude, and latitude of their habitat; males generally are heavier than females.

Only two age-class distinctions can be made in the field: juveniles (less than 1 year old) and adults (1 or more years old). Juveniles are noticeably smaller and have smaller reproductive organs.

Similar species-Ground squirrels are sometimes called gophers in local expression, but pocket gophers are most often confused with moles. The following tabulation shows the differences distinguishing pocket gophers from moles.

Pocket gophers	Moles
Large yellow incisors	No incisors
Blunt snout, small eyes and ears	Long snout, no apparent eyes or ears
Cylindrical, winter "casts," aboveground	Tunnels form low surface ridges
Fan-shaped mounds, dirt "plugs" near edge	Circular mound plug near center

Life history-An evaluation of pocket gopher damage requires a clear understanding of resource management goals and objectives and how gophers may affect those objectives. If their activities are interfering with management objectives, damage evaluation must begin with a knowledge of the animal; how to identify it and its characteristics and behaviors, and how its populations increase and decrease.

Reproduction-Usually, only one litter is produced per year in the northern part of their range, but two litters per year are common in southern parts of their range. Breeding usually occurs in early spring but may occur at any time in the southern parts of their range. After a gestation period of about 18 days, a litter of four to eight young is born in the burrow system of the female and reared by her for about 40 days. The juveniles then disperse and establish their own burrow systems. Burrowing through snow facilitates pocket gopher dispersal.

Population Cycles-Pocket gopher populations are dynamic and exhibit random fluctuations. Gopher numbers continue to increase until an imbalance occurs between the population level and the capacity of the habitat to support it. During the annual cycle, pocket gopher populations generally peak at a high level between August and October and then begin to decline until spring, when the population is increased by the young. The population is comprised of up to 75 percent juveniles. The range of fluctuation that populations undergo can be dramatic. Densities have been recorded as high as 62 per acre.

Natural limiting factors that regulate pocket gopher populations include predation, weather, food and cover, and to some extent, gopher territoriality.

The major predators of gophers include weasels, coyote, bobcat, badger, great horned owl, barn owl, hawks, and snakes. Dispersing juveniles have the greatest vulnerability to predators because they spend more time traveling aboveground. Predation, however, serves more to slow the rate of increase than to prevent the population from peaking.

The greatest influence of weather on gopher populations occurs in winter and late spring and relates to the amount of snowfall received. An extremely deep snowpack with a high water content results in high mortality of both adults and newborn young, particularly when the snow melts rapidly and saturates the ground with water, which floods the burrows. Too little snowfall results in even higher gopher mortality, because most forest and range soils percolate ground water rapidly and the soil freezes solid without the insulating effects of deep snow. Pocket gophers may freeze in their burrows under these conditions.

Gophers are herbivorous and highly adaptable in their feeding habits. The relative abundance and quality of forage and the amount and type of habitat available directly correlates with the density of pocket gophers in a particular area. The territorial size of individual gophers depends on habitat conditions, and because these territories are aggressively protected, only a limited density within a given area will occur.

The maximum life span of pocket gophers is about 5 years; few gophers live beyond 2 years, however. Juveniles (less than 1 year old) have the highest mortality rate in pocket gopher populations, and winter mortality of all age groups takes the greatest toll.

Habitat characteristics-

Want community types-Pocket gophers are remarkably adaptable and occupy a wide range of plant communities from sea level to over 10,000 feet in elevation. The communities most preferred by gophers are those supporting an understory of relatively lush stands of fleshy-rooted forbs or rhizomatous sedges and, to a lesser extent, grasses. Rangelands, meadows, clearcut areas, burn areas, and open coniferous forests are the most desirable sites, if adequate soil depth for burrowing is present. Plant community types can be stratified to determine the risk of pocket gopher damage (Volland 1974). Some of the factors enhancing the selection of a site by pocket gophers are the palatability of the vegetation, the associated plant species or the combination of plant species occurring in the area, the climate and topography of the area, and the seral stage of the plant community; for example, whether it is a herbaceous community or a shrub community.

Grass seeding on disturbed sites in Idaho (Green and others 1987) significantly delayed natural succession, thereby resulting in high pocket gopher populations

Soil conditions--Because pocket gophers live underground in burrows, soil characteristics also help determine pocket gopher habitat preference. Burrow systems usually are located in friable, light-textured soils with good drainage, poor water-holding capacity, and high porosity. Clay soils, soils with a depth of less than 6 inches, soils with a shallow water table, and soils that are continuously wet are unfavorable for pocket gopher burrowing. Pocket gophers tend to use soils with a moisture range up to 50 percent.

Pocket gopher burrow systems provide shelter and access to forage. Each adult has its own burrow system covering an area of about 0.02 to 0.1 acre. The systems consist of runways 4 to 48 inches below the ground surface. Side tunnels from the main runways are used as exits and for deposition of soil, debris, excess food, and feces. Larger chambers are used for nest sites and food storage. Tunnels are from 2 to 3 inches in diameter. Feeding tunnels are shallow, normally 2 to 8 inches below the surface, and are most extensive in areas where vegetation is sparse.

Food caches are maintained near nest chambers, and shallow underground food caches also are located 3 to 4 inches below the ground in lateral chambers loosely plugged-off from the main burrow system. Large amounts of plant materials may be stored.

The burrow system is a closely regulated microenvironment, and a gopher will generally plug any openings in the system within 48 hours-often within 24 hours or less.

By building, maintaining, and living in burrow systems, pocket gophers leave three types of physical signs on the surface of the ground that are visible in the snow-free period: mounds, winter soil casts, and tunnel entrances that gophers have plugged with soil (known as soil plugs).

The typical horseshoe-shaped mounds pushed up by gophers are the result of soil excavated as they extend and repair their burrow systems. Mound building is most common in late summer and fall when juveniles are establishing burrow complexes and older animals are enlarging burrow systems.

In winter in the northern parts of their range, gophers extend their burrow systems into the snow, apparently to facilitate their search for food. Later, excess soil is pushed into these snow burrows to create the ribbonlike “winter casts” that become evident as the snow melts. These winter casts can indicate where damage might occur, if suitable conditions are present.

Soil plugs are more difficult to detect. They are small circles of disturbed soil at the ground surface or a small circular depression toward the edge of a mound. These usually are formed where gophers have emerged to forage and plugged the hole upon reentry. Vegetation may be clipped around soil plugs. In spring, soil plugs and winter casts may be the only soil indicators of current pocket gopher activity.

Feeding habits-pocket gophers are herbivorous mammals and use all portions of plants in their diet. Roots, stems, leaves, and bark (chewed from woody species) provide forage for gophers. Because of their burrowing habits, roots are readily available, but pocket gophers also make openings from their tunnels and forage for food and nest material aboveground. In some instances, they have been observed pulling entire plants down through the soil into their burrows. Barking and clipping of shrubs and trees occurs aboveground, especially under snow in winter.

Forbs are the most preferred food plants of pocket gophers. Grasses are also used and may constitute a major component of the gopher's diet in winter. The outer bark and roots of woody species are used by gophers in winter, when other fresh vegetation is sparse, and in summer and fall when other vegetation is drying up and roots are being collected for food caches.

The habit of storing food in underground caches may account for the harvest of considerably more vegetation than is actually eaten. Roots constitute the major portion of the forage collected for food caches.

Damage problems and their evaluation-

Forest lands-pocket gopher damage to forest crops was first reported in the early 1900s, but it did not become a serious reforestation problem until the 1950s. This increased importance is the result of intensified management and of recognition that gophers are responsible for some damage previously attributed to porcupines, mice, squirrels, livestock, and unknown causes.

Increases in pocket gopher problems and subsequent damage are directly related to the opening up of timber stands through harvest, insect and disease losses, or wildfires that result in a flush of seral vegetation (forbs and grasses). Gophers, normally, are widely but sparsely distributed in timber stands, and are primarily concentrated at sites where preferred ground vegetation provides ample forage; for example, river banks, spring areas, meadows, and other breaks in the forest canopy. Dense brush areas often produce low food volumes, which limit gopher populations on those sites.

In the Nez Perce National Forest, Idaho, severe site disturbance in 1986 resulted in increased pocket gopher activity: the number of mounds ranged from 300 per acre on minimally disturbed, broadcast-burned sites to more than 6,000 per acre on severely disturbed areas where slash had been piled by bulldozer (Boyd 1987). The practice of grass seeding on disturbed sites significantly delayed natural succession, thereby resulting in higher gopher populations and increased seedling mortality.

Substantial gopher populations can become established in 2 to 3 years when a low residual population is present on or near a cutover area. The current reforestation policy is to plant or seed as soon as possible after harvest treatment. This allows tree seedlings to develop into larger, less susceptible sizes, as the gopher population is expanding. If small, slow-growing conifers are planted where gopher populations are high, the trees are subject to severe damage and mortality in the first 3 to 5 years after planting. A second advantage of rapid reforestation is the reduced competition for available soil moisture by the seedlings, often resulting in higher seedling survival rates.

Heavy pocket gopher infestations in regeneration areas have commonly resulted in seedling losses of 20 to 30 percent and, occasionally, up to 70 percent in 1 year. Losses of seedlings due to pocket gopher damage in regeneration areas usually continue over a period of years, so that what may appear as acceptable yearly gopher-caused seedling mortality is actually, in a cumulative respect, excessive.

Damage identification--The two most common types of tree damage by gophers are root pruning and a combination of stem barking and clipping. Stems of small seedlings (basal diameters of 1/2 inch or less) often are cut into two or more sections. Seedlings frequently are clipped at or near ground level and the roots or stems are taken. Gophers may pull entire seedlings into their burrow systems, which leaves no evidence of damage other than missing seedlings. If seedlings are missing, suspect gopher or elk damage. Root pruning and barking of small seedlings occur year-round but are most frequent in winter.

Root pruning on larger seedlings and saplings also occurs year-round. The seasonal frequency has not been determined, primarily because damage generally does not become evident until long after the trees have been injured. Some trees also incur damage over a period of several years. Characteristic indicators of root-pruned trees include shortened needles, premature needle drop, shortened internodes, and overall poor development.

Clipping and barking on larger trees occur primarily underground or aboveground under snow cover. This damage is more prevalent in areas where heavy snowpacks persist or food quantity is short. Girdling is often complete and leaves white stems easily seen in spring.

Other types of tree damage caused by gophers include root exposure by burrowing and burying of seedlings by winter casts or mounds. Root exposure occurs most often in conjunction with root gnawing and barking. It is usually of minor importance in comparison with other types of damage. Damage from winter casts or mounds deposited on small planted or natural seedlings is a common occurrence in areas of high gopher density and may injure or kill seedlings.

Rangelands--Damage by pocket gophers to rangelands differs with livestock use and condition of the range. In the past, much time, effort, and money were spent for pocket gopher control on rangelands in poor condition. Pocket gopher control is seldom economically feasible on poorly managed rangelands or those in fair or better condition.

Soil erosion-Pocket gopher activity can accelerate soil erosion in some areas depending on slope, soil type, and the action of water. Tunnel collapse and water running through burrows may intensify already existing erosion potentials.

Dams and dikes-Pocket gopher activity can affect dams and dikes by weakening their structural design or decreasing their water-holding capacity.

Damage surveys-There are three methods of surveying pocket gopher activity and relative abundance. The purpose of the survey determines which method is used. The first, the reconnaissance survey, evaluates the presence or absence and relative numbers of pocket gophers. This method is used to determine the extent of pocket gopher damage potential and usually is initiated when a timber management proposal entails some form of regeneration harvesting as an alternative. The second type, the gopher-mound survey, determines the level of gopher activity in an area and provides an indication of gopher abundance. Its main purpose is to determine the location and extent of gopher control needs. The last method, the open-burrow survey, evaluates the effectiveness of baiting or trapping as a control technique.

Reconnaissance survey--This survey is usually a part of another examination, such as a timber sale reconnaissance. The primary purpose is to determine if an active gopher population exists in the area, and if so, the extent and relative size of the population,

Information on gophers is collected at each plot, when a timber-sale planning or other survey is being conducted. The presence of recent mounds (mounds formed during the year) or winter casts are primary indicators of gopher presence.

If a joint silviculture examination and gopher reconnaissance survey reveals moderate gopher activity on 50 percent of a planned timber sale area and if the silvicultural prescription developed for the area calls for a regeneration harvesting method, the reforestation portion of the prescription should consider the following issues: the type of regeneration that will occur; the ease with which it will be obtained; the amount that could be lost to gophers; and the effect of timber harvesting on the population of gophers present at the site. These data and the information obtained during the gopher reconnaissance will allow the consideration of silvicultural alternatives and alert the land manager to assess possible treatment or control alternatives, before the project's implementation.

Gopher-mound survey-An indication of the pocket gopher population level and extent of control needs can be obtained with a gopher-mound survey. This survey is particularly useful when management alternatives are being considered, and it should be conducted whenever gophers are a potential problem. It often is conducted as part of another survey, such as a stocking survey.

The gopher-mound survey determines the percentage of an area that has current gopher activity by using the presence of recent mounds (mounds formed during the year) to determine the approximate size and distribution of the population. The percentage of plots with sign is used as an index to population density and as a basis for determining control needs.

Standard plot size should be 1/100 of an acre or 11.8-foot radius. Plot sizes differ if they are part of another survey being conducted simultaneously.

Minimum sampling intensity should not be less than that of the associated survey, or 5 percent of the area. The number of plots and their distribution should be sufficient to determine the location of gopher population centers, the approximate number of mounds per acre, and the range in numbers over the area. (Counting the number of mounds may not provide better information than simply determing the presence or absence of fresh gopher activity on the sampling plots.) These data will provide the bases for determining control needs, based on staff experience with local conditions.

The extent of the area affected and the number of mounds indicate the relative feeding pressure by pocket gophers. Although food habits differ by site and availability, the more gopher activity, the greater the potential for damage to conifer seedlings.

Wherever pocket gophers occur, some damage and mortality of planted seedlings can be expected. Temporary population reductions of pocket gophers in plantations are probably needed if some or all of the following conditions occur:

- Percentage of active gopher plots exceeds 25 percent of 1/100-acre plots on new plantations (0-2 years old) or 40 percent of 1/100-acre plots on established plantations (3-5 years old).
- Current stocking level of seedlings is low or marginal, and additional environmentally caused mortality can be expected.
- Trees are growing slowly and are less than 0.2 inch in caliper about 1 inch above ground level.
- Number of active pocket gopher systems exceeds two per acre.
- Food supply of gophers will be significantly altered by herbicide or other treatment, which will cause these animals to seek alternative food sources.

The gopher-mound survey and the above criteria should not be relied on as sole determinants for implementing a control project. There also is need to evaluate actual losses occurring in a plantation. The same densities of pocket gophers in different habitats with different seedling sizes, survival rates, and other variables will result in different impacts.

It is essential that local experience and conditions be considered in making the final determination of the need for temporary population reductions.

Open-burrow survey-The objective of this survey is to determine the reduction in gopher activity that occurs after an operational control program.

Sampling points are established in an area before treatment. These should be at least 100 feet apart and include recent (less than 1 week old) gopher activity.

A minimum of 40 sampling plots (or fewer on units of less than 10 acres) should be used per treatment area. The plots need to be flagged and numbered to facilitate resurveying. An active burrow system is opened on each plot having recent sign. Twenty-four to 48 hours later, the area is revisited and notation is made on whether the opened burrows were plugged or remained open. A survey after 48 hours is preferred by some experienced biologists. Repeat the survey 7 to 14 days after a control treatment. If the direct control operation was successful, there should be significantly fewer plugged burrows found during the second survey.

Biologists believe that a reduction in activity of at least 80 percent is needed to accomplish a significant reduction in damage. Areas with less than an 80-percent reduction in activity should be considered for retreatment; baiting techniques and other operational conditions should be analyzed to ensure that control activities are optimum.

Methods of damage management-The history and current status of pocket gopher damage to conifers in western forests are well documented (Borrecco and Black 1990, Crouch 1986). At the present time, direct control of damaging gophers, primarily by baiting or trapping, is the most widely used approach to alleviating pocket gopher damage. in the future, integrating indirect or ecological control to reduce the habitat suitability for gophers with direct control practices may prove to be more effective and less costly.

Indirect control by habitat manipulation-Indirect control to limit damage to seedlings by pocket gophers is accomplished by reducing habitat suitability, providing alternate (buffer) forage, or by silvicultural modifications, including planting additional seedlings.

Herbicide applications-Treating an area with selective herbicides can be done to reduce the availability of gopher foods. Vegetation management with herbicides, principally to control perennial grasses and forbs, can result in reduced gopher numbers and may improve conifer survival by decreasing competition for moisture by other vegetation. Herbicide treatment to control gophers requires a broader area of coverage than does site preparation, and it is recommended that the planting of conifer seedlings be delayed for one winter between herbicide treatments and reforestation, to allow time for a sufficient reduction in the gopher population. It also prevents the gopher population (at the pretreatment level) from being sustained by a primary food source of planted seedlings.

Numerous herbicides are available for such use. The type of herbicide, the timing of application, and the method and rate of application depend on the chemicals considered, their selective toxicity, and label requirements. Identification of the plants or plant types being used as a food source will help indicate the herbicide needed. Herbicides need to control the food source and, with the large number of approved chemicals and the continual changes in these chemicals, recommendations should be obtained from specialists at either the National Forest or the Regional Office.

The response of pocket gophers to herbicide treatments will differ with the type of herbicide application, because the impact of the herbicide on gopher foods depends primarily on the composition and density of the pretreatment vegetation. Because of their highly selective toxicity, some herbicides may cause little change, as gophers may switch to less desirable vegetation for food.

Although selective herbicide treatments show a potential to promote the survival and growth of conifer seedlings and make habitats less favorable for pocket gophers, the effectiveness of this method to reduce damage has not been widely studied. On herbicide-treated sites, the seedlings may be better able to sustain minor damage by gophers, and a reduction in gopher numbers usually leads to a reduction in gopher-caused seedling mortality.

A disadvantage of herbicide treatments involves the possible adverse effects on the food and cover plants used by other wildlife species. Abrupt alterations in the vegetative density and composition of an area can have a significant impact. In most cases, the impact on other wildlife is temporary, because the changes in vegetation are normally of short duration. Before herbicide treatments are undertaken, an evaluation of the importance of the treatment site to all wildlife should be completed.

Silvicultural modifications-Habitat alteration by modifying silvicultural practices has great potential for effective, long-lasting control through preventive management. Emmingham and others (1992), for example, found that the use of the shelterwood regeneration method, in place of clearcuting, creates less favorable habitats for gophers and reduces damage to developing stands. In many instances, gopher damage could be avoided or reduced through early recognition of the animal's probable response to habitat changes resulting from silvicultural treatments.

Protecting conifers is difficult on a plantation densely populated with gophers. Recruitment of animals from inside or outside the plantation boundaries tends to maintain the habitat at or near its carrying capacity. Rather than waiting to confront the problem under these conditions, a logical alternative is to anticipate the potential damage and attempt to prevent the population buildup that causes it.

***Temporary buffer* strips-In** this method, an uncut strip of timber, 500 feet wide (or wider), is left between logged units and gopher-populated areas (Barnes 1974). Meadows, open stands, or any area with abundant food supplies adjacent to harvest units should be checked for presence of gophers. Buffer strips represent a temporary measure and essentially delay the invasion of gophers into harvested areas (unoccupied or only sparsely occupied by gophers), thereby reducing the potential for damage to seedlings. This delay can be useful, because in some areas where sufficient natural regeneration can be obtained, even moderate pocket gopher populations will not pose a problem.

In some situations, buffer strips are most effective when used in combination with the direct control methods of baiting or trapping. The need for direct control before harvest is obvious where a reservoir of gophers occurs within a planned harvest unit. Direct control in buffer strips is also necessary, if substantial gopher populations are present **in** these strips. Where leaving strips of standing timber is not practical; direct control in stands adjacent to gopher-occupied areas or along plantation boundaries will have a buffer-strip effect and should be considered before logging.

***Site* preparation-Site** preparation, in general, is beneficial to tree growth and survival, but the effect of site preparation on seedling survival and growth (and on associated vegetation) must be reviewed in relation to pocket gopher population responses and damage. Site preparation techniques that disturb large amounts of soil should be used as little as possible in areas prone to pocket gopher damage. This practice may result in rapid invasion of pocket gophers from adjacent populated areas, or an increase in breeding success by established gophers. Newly disturbed soil often allows gophers to move rapidly underground. Gophers use disturbed soil along roads and terraces to travel up to 1 mile or more. (On private forest lands in south-central Oregon, intensive, large-scale site preparation with large, tractor-drawn Rototillers, combined with herbicide treatments to control the recovery of herbaceous vegetation, decimated resident pocket gopher populations for a sufficiently long period to enable successful regeneration.)

Highly disturbed soils created by plowing, discing, or machine planting often predispose seedlings to gopher damage by creating a nearly readymade burrow system. Gophers follow these readymade burrows, gathering food as they go.

Limited site preparation is a damage control measure that can be used to deter the distribution of gophers. Site preparation with selective herbicides also may be an extremely useful technique (see above).

Stage-overstory removal--The harvest method selected in a potential area of pocket gopher damage also can be a control measure. The relation of tree crown-cover to herbage production indicates that clearcutting results in the best conditions for pocket gopher invasions, establishment, and population increases. Partial cutting in certain conifer stands minimizes the increase of the understory vegetation due to continual partial shading, retains conifer reproduction in the understory (which is usually past the stage most susceptible to pocket gopher damage), and results in minimal soil disturbance. Depending on the habitat type, such an alteration generally supports fewer gophers than does a comparable clearcut site. On some sites, however, natural regeneration after partial cutting is unsuccessful because of factors other than gophers, but gopher populations build rapidly and may be mistakenly blamed for regeneration failure. Shelterwood cutting and underplanting shelterwood units, for example, reduced pocket gopher damage to pine plantations in eastern Oregon (Emmingham and others 1992).

Stage-overstory removal and the vegetative communities created must be carefully analyzed, as many timbered types do not readily lend themselves to this silvicultural treatment. The treatment also may not be compatible with stand composition requirements.

Early **planting--Planting** should occur as soon as practicable after harvest. Waiting longer than 1 year to begin reforestation allows an increase in food supplies for gophers, and this often results in higher overall population levels. It usually takes 2 to 3 years after a timber harvest for significant increases in herbaceous vegetation to occur and for pocket gophers to establish a population level detrimental to seedling survival. Planting immediately after harvest will give seedlings a head start.

Size of planting stock-Large planting stock (2-1 or 3-O) is less susceptible to gopher damage than are small-sized seedlings. Seedlings less than 1/2 inch in caliper width are commonly clipped by gophers, especially in winter where feeding takes place under snow. Larger diameter seedlings may be chewed but may not be completely girdled. Also, large-caliper stems are seldom bent or pinned down in the snow by the formation of winter casts. Such activity normally leads to misshapen trees.

Direct population control-Direct control techniques include hand- and machine-baiting, trapping, and use of individual tree protectors. Choice of these methods should be based on site characteristics, season, available labor, economic considerations, and local experience.

Trapping-Several types of traps are available for controlling pocket gophers, although the Macabee kill-trap is probably the most popular. Trapping has been used on forest lands to a limited extent. It is extremely slow and time consuming and is practical only in small areas, in high-value situations such as nurseries or experimental areas, or as a supplement to other forms of damage control. Consequently, there are few forest situations where trapping is feasible. This method is, however, of value as a way to estimate population densities.

Trapping procedures are as follows:

1. Select an area with recent mound-building activity.

2. Open the lateral runway with a trowel.

3. Set a gopher trap and insert it, prongs forward, well back into the burrow (fig. 29). If the lateral runway is very short, the main runway often will be exposed during excavation. In that case, a trap should be set in each arm of the main burrow.

4. Secure traps with a light chain or wire and pin.

5. Leave entrance hole open to attract the gopher.

6. Mark each trap spot with flagging so that it can be relocated easily.

7. When trapping is done in spring, traps should be reset after a catch is made because a burrow system may have more than one occupant at that time.

Baiting--Hazards to nontarget animals have been evaluated (Barnes and others 1985, Evans 1987, Fagerstone and others 1980). Baiting by hand or machine is a much faster operation than trapping and is safe and effective when done properly. But it usually requires one or more annual followup treatments. The number of baitings and their frequency differs from area to area. Initial control success, tree damage, vegetative conditions, and potential for reinvasion are among factors to be considered. Baiting should be done during periods of greatest local mound-building activity; using larger baiting crews for shorter periods often is advisable.

Hand-baiting requires three steps: location of a runway by probing or excavation; placement of the toxic bait in the burrow by hand, spoon, or other appropriate means; and covering the exposed burrow. Hand-baiting by spoon or bait dispenser may be useful for gopher control on small acreages or steep terrain with isolated populations, or to maintain control over low populations to restrict their dispersion into unoccupied or sparsely occupied habitats. This method is particularly useful in treating peripheral populations or spot-treating populations before they build.

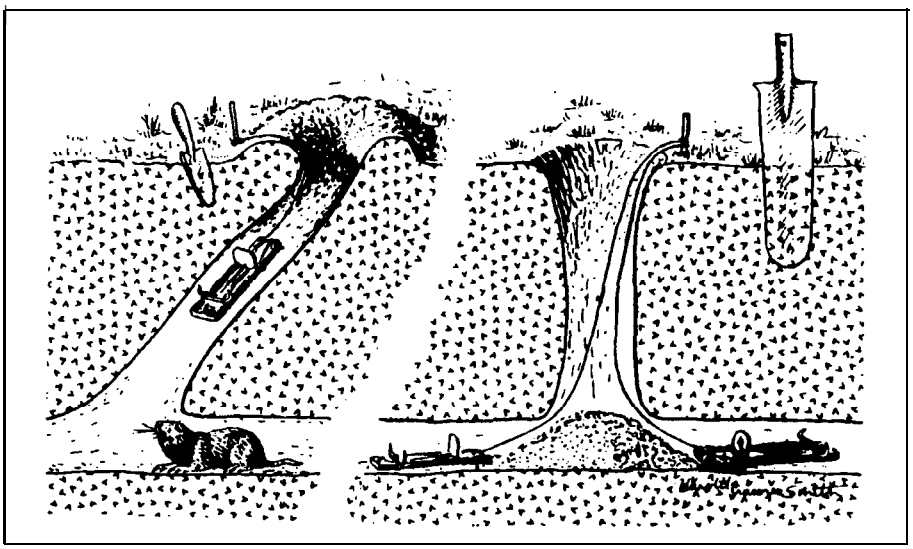


Figure 29 -Trap placement for pocket gophers.

Effectiveness of hand-baiting can be checked readily by an open burrow survey. If the burrow systems are still occupied, they usually will be closed within 48 hours. Activity checks should not be made until bait has been exposed for 2 weeks.

Strychnine-treated oats is currently the bait of choice for pocket gopher control; zinc phosphide also is registered for this purpose. Anticoagulant baits are registered for pocket gopher control in some states. Check with your wildlife biologist, Regional pesticide-use specialist, or APHIS-ADC regarding the status of bait registrations and control recommendations.

Hand baiting-Any site regularly occupied by pocket gophers may be hand-baited, but there are several conditions that influence control effectiveness:

- 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 horseshoe shape. Recent mounds often will be darker than surrounding soil because of their higher moisture content.
- Soil moisture and soil type should be such that burrow crumbling does not occur when probing or excavating tunnels for baiting. Moisture content becomes less critical in soils that are well structured, fine textured, or heavily sodded. Granitic soils and sandy soils are extremely difficult to probe; suitable moisture conditions are required during the operation.
- Guidance of experienced baiters is necessary to ensure correct bait placement.
- The number of available baiters must be sufficient to permit complete and careful coverage of the area requiring protection within a reasonable time. This often becomes a problem on large areas.

Probing (with bait dispensers)--Probing is the most commonly followed method of hand-baiting. It is the fastest hand-baiting technique but requires considerable knowledge of gopher habits to be done effectively.

Expertise in using the probe is gained mainly through experience and self-training. The first step is to check a spot near a fresh gopher mound for the presence of a burrow. The probe then is pushed gradually into the ground at that spot. If the choice is correct, a sudden release of pressure will be felt when the probe enters the burrow.

Initial attempts at probing should be verified by digging out the lateral and part of the main runway. In this way, errors can be quickly corrected.

The following sequence should be followed when baiting with a probe:

1. Select an area with recent mound-building activity.
2. Locate the main runway by probing a lateral runway to its junction with the main runway. Laterals usually join a main run within 2 feet or less. One or two test probes down each arm of the main runway to form a rough "T" will verify the location of the runway. Main runways also may be located by the presence of small convex earth plugs. The plugs are made when gophers close their burrows after returning from surface excursions. A probe can be made directly adjacent to the earth plug, as the main runway is often immediately below.
3. Enlarge a probe hole in the main runway to accept the bait, but be careful to avoid making a deep hole in the bottom of the burrow.

4. Drop 1 teaspoonful of strychnine-treated oats into the burrow. Most baiting operations will require from 1/2 to 1 pound of strychnine-treated oats per acre.
5. Carefully cover all probe holes with clods, bark, stones, or other suitable material, to prevent light or dirt from entering the burrow system, Covering the probe holes also will reduce the chance of nontarget wildlife eating the bait. If the holes are left open, gophers may push the bait aboveground while closing the holes, thereby possibly exposing the bait to nontarget species.
6. Bait two spots in what appears to be the active working area of a single gopher.
7. Mark treated areas with plastic flagging. This will prevent confusion and facilitate inspections.

Excavating-Opening main runways with a garden trowel (excavating) is a positive method of locating good baiting spots. The only disadvantage is that it is relatively slow. Excavating is an excellent way to study the arrangement of the burrow systems of gophers and, in this respect, serves as a useful tool for training inexperienced baiters to use a probe. One or two days of burrow excavation before advancing to a probe will help ensure good control results.

The baiting procedure is very similar to that followed in the probing technique, except that the hole is opened to allow bait placements. Follow the steps outlined for hand baiting with a probe.

Machine-baiting procedures-An improvement over hand-baiting is the mechanical bait dispenser-it is faster and just as efficient. This device allows an operator to intersect runways and deposit bait in the same operation. With this device, 1 acre per hour can be treated. The Forestland Burrow Builder provides an effective means of controlling pocket gophers within limits determined by slope, surface and subsurface obstructions, soil texture, and soil moisture. Soil conditions must be suitable for preparing and maintaining a burrow. Excessively dry or coarse-textured soils do not allow this to occur.

The machine creates an artificial burrow and at the same time deposits small amounts of strychnine-treated oat bait. (A Rhoplex-binder added to this bait allows the oats to flow smoothly from the hopper of this machine.) Gophers locate the new burrows and eat the deposited bait within a few days. Maximum control usually is achieved within 7 to 10 days after treatment. The machine can be used to treat 2-1/2 to 6 acres per hour. The crew includes a tractor operator and bait checker.

Machine-baiting has been shown repeatedly to be cost-effective in controlling pocket gopher damage, especially on large plantations. It is currently the most widely followed method of controlling gopher damage, but treatment must be done correctly to assure effectiveness, and even successful baiting provides only temporary relief. This is an important concept, because tree protection may be necessary for several years, depending on the rate of tree growth. Complete population reductions rarely if ever occur, and offspring of survivors may quickly repopulate unoccupied burrow systems. In many areas, rapid invasion from adjacent, uncontrolled populations also can be expected. An abundance of unoccupied systems likely will increase survival of dispersing young, and reduced population densities may temporarily stimulate reproduction and survival.

Use of the burrow builder on forest lands introduces additional factors not encountered with hand-baiting. The artificial burrows may persist for several years, and the possibility that they may facilitate reinvasion should be considered. One of the most critical factors governing the use of the burrow builder is soil moisture. In dry climates, where most gopher-reforestation problems occur, use of the machine often is restricted to short periods in spring and fall. Moisture requirements usually can be met in spring, but the potential for reinvasion will necessitate fall treatment in most cases. Fall moisture is unpredictable, and at higher elevations may first appear in sufficient quantity as snow. The necessity of last-minute scheduling places an added burden on management.

Environmentalconsiderations-Strychnine-treated oat bait is sold by the Pocatello Supply Depot, USDA-APHIS, 238 E. Dillon, Pocatello, ID 83201. Strychnine-treated bait placed belowground is effective only for a limited time, ranging from 1 week to 1-112 months, depending on soil moisture and other factors. Strychnine does not accumulate in the body, and it may be consumed at very low dosages over prolonged periods with little or no ill effects. Ingestion of extremely high doses may cause immediate sickness and death in many animals. Sublethal doses may cause bait aversion. In some cases, animals may excrete low dosages of the poison through normal metabolism.

Small mammals that readily eat the bait, such as ground squirrels, can be killed in treatment areas (Anthony and others 1984). Secondary hazards to predators that feed on gophers appear to be greatly lessened by the tendency of gophers to die underground (Barnes and others 1985). Studies by the EPA and the U.S. Fish and Wildlife Service of strychnine baiting for gopher control found very minor losses to other than the target species when bait was correctly placed. Most of these losses were to burrowing animals intercepting burrows or using food found underground. Secondary poisoning may occur only from ingestion of material stored in the gophers' cheek pouches. In response to a question on whether grizzly bears (an endangered species) would be affected by strychnine baiting for pocket gopher control, the U.S. Fish and Wildlife Service conducted research with radio-collared gophers in the Targhee National Forest in Idaho (Barnes and others 1985). They concluded that carcasses of gophers in baited areas did not pose a hazard. Also, grizzly bears were not likely to consume lethal amounts of baits stored in gopher nests, although baits stored in gopher food caches could present a risk.

Under the Endangered Species Act, the Forest Service must request formal consultation and a biological opinion from the U.S. Fish and Wildlife Service where management activities may affect an endangered species.

A formal consultation regarding the potential impact on grizzly bears of direct control of pocket gophers by strychnine baiting resulted in a biological opinion. The opinion requires that the following steps be taken before baiting for pocket gophers in grizzly bear range:

- Use of strychnine baits is permitted in occupied grizzly habitats, with Regional Forester approval.
- Presently, a review of Forest Service rodent control plans is required by the U.S. Fish and Wildlife Service, where endangered species may be affected.

- In grizzly bear range, a proposed treatment area is to be surveyed for grizzly sign or grizzlies before control program is begun. If there is evidence that a grizzly is physically present in the area, a strychnine-baiting program may not be initiated, or if already begun, the program must be discontinued.

Strychnine and other chemicals used in various control operations are often misunderstood; an effective education program for the applicators and concerned publics will be required. This program often needs to begin inside the Forest Service, so that those most directly involved with the program understand and are committed to it.

In all suppression actions, direct or indirect, the program objective is to alleviate reforestation damage. The killing of individual animals is only one of many alternatives. Managers should consider all options, and the benefits and costs of each. Direct suppression through baiting is often the least suitable alternative in the long run.

Individual seedling protectors--Plastic-mesh tubing, such as Vexar, is an effective but costly means of limiting gopher damage. Partially buried seedling protectors (to protect both roots and stems) have reduced damage by 85 to 90 percent over 1 year. In small reforestation areas exposed to heavy pocket gopher damage, seedling protectors can be cost-effective but are very labor intensive. Because of the labor involved, costs for controlling gopher damage with this treatment may increase planting costs by 50 to 150 percent.

In snow country, seedling protectors cannot be used on slopes greater than 25 percent without extensive maintenance, because snow movement frequently causes terminal buds to grow through the plastic mesh, thereby distorting tree growth. Even under optimal conditions, tubing often causes an excessive amount of distortion of tree growth. Information is not available on the rate of breakdown of the tubing underground and potential adverse impact on root growth. Seedling protectors (to provide belowground protection), whether installed during planting or by prepacking seedlings and protectors at the nursery, must be handled with great care to ensure **good seedling survival. For additional details see Campbell and Evans (1975; also** reprinted in appendix 3).

Prediction and prescription matrix-

Ecological considerations-Management of animal damage is most effective when based on sound ecological principles. The response of pocket gophers to timber harvest and reforestation is most influenced by the species of seral vegetation that revegetate harvested sites, the composition and productivity of these plant communities, and the abundance of gophers or the proximity of populated areas before harvest. All these factors may differ with habitat type, silvicultural method, and the system of logging.

The habitat type classifies aggregates of land capable of producing similar plant communities at climax. Each climax plant community reflects the integration of environmental factors on the resultant vegetation. One habitat type may support a variety of disturbance-induced, seral, plant communities. The classification of climax overstory and understory vegetation is possible at any successional stage because this vegetative succession, anywhere within one habitat type, ultimately produces similar communities at climax.

Table 2-Options for controlling pocket gopher damage in relation to plant community classes

Control option	Community class: Class 1[a] A	Class 1[a] B	Class 1[a] C	Class 2[a] A	Class 2[a] B	Class 2[a] C	Class 3
Indirect:							
Herbicide	?	x	x	XP-F	XF	XF	?F
Silvicultural method-							
Shelterwood	N/A	N/A	N/A	X	X	X	X
Selection	N/A	N/A	N/A	X	X	X	X
Intermediate treatment	N/A	N/A	N/A	X	X	X	X
Size planting stock	x	x	x	x	x	x	X
Buffer strips	N/A	N/A	N/A	X	X	?	X
Site preparation-							
Mechanical[b]	N/A	N/A	N/A	X	X	X	N/A
Hand	N/A	N/A	N/A	N/A	?	X	N/A
Herbicides[C]	x	x	x	x	x	x	N/A
Early planting	x	x	x	x			
Direct:							
Baiting, hand and machine	XP	XP-F	XP-F	XF	XF	XF	XF
Trapping	?	N/A	?	N/A	N/A	N/A	X
Plastic tubes	N/A	X	X	X	X	X	X
Monitor							Primary

N/A = not applicable; P = pretreatment; F = followup.

[a]Class 1 and 2 communities are further defined by the range within the classification. Class 1A is the least typical of the type, with the lowest continuous gopher populations. Class 1B is the most typical. Class 1C forms an intergrade between classes 1 and 2, being more commonly like class 1 than 2. Class 2 has a similar classification system (see text for details and examples).

[b]Dozer stripping

[C]Limit application, strip or spot

The variety of seral plants differs in composition, based on the habitat type, because of the variation of environmental interactions and the ability of various plants to cope with a given environment. This composition is predictable. The variation in the makeup of a seral plant community affects the habitat suitability of each community for gophers. A stratification of communities associated with habitat types can be used to assess the risk of gopher damage when allocating or planning for resource uses on a site. This determination will indicate where values and risks are the greatest.

Matrix development-The preference of pocket gophers for certain identifiable habitat types suggests that communities may be grouped into three classes (table 2).

Class 1: Those communities having moderate to high incidence of gophers in natural and disturbed stands.

Class 2: Those having a low incidence but a high potential for gopher occupancy.

Class 3: Those showing little observed gopher activity before and after activity or disturbance at the site.

The understory vegetation provides the principal means of identifying and mapping these communities, irrespective of their successional status. Consequently, expected tree mortality and necessary gopher control measures can be planned before harvesting class 1 communities. Field identification of class 1 sites becomes important in predicting postdisturbance infestation sources,

Class 2 communities usually support impoverished herbaceous understories in the undisturbed condition. Burning or scarification will stimulate grass and forb production up to 10 times pretreatment levels. The burst of food supply makes these communities attractive to scattered, onsite gophers or those populations from adjacent class 1 communities. For this reason, severe gopher damage within class 2 communities usually is localized and must be treated as it occurs. In some areas, potential damage has been reduced by leaving near-natural buffer strips between class 1 and 2 communities; this is a viable alternative.

Class 3 communities are dominated by shrubs that are not preferred gopher food. Seral forbs created by disturbance seldom occur in this class. Once identified, little consideration of gopher damage and control is necessary.

The classification of the habitat type or community as to class must be made at the National Forest or Ranger District level and may be based on evidence or experience. Some examples follow.

Class 1 communities often are open stands where herbaceous material is predominately fleshy-rooted forbs preferred by pocket gophers. In the Pacific Northwest, examples are poorly stocked subalpine fir/elk sedge habitat type, predominated by open-grown lodgepole pine, with clusters of lupine occurring throughout; mixed stands of various conifers and aspen present; large volumes of fleshy-rooted forbs are common in the aspen areas.

Class 2 communities often are dense old growth or densely stocked small saw timber or pole-size stands, with mostly dense sod-forming grasses. In some cases, these may be lightly stocked and composed entirely of bunchgrasses with few forbs or other vegetation present. When disturbed, dormant seed (soil-stored) will flourish, producing abundant moderately to highly desirable forbs, shrubs, or grasses. Some examples in the Pacific Northwest are Douglas-fir/pinegrass that has been harvested by using various silvicultural systems with resultant fireweed, geranium, lupines, and pinegrass producing abundant growth. Often roads and skid trails are present that produce numerous annuals; ponderosa pine/bitterbrush habitat that has been lightly harvested and disturbed often produces abundant forbs, especially lupine, or soil-stored forbs with bulbous early growth characteristics.

Class 3 communities often are dominated by brush species that sprout, sucker, or have root regenerating systems that allow rapid occupation of such areas by brush. Brush communities that are sporadic in their occurrence or support both brush and grass-herbaceous cover normally will be in class 1 or class 2 communities, depending on the specific situation. Some changes in classification may occur because of silvicultural activities that affect the ability of an area to produce pocket gopher food plants.

References-

Anderson, R.J. 1976. Relation of the northern pocket gopher to forest habitats in south central Oregon. Corvallis, OR: Oregon State University. 46 p. M.S. thesis.

Anthony, R.M.; Barnes, V.G., Jr.; Evans, J. 1978. "Vexar" plastic netting to reduce pocket gopher depredation of conifer seedlings. In: Howard, W.E., ed. Proceedings, 8th vertebrate pest conference; 1978 March 7-9; Sacramento, CA. Davis, CA: University of California: 138-144.

Anthony, R.M.; Lindsey, G.D.; Evans, J. 1984. Hazards to ground squirrels and associated secondary hazard potential from strychnine baiting for forest pocket gophers. In: Clark, D.O., ed. Proceedings, 11 th vertebrate pest conference; 1984 March 6-8; Sacramento, CA. Davis, CA: University of California: 25-31.

Barnes, V.G., Jr. 1973. Pocket gophers and reforestation in the Pacific Northwest: a problem analysis. Spec. Sci. Rep. Wildl. 155. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 18 p.

Barnes, V.G., Jr. 1974. Response of pocket gopher populations to silvicutural practices in central Oregon. In: Black, H.C., ed. Proceedings, symposium on wildlife and forest management in the Pacific Northwest; 1973 September 11-12; Corvallis, OR. Corvallis, OR: Oregon State University: 113-119.

Barnes, V.G. Jr.; Anthony, R.M.; Fagerstone; K.A.; Evans, J. 1985. Hazards to grizzly bears of strychnine baiting for pocket gopher control. Wildlife Society Bulletin. 13: 552-558.

Birch, L.E. 1987. Monitoring pocket gopher control contracts. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 93-104.

Black, H.C.; Hooven, E.F. 1977. Effects of herbicide-induced habitat changes on pocket gophers in southwestern Oregon. In: Proceedings, 29th annual California weed conference; Sacramento, CA. California Weed Conference: 119-127.

Borrecco, J.E.; Black, H.C. 1990. Animal damage problems and control activities on National Forest System lands. In: Davis, L.R.; Marsh, R.E.; Beadle, D.E., eds. Proceedings, 14th vertebrate pest conference; 1990 March 6-8; Sacramento, CA. Davis, CA; University of California: 192-198.

Boyd, R.J. 1987. Vegetation management and animal damage. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 55-58.

Burton, D.H.; Black, H.C. 1978. Feeding habits of Mazama pocket gophers in south-central Oregon. Journal of Wildlife Management. 42(2): 383-390.

Chase, J.D.; Howard, W.E.; Roseberry, J.T. 1982. Pocket gophers. In: Chapman, J.A.; Feldhamer, G.A., eds. Wild mammals of North America: biology, management, and economics. Baltimore, MD: Johns Hopkins University Press: 239-255.

Crouch, G.L. 1979. Atrazine improves survival and growth of ponderosa pine threatened by vegetative competition and pocket gophers. Forest Science. 25(2): 99-111.

Crouch, G.L. 1986. Pocket gopher damage to conifers in western forests: a historical and current perspective on the problem and its control. In: Salmon, T.P.; Marsh, R.E.; Beadle, D.E., eds. Proceedings, 12th vertebrate pest conference; 1986 March 4-6; San' Diego, CA. Davis, CA: University of California: 196-198.

Emmingham, W.H.; Holthausen, R.; Vomocil, M. 1992. Silvicultural systems and stand management. In: Black, H.C. tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 123-142. Chapter 6.

Evans, J. 1987. Efficacy and hazards of strychnine baiting for forest pocket gophers. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 81-83.

Fagerstone, K.A.; Barnes, V.G., Jr.; Anthony, R.M.; Evans, J. 1980. Hazards to small mammals associated with underground strychnine baiting for pocket gophers. In: Clark, J.P.; Marsh, R.E., eds. Proceedings, 9th vertebrate pest conference; 1980 March 4-6; Fresno, CA. Davis, CA: University of California: 105-108.

Green, P.; Harper, D.; Jensen, M. **1987.** Pocket gopher and successional plant community relationships within the grand fir-wild ginger habitat type of northern Idaho. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 85-86.

Horton, A.J. 1987. Animal damage prediction models in conifer plantations. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 29-35.

Hull, A.C., Jr. 1971. Effect of spraying with 2,4-D upon abundance of pocket gophers in Franklin basin, Idaho. Journal of Range Management. 24: 230-232.

Marsh, R.E. 1987. The role of anticoagulant rodenticides in pocket gopher control. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 87-92.

Marsh, R.E.; Steele, R.W. 1992. Pocket gophers. In: Black, H.C. tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 205-230. Chapter 10.

Reid, V.W.; Hansen, R.M.; Ward, A.L. 1966. Counting mounds and earth plugs to census mountain pocket gophers in forest ecosystems. Journal of Wildlife Management. 30: 327-334.

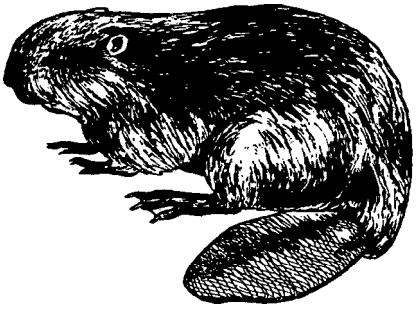
Teipner, C.L.; Garton, E.O.; Nelson, L., Jr. 1983. Pocket gophers in forest ecosystems. Gen. Tech. Rep. INT-154. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 53 p.

Teitjen, H.P. 1973. 2,4-D, vegetation and pocket gophers. In: Turner, G.T.; Hansen, R.M.; Reid, V.H. [and others], eds. Pocket gophers and Colorado mountain rangeland. Bull. 554S. Fort Collins, CO: Colorado State University, Agriculture Experiment Station. 90 p.

Volland, L.A. 1974. Relations of pocket gophers to plant communities in the pine region of central Oregon. In: Black, H.C., ed. Proceedings, symposium on wildlife and forest management in the Pacific Northwest; 1973 September 11-12; Corvallis, OR. Corvallis, OR: Oregon State University: 149-166.

Beaver
(Castor *canadensis)*

Description-The beaver is the largest rodent in North America, sometimes weighing over 60 pounds. Its large size, flat scaly tail, and webbed hind feet easily distinguish it from other native mammals and from the nutria, which is much smaller and has a round tail. Beaver are golden to dark brown above, somewhat lighter below.



Economic significance-Beavers were eliminated from much of their former range by over-trapping, but with proper management they have become reestablished and are now common in many areas.

Beaver skins provide a minor source of income to some trappers. Most pelts are used in Europe for making fur coats and hats and for trimming cloth garments.

Beavers are noted for their dam-building and tree-felling activities that have both short- and long-term effects on the areas they occupy. Streams are slowed and usually warmed, streamside shade is reduced, vegetative structure is changed, water-borne sediment is deposited in slack water of the ponds, stream courses are sometimes altered, and downstream flows are usually stabilized during the dry season.

Tree-cutting damage is usually of less importance than the damage produced by the plugging of culverts and flooding of roads and timber stands as new ponds are created. Tree cutting by beavers is usually a problem only when trees are removed in campgrounds or scenic areas. Recent estimates of beaver flooding damage to timber include $45 million in Georgia and $17 million in Mississippi (Robles 1987).

Life history information-

Preferred habitat-water courses with aspen, willow, cottonwood and associated streambank vegetation are the most suitable sites. Smaller streams with flows from 2 to 12 feet per second are very attractive to beavers.

Feeding habits-Bark, twigs, leaves, roots, and a wide variety of aquatic plants are major food items. Cottonwood, aspen, and willow are the principal tree species eaten. Conifers occasionally are eaten but are not a staple food.

Activity-Dam building and feeding occur primarily at night. Travel usually is restricted to small areas around ponds or water courses. Young beavers dispersing from colonies may travel many miles to find new habitat.

Reproduction-Beavers are polygamous and mate once a year in late January or February. They are capable of breeding when 2 years old. From two to six kits are born in April or May after a 3-month gestation period. The young remain as part of the colony until 2 years of age, when they leave to establish their own homes.

Damage problems and their management-

Identification--Beavers can be identified by the presence of characteristic beaver dams, conical stumps with prominent tooth marks, and large wood chips present around stumps. Peeled sticks also may be present in or near water (fig. 30).

Determining ***the*** need ***for damage*** management-Beavers are valuable when their activities can be tolerated. In considering the need and method of control, it should be remembered that the ponds maintained by beavers generally have a high value for recreation and as fishery and wildlife habitat.

Management methods-

Trapping and shooting-Trapping is the most common method of removing individuals, but shooting may be more effective. In both instances, results may be only temporary, however. To remove problem beavers, get assistance from APHIS-ADC, state wildlife biologists, or licensed private trappers. APHIS-ADC has found that shooting by using a night scope is one of the most efficient, selective, and expedient methods of removing nuisance beavers. Consult with state wildlife officials regarding regulations pertaining to the taking of beaver by means of trapping or shooting.

Fencing--A fenced lane can be constructed that will effectively discourage beavers intent on plugging culverts or building dams in undesirable locations. (See chapter 4 for design of the beaver-baffler fence.)

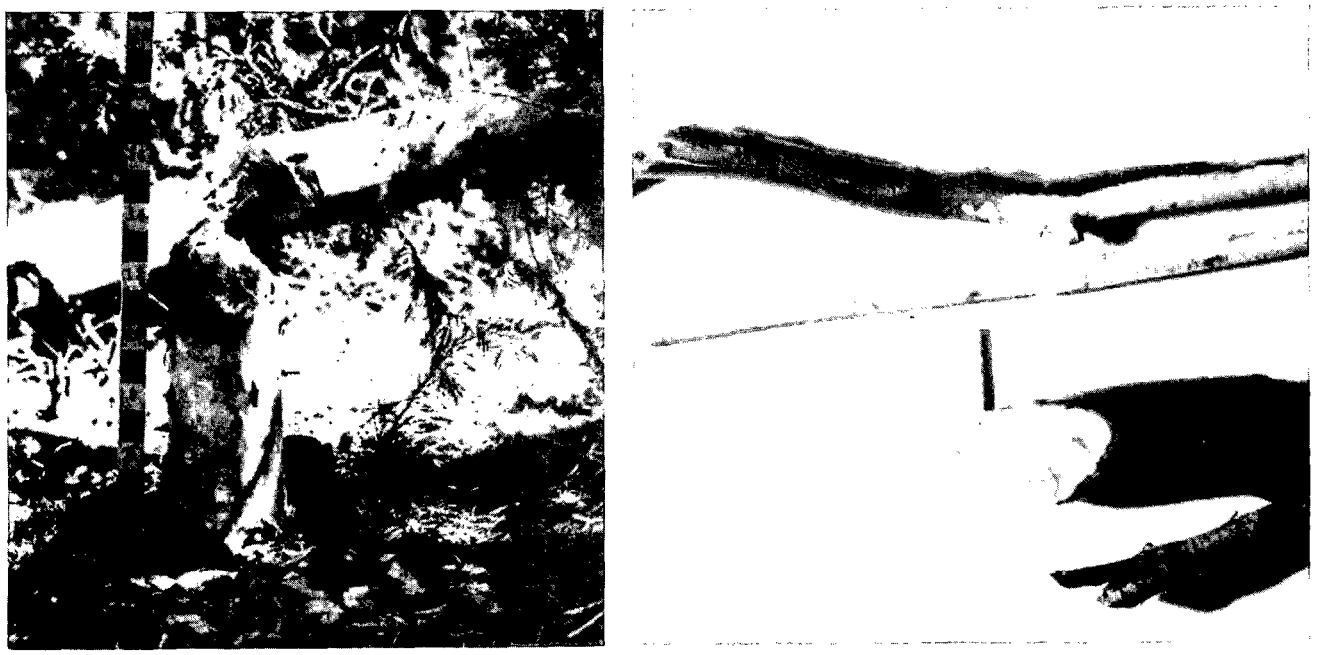


Figure 30-Beaver damage showing typical conical-shaped stump (left), and peeled sticks with uniform horizontal toothmarks (right).

Tree guard-preventing beavers from damaging individual trees in areas such as campgrounds requires intensive protective measures and continuous surveillance. Individual trees can be surrounded by a sheet metal or 2- by 2-inch-wire fence built from the ground to a height of 3 feet. Fencing may be ineffective in deep snow.

Explosives-Explosives have been used to rupture dams and drain water impoundments. Trapping usually precedes dam destruction. In Louisiana, where 117 beaver dams were demolished with water gel explosives, researchers found that deep water dams could be removed more effectively than shallow water dams, and that dams removed in late summer were rebuilt less frequently than those removed in early and midsummer (Dyer and Rowell 1985). Prompt draining of flooded timber land is important, particularly during the growing season.

Plastic tubing-Plastic drainage tubing and wire mesh culverts have been used to control water levels at nuisance beaver sites in New York (Roblee 1983). T-culvert guards have also proven to be effective in recent trials (Roblee 1987).

The San Dimas Technology and Development Center, Pacific Southwest Region (444 E. Bonita Avenue, San Dimas, CA 91173, phone 818/332-6231), has evaluated methods of keeping beavers from building dams at culverts and developed a downspoutdesign showing great promise. Contact them for design details on downspouts, perforated pipes, bafflers, and perforated culvert extensions. They are soliciting field experience with these designs or other new concepts.

References-

Allred, M. 1981. The potential use of beaver population density in beaver resource management. Journal of the Idaho Academy of Science. 17(1): 14-24.

Borrecco, J.E.; Black, H.C. 1990. Animal damage problems and control activities on National Forest System lands. In: Davis, L.R.; Marsh, R.E.; Beadle, D.E., eds. Proceedings, 14th vertebrate pest conference; 1990 March 6-8; Sacramento, CA. Davis, CA: University of California: 192-198.

Bradt, G.W. 1947. Michigan beaver management. Lansing, Ml: Michigan Department of Conservation, Game Division. 56 p.

Dyer, J.N.; Rowell, **C.E. 1985.** An investigation of techniques used to discourage rebuilding of beaver dams demolished by explosives. In: Bromley, P.T., ed. Proceedings, 2d Eastern wildlife damage conference; 1985 September 22-25; Raleigh, NC. Raleigh, NC: North Carolina State University: 97-120.

Fisher, P.H. 1986. Keeping beavers from plugging culvert inlets. Engineering Field Notes. Washington, DC: U.S. Department of Agriculture, Forest Service. 18: 9-13.

Fitzgerald, W.S.; Thompson, R.A. 1988. Problems associated with beaver in stream or floodway management. In: Crabb, A.C.; Marsh, R.E., eds. Proceedings, 13th vertebrate pest conference; 1988 March 1-3; Monterey, CA. Davis, CA: University of California: 190-195.

Hill, E.P. 1982. Beaver (Castor canadensis). In: Chapman, J.A.; Feldhamer, G.A., eds. Wild mammals of North America: biology, management, and economics. Baltimore, MD: Johns Hopkins University Press: 256-281.

Medin, D.E.; Torquemada, K.E. 1988. Beaver in western North America: an annotated bibliography, 1966 to 1986. Gen. Tech. Rep. INT-242. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 18 p.

Owen, C.N.; Adams, D.L.; Wigley, T.B. 1984. Inefficacy of a deer repellent on beavers. Wildlife Society Bulletin. 12: 405-408.

Provost, E.E. 1958. Studies on reproduction and population dynamics in beaver. Pullman, WA: Washington State University. 78 p. Ph.D. dissertation.

Roblee, K.J. 1983. The use of corrugated plastic drainage tubing and wire mesh culverts for controlling water levels at nuisance beaver sites. In: Decker, D.J., ed. Proceedings, 1st Eastern wildlife damage control conference; 1983 September 27-30; Ithaca, NY. Ithaca, NY: Cornell University, Cooperative Extension: 56-57.

Roblee, K.J. 1987. The use of T-culvert guard to protect road culverts from plugging by beavers. In: Holler, N.E., ed. Proceedings, 3d Eastern wildlife damage control conference; 1987 October 18-21; Gulf Shores, AL. Auburn, AL: Auburn University, Cooperative Extension: 25-41.

Wigley, T.B., Jr. 1981. A model of beaver damage and control. State College, MS: Mississippi State University. 151 p. Ph.D. dissertation.

Nutria (Myocaster copypu)

Description-These semiaquatic rodents are native to South America. They resemble beavers but have long round tails. Males sometimes weigh as much as 20 pounds, but most adults weigh about 8 pounds. Their hind feet are webbed between the inner four toes.

Economic significance-Nutria may cause damage to newly planted cypress seedlings and are a deterrent to natural regeneration of cypress in some flooded areas of the Southeastern United States. They also may cause minor damage to Douglas-fir plantations in western Oregon and Washington.

Life history information-

Preferred habitat-Wetlands and flooded areas provide ideal habitat. Through escape from fur farms and distribution by fur trappers, nutria have established substantial populations in Oregon and Washington, North Carolina to Maryland, and Alabama to Texas. Wild populations have been reported in at least 40 States.

Feeding habits-Nutria commonly feed on the basal parts of soft grasses or aquatic plants. They may eat several pounds of food daily.

Activity--When alarmed on land, these animals splash into water and may remain hidden in aquatic vegetation. Like muskrats, they build feeding platforms of discarded plant parts. They may dig extensive burrow systems and are primarily nocturnal animals.

Reproduction-Nutria breed throughout the year; litter size averages five young, after a 130-day pregnancy. Newborns are fully furred, with their eyes open and can swim immediately.

Damage problems and their management-Nutria have been damaging newly planted cypress seedlings in Louisiana since the late 1940s. By 1960, the problem was so serious that the USDA Soil Conservation Service recommended that further plantings be suspended until a control method was available. In a 1985 test, plastic seedling protectors were chewed through at the water level, the seedlings were clipped and dropped and the taproots pulled out. The taproot bark and root collars were eaten. All seedlings were destroyed within 8 weeks. Chickenwire fences provided excellent protection from nutria in dry areas. Individual wire tubes for use as seedling protectors were found to be difficult to make and install.

Zinc phosphide is the only Federally registered toxicant for use in nutria control and usually is used with fresh carrot bait, after prebaiting. Baiting procedures are difficult and must be carefully followed for effectiveness and safety. Forest Service personnel should consult with their wildlife biologist, Regional Office pesticide-use specialist, or APHIS-ADC personnel for the latest control recommendations before initiating control practices. In some states, nutria are protected furbearers; consult state wildlife officials before initiating controls.

References-

Connor, W.H.; Toliver, J.R. 1987. The problem of planting Louisiana swamplands when nutria *(Myocaster coypu)* are present. In: Holler, N.R., ed. Proceedings, 3d Eastern wildlife damage control conference; 1987 October 18-21; Gulf Shores, AL. Auburn, AL: Auburn University, Cooperative Extension: 42-49.

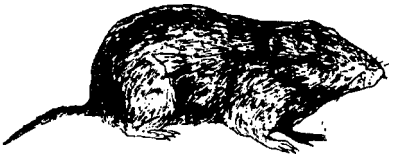
Evans, J. 1983. Nutria. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension: B-61 to B-70.

Evans, J. 1987. Vexar seedling protectors did not reduce nutria damage to planted bald cypress seedlings. Tree Planters Notes. 38(3): 26-29.

Willner, G.R. 1982. Nutria. In: Chapman, J.A.; Feldhamer, G.A., eds. Wild mammals of North America: biology, management, and economics. Baltimore, MD: Johns Hopkins University Press: 1059-1076.

Meadow Voles
(Microtus spp.)

Description-Meadow voles (also known as field mice) are mostly brownish gray, with dense fur, beady eyes, small ears, and relatively short tails. The several species of meadow voles differ widely in size; the combined length of their heads and bodies ranges from 2 to 5 inches. Vole presence is indicated by 1/2-inch-wide runways through matted grass. Further evidence includes small piles of droppings and short clippings of grass along these runways. Lemmings, tree voles, and redback voles may be confused with *Microtus* spp. Individual species coloration is the main distinguishing factor.



Economic significance-Meadow voles eat conifer seeds, newly germinated seedlings, and bark of young trees. They can cause serious damage to conifer plantations, especially where snow occurs in winter. Meadow voles also are detrimental to many agricultural crops during periods when their populations are high.

Life history information-

Preferred habitat-Meadow voles occur in a variety of sites with sufficient vegetation to provide food and cover. Grassy areas provide the most desirable habitat.

Feeding habits-All types of vegetation, including grass, herbaceous foliage, twigs, roots, seeds, and bark, are eaten.

Activity--Meadow voles are active both day and night throughout the year. Their presence is readily detected by distinct winding runways beneath the vegetation. Each vole usually maintains its own set of runways, but its territory may be occupied by several voles. Individual home territories range from a few square feet to areas as large as 0.1 acre.

Damage problems and their management-

Identification-Barking of small limbs and seedlings is characterized by indistinct tooth marks and a fuzzy, roughened appearance (fig. 31). Areas of dense ground vegetation have numerous distinct runways.

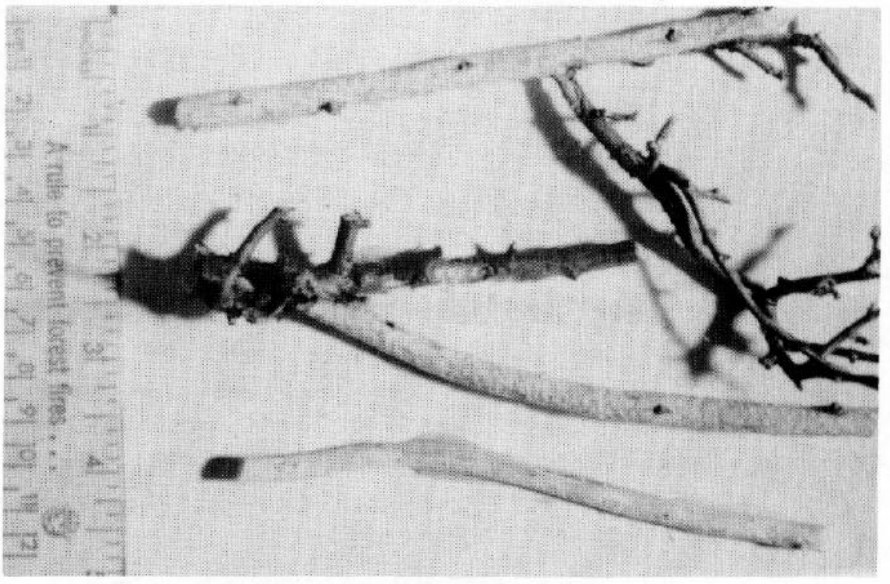


Figure 31—Vole-barked seedlings showing typical roughened stem.

Determining the need for damage management—Meadow vole populations fluctuate dramatically, often causing damage at high-population levels, with populations dropping after damage is noticed and before control is undertaken. When considering whether to undertake damage management, be sure to verify that a problem still exists, as the population can crash in a matter of weeks.

Management methods—

Baiting—Meadow voles usually can be controlled with 2-percent zinc phosphide-treated grain. Distribute the bait in quantities of 1/2 teaspoonful directly in runways and burrows. The quantity of bait needed per acre will differ depending on vole density and distribution and on the density of cover.

Six pounds of bait per acre normally is enough to control high populations in dense cover. Correct bait placement is very important, as the voles seldom venture from the protection of their runways. Baiting is most effective in late fall. Baiting may be needed for several years in problem areas.

Anticoagulants are registered for use in some states. Check with your wildlife biologist or Regional Office pesticide-use specialist to determine the status of toxicants registered in your area.

Habitat manipulation—Removing food and cover is an effective method for controlling damage by meadow voles, but it may have adverse effects on other wildlife. This approach to damage control is most applicable in old fields and other areas having dense grass cover. Habitat manipulation can be accomplished most effectively by spraying with herbicides or by cultivation (both methods are especiallly appropriate for Christmas tree plantations). Mowing or grazing may be applicable in some situations.

References-

Askham, L.R. 1992. Voles. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 187-204. Chapter 9.

Caslick, J.W. 1969. How to control mouse damage in conifers. In: The Conservationist. Albany, NY: New York State Department of Conservation. August-September: 28-29.

Caslick, J.W.; Decker, D.J. 1977. Control of wildlife damage in orchards and vineyards. Info. Bull. 146. Ithaca, NY: New York State College of Agriculture and Life Sciences, Cornell University. 18 p.

Caslick, J.W.; Eadie, W.R. 1969. Inexpensive bait stations for mouse control in tree plantings. American Christmas Tree Journal. November: 19-20.

Gill, A.E. 1977. Food preferences of the California vole, *Microtus caifornicus.* Journal of Mammalogy. 58(2): 229-223.

Goertz, **J.W. 1964.** Habitats of three Oregon voles. Ecology. 45(4): 846-848.

Jameson, E.W., Jr. 1958. The cost and effectiveness of controlling *Mircrotus* with zinc phosphide. Journal of Wildlife Management. 22(1): 100-103.

Kartman, L.; Murray, K.R.; Prince, F.M. [and others]. 1958. Public health implications of the *Microtus* outbreak in Oregon and California during 1957-58. California Vector Views. 5: 19-24.

Oregon State University Cooperative Extension Service. 1959. The Oregon meadow mouse irruption of 1957-1958; a collection of reports from several agencies on various aspects of the irruption. Corvallis, OR: Oregon State College. 88 p.

Radvanyi, A. 1980. Control of small mammal damage in Alberta oil sands reclamation and afforestation programs. Forest Science. 26(4): 687-702.

Deer Mouse
(*Peromyscus* spp.)

Description—Deer mice are the most widely distributed members of this genus. They are distinguished from other mice by large membranous ears. Color is yellowish brown to grayish above, with white or gray underparts; feet are white. The tail is sharply bicolored, white below and dark above. Total length is about 7 inches; the tail is nearly half of the total length.

Economic significance—Deer mice are considered the most devastating of the seed-eating rodents. Field studies have shown that they eat and cache large quantities of conifer seed and that even one or two mice per acre can seriously deplete natural seed fall or artificial seeding.

Life history information—

Preferred habitat—Deer mice occupy nearly all habitat types on forest lands. Their need for ground cover is not as critical as it is for meadow voles and shrews. Large numbers of deer mice are often found on burned areas, even though ground cover may be sparse.

Feeding habits—Seeds, fruits, and insects provide the major sources of food. Coniferous seeds usually are readily accepted, especially seeds of Douglas-fir and pines.

Activity—Deer mice are active throughout the year. They are primarily nocturnal. The average home range is about 4 acres.

Reproduction—Litter sizes range from three to seven, with an average of four litters each year. The gestation period is from 22 to 25 days. Young mice may breed when 6 to 8 weeks old. Populations usually peak in autumn.

Damage problems and their management—

Identification—Conifer seeds are eaten by gnawing a small irregular hole in one end or side of the hull and removing the endosperm (fig. 32). Deer mice often leave an empty boat-shaped hull with clean-cut edges at the opening.

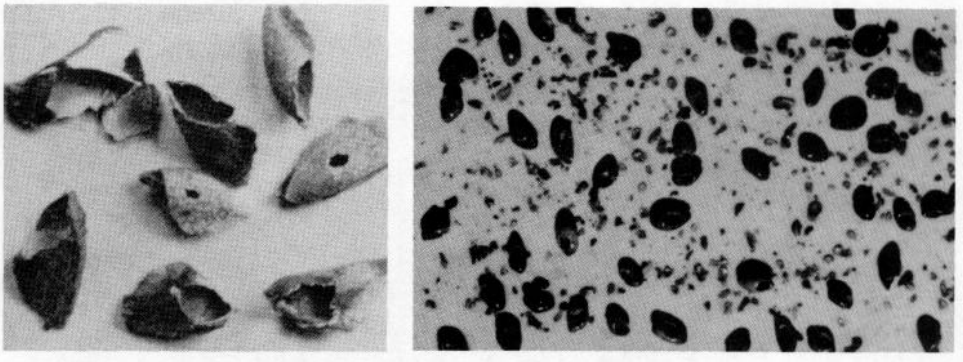


Figure 32—Douglas-fir seeds (left) and ponderosa pine seeds (right) opened by deer mice.

Determining the need for seed protection--Populations of small mammals normally exceed the minimum density required to consume or cache most of the seed distributed in direct seeding. Density of deer mice alone is rarely below one per acre on forest lands, which is sufficient to cause significant seed depredations (Hooven 1958, Moore 1940). Thus, successful establishment of broadcast-seeded Douglas-fir is unlikely, if the acceptance rate of seed spots (see chapter 3) exceeds 5 percent or more of the seed spots in one night (Moore 1940).

Assuming that a 5-percent catch of seed-eating mammals is comparable to a 5-percent rate of seed-spot acceptance, seed protection would be required whenever the catch on trapline transects (see chapter 3) exceeded 5 per 100 trapnights.

Management methods-

Seed protection-Although once commonly used, no chemical treatments currently are recommended. More tests are needed to determine whether supplemental feeding at the time of conifer seeding might protect seeds until germination, as has been shown for an initial g-week-test period in Canada (Sullivan and Sullivan 1982).

References-

Anthony, R.G.; Morrison, M.L. 1985. Influence of glyphosate herbicide on small-mammal populations in western Oregon. Northwest Science. 59: 159-168.

Black, H.C. 1969. Fate of sown or naturally seeded coniferous seeds. In: Black, H.C., ed. Proceedings, symposium on wildlife and reforestation in the Pacific Northwest; 1968 September 12-13; Corvallis, OR. Corvallis, OR: Oregon State University, School of Forestry: 42-51.

Black, H.C.; Hooven, E.F. 1974. Response of small-mammal communities to habitat changes in western Oregon. In: Black, H.C., ed. Proceedings, symposium on wildlife and forest management in the Pacific Northwest; 1973 September 11-12; Corvallis, OR. Corvallis, OR: Oregon State University, School of Forestry: 177-186.

Borrecco, J.E.; Black, H.C.; Hooven, E.F. 1979. Response of small mammals to herbicide-induced habitat changes. Northwest Science. 53: 97-106.

Gashwiler, J.S. 1967. Conifer seed survival in a western Oregon clearcut. Ecology. 48(3): 431-438.

Gashwiler, J.S. 1969. Deer mouse repopulation of a poisoned Douglas-fir clearcut. Journal of Forestry. 67(7): 494-497.

Hooven, E.F. 1958. Deer mice and reforestation in the Tillamook Burn. Res. Note 37. Corvallis, OR: Oregon Forest Lands Research Center. 31 p.

Hooven, E.F.; Black, H.C. 1976. Effects of some clearcutting practices on small-mammal populations in western Oregon. Northwest Science. 50: 189-208.

Jameson, E.W. 1952. Food of deer mice, *Peromyscus rnaniculatus* and **P.** boylei, in the northern Sierra Nevada, California. Journal of Mammalogy. 33: 50-60.

King, J.A., ed. 1968. Biology of *Peromyscus* (Rodentia). Spec. Publ. 2. American Society of Mammalogy. 593 p.

Lawrence, W.H.; Rediske, J.H. 1962. The fate of sown Douglas-fir seed. Forest Science. 8: 210-218.

Maguire, C.C. **1989.** Small mammal predation on Douglas-fir seedlings in northwestern California. Wildlife Society Bulletin. 17: 175-178.

Marsh, R.E.; Howard, W.E.; Cole, R.E. 1977. The toxicity of chlorophacinone and diphacinone to deer mice. Journal of Wildlife Management. 41(2): 298-301.

Moore, A.W. 1940. Wild animal damage to seed and seedlings on cut-over Douglas-fir lands of Oregon and Washington. Agric. Tech. Bull. 706. Washington, DC: U.S. Department of the Interior. 28 p.

Piper, S.E.; Johnson, E. 1940. Some studies of *Peromyscus* and other rodents in the San Bernardino Mountains of California, 1937 to 1940. California Department of Agriculture Bulletin. 29(3): 131-145.

Sullivan, T.P.; Sullivan, D.S. 1982. Reducing conifer seed predation by use of alternate foods. Journal of Forestry. 80(8): 499-500.

Radvanyi, A. 1970. Lodgepole pine seed depredation by small mammals in western Alberta. Forest Science. 17: 213-217.

Radvanyi, A. 1970. Small mammals and regeneration of white spruce forests in western Alberta. Ecology. 51: 1102-1105.

Ritchie, C.; Sullivan, T.P. 1989. Glyphosate treatment and deer mice in clearcut and forest. Northwest Science. 61: 199-202.

West, S.D. 1992. Seed-eating mammals and birds. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 167-186. Chapter 8.

Williams, 0. 1955. Home range of *Peromyscus maniculatus rufinus* in a Colorado pine community. Journal of Mammalogy. 36(1): 42-45.

Williams, 0. 1959. Food habits of the deer mouse. Journal of Mammalogy. 40: 415-419.

Pine Mouse
(Microtus pinetorum)

Although pine mice (also called pine voles) are not known to cause extensive damage in tree plantations, they may damage or destroy seedlings in nurseries and have been destructive in progeny tests in South Carolina. These mice girdle roots and tree trunks. Where extensive damage occurs in National Forests, Regional Office approval should be sought to try control methods used by apple orchardists. Bait stations made of polyvinyl chloride (PVC) tubing, joined to form an inverted "7," provide a practical means of controlling voles in New York apple orchards during winter and spring.

References-

Caslick, J.W.; Eadie, W.R. 1969. Inexpensive bait stations for mouse control in tree plantings. American Christmas Tree Journal. November: 19-20.

Tobin, M.E.; Richmond, M.E. 1987. Bait stations for controlling voles in apple orchards. In: Holler, N.E., ed. Proceedings, 3d Eastern wildlife damage control conference; 1987 October 18-21; Gulf Shores, AL. Auburn, AL: Auburn University, Cooperative Extension: 187-195.

House Mouse
(Mus musculus)

In storage structures, nationwide, house mice may seriously damage property and they, or their parasites, may transmit several diseases to humans. Effective control programs include rodentproof construction, sanitation, and direct population reduction through the use of toxicants, traps, or glue boards,

Mouseproof construction includes sealing all openings 1/4 inch or larger in building foundations and around service openings (pipes, wires, vents). Doors and screens must fit tightly and be reinforced with sheet metal, where needed. Detailed instructions on rodentproofing are available from APHIS and the Cooperative Extension Service.

Because 50 or more traps are needed in a medium-sized storage building to remove an infestation of house mice, trapping is seldom practical. Glue boards exposed to dusty conditions lose their effectiveness quickly.

In Forest Service storage facilities, anticoagulant baits exposed in bait boxes (see fig. 11) usually are effective. Because house mice may travel only a few feet, bait boxes should be no more than 10 feet apart. Careful attention to providing a continuous supply of fresh, high-quality bait is needed.

References-

Caslick, J.W.; Decker, D.J. 1980. Rat and mouse control. Info. Bull. 163. Ithaca, NY: Cornell University, Cooperative Extension. 22 p.

Salmon, T.P.; Lickliter, R.E. 1984. Wildlife pest control around gardens and homes. Publ. 21385. Davis, CA: University of California, Cooperative Extension. 90 p.

Timm, R.M. 1983. House mice. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension Service: B-27 to B-44.

Woodrats
(Neotoma spp.)

Description-Woodrats, otherwise known as pack rats, often are confused with Norway rats. Both the dusky-footed woodrat and the bushy-tailed woodrat are easily distinguished from the Norway rat by the woodrats' soft, fine fur covering the body. The dusky-footed woodrat also has a hairy, unscaled tail. Woodrats have large ears and usually have white feet and underparts. Head and body length is 7 to 8 inches.

Economic significance-The dusky-footed woodrat occasionally strips bark from the crowns of young conifers for nest material. This injury usually occurs in dense, 10- to 30-year-old stands and seldom is widespread. Both the dusky-footed woodrat and the bushy-tailed woodrat cause problems in buildings by fouling stored materials and food supplies.

Life history information-

Preferred habitat-Woodrats may be found in forest habitats throughout their range.

Feeding habit-Primary foods are green foliage, fruits, and seeds. Food is stored for winter use.

Activity—Woodrats are mostly nocturnal. Bulky nests are built primarily of sticks, on the ground or in trees, and are lined with various shredded materials, including tree bark and moss.

Reproduction—Usually, only one litter is born per year. The gestation period is about 30 days. Litters range from two to four young.

Damage problems and their management—

Identification—Woodrats characteristically build large bulky stick-nests on the ground and in the crowns of trees. They also may build nests in caves and buildings. A musty odor and oblong fecal pellets about 1/2 inch long are generally apparent wherever wood rats are present. The dusky-footed woodrat occasionally damages sapling and pole-size conifers by barking and girdling of the upper boles and limbs, in 10- to 30-year-old stands of conifers (fig. 33). Much of the bark used for nest building is removed without exposing the sapwood, whereas feeding of most rodents exposes the sapwood.

Determining the need for management—Control of offending individuals is the best approach. Preventive control is effective only in and around buildings. Damage in second-growth stands is sporadic, with the stand growing beyond a susceptible size in about 30 years.

Management methods—A combination of silvicultural treatments and the removal of offending individuals is the most effective approach for controlling and preventing woodrat damage to conifer plantations.

Baiting—Where registered for this use, anticoagulants may be used to control woodrats in buildings.

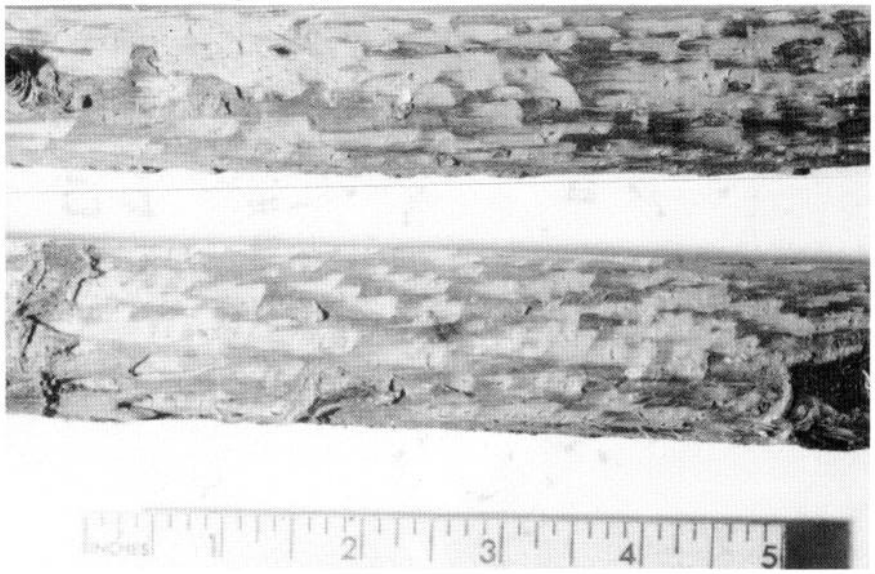


Figure 33—Barking by woodrat showing patchy appearance and toothmarks in sapwood. Much of the outer bark is removed without removing sapwood.

Trapping-In buildings, a particularly effective trap set for capturing woodrats is the stovepipe set. Place a section of stovepipe 6 inches in diameter along a wall and set a Conibear 110 or a no. 0 jump trap in it (see chapter 4). Bait the trap with nutmeats or raisins. A board leaned against the wall to form a tunnel also may be used to make a trap set. Seal all points of woodrat access to prevent re-entry into buildings.

In the field, woodrats are easily taken with wooden-base rat traps or live-traps placed near nests or in active runways and baited with prunes, raisins, or nutmeats

Shooting--Shooting is usually ineffective as a control. It can be done on a limited basis in areas where shooting does not pose a hazard, but it is generally only a temporary measure.

Nest destruction--Nest destruction has been suggested as a control approach during periods of inclement weather. In areas of dense brush cover or litter it is unlikely, however, that the resulting exposure of the animals will be sufficent to cause their death. No data are available on the effectiveness of this procedure (California Forest Pest Council 1992).

Silvicultural modifications-Precommercial thinning and sanitation cutting of slash and brush to reduce favorable habitat conditions and to improve growing conditions for young conifer stands have proven effective in reducing and preventing woodrat problems (California Forest Pest Council 1992).

References-

California Forest Pest Council. 1992. Forest pest conditions in California-1992. Sacramento, CA: California Department of Forestry and Fire Protection. 43 p.

Clark, J.P. 1986. Wood rat. In: Vertebrate pest control handbook. Sacramento, CA: State of California, Department of Food and Agriculture, Division of Plant Industry: 619-1 to 619-3.

Cranford, J.A. 1977. Home range and habitat utilization by Neotoma fuscipes as determined by radiotelemetry. Journal of Mammalogy. 58(2): 165-172.

Hooven, E.F. 1959. Dusky-footed woodrat in young Douglas-fir. Res. Note 41. Corvallis, OR: Forest Lands Research, Oregon Forest Research Center. 24 p.

Lindsdale, J.M.; Tevis, L.P., Jr. 1951. The dusky-footed woodrat. Berkeley, CA: University of California. 664 p.

Marsh, R.E. 1962. Mole and woodrat control. In: Proceedings, National Pest Control Association; 1962 February 6-7; Sacramento, CA. Elizabeth, NJ: National Pest Control Association: 98-112.

Murray, K.F.; Barnes, A.M. 1969. Distribution and habitat of the woodrat, Neotoma *fuscipes,* in northeastern California. Journal of Mammalogy. 50: 43-48.

Salmon, T.P. 1983. Woodrats. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension Service: B-121 to B-124.

Sullivan, T.P. 1992. Tree squirrels, woodrats, and beaver. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 271-287. Chapter 13.

Porcupine
(Erethizon dorsatum)

Description-The most distinctive characteristic of this large, yellowish-black rodent is the stiff quills, especially on the rump and tail. The animals weigh up to 33 pounds.

Economic significance-Clipping and basal barking by porcupines on seedlings and saplings often kills the trees. (Pocket gophers cause similar damage.) Barking of the upper portions of older trees results in deformities that reduce commercial value. Most of the feeding on conifers occurs from late summer through winter. Damage usually occurs in conifer stands between 5 and 30 years old. The most serious damage results from complete removal of bark from the tree bole.

Occasionally, dogs, livestock, and wild animals are blinded or unable to feed because of quill punctures after an encounter with a porcupine. The injured animal may die.

Porcupines also cause nuisance damage around campgrounds and administrative sites. Signs, harnesses, tool handles, automobile tires, privies, and other objects often are damaged.

Life history information-

Preferred habitat-Favored areas are conifer forests where there are rock outcrops or old trees and logs suitable for dens.

Feedjng habits-Bark, buds, grasses, and forbs are taken seasonally. Bark feeding usually does not start until late summer when herbaceous vegetation becomes mature and dry. Feeding injuries to coniferous trees by porcupines are well documented in the Northeastern, North-Central, and Western United States. Damage also is serious in young Sitka spruce plantations in Alaska.

Porcupines prefer to feed on large-diameter stems, as well as the dominant and codominant trees within a given stand. Any damage to a hemlock stem may affect future timber production or quality and may increase the tree's susceptibility to attack by insects and diseases.

Activity-Porcupines actively forage from dusk through early morning. Animals often remain in one area for many days, particularly during stormy weather.

Reproduction-A single young is born each year during May or June, after a gestation period of about 7 months. The minimum breeding age is 1 year, with most females breeding each year.

Damage problems and their management-

Identification--Porcupine use is characterized by prominent horizontal tooth marks, 1/8 inch wide, in the sapwood (fig. 34). On larger, heavily barked trees, pieces of the outer bark, 1/2 to 1 inch, often are found at the base of trees. Clipped conifer needles, quills, and oblong droppings 1 inch long also indicate porcupines.

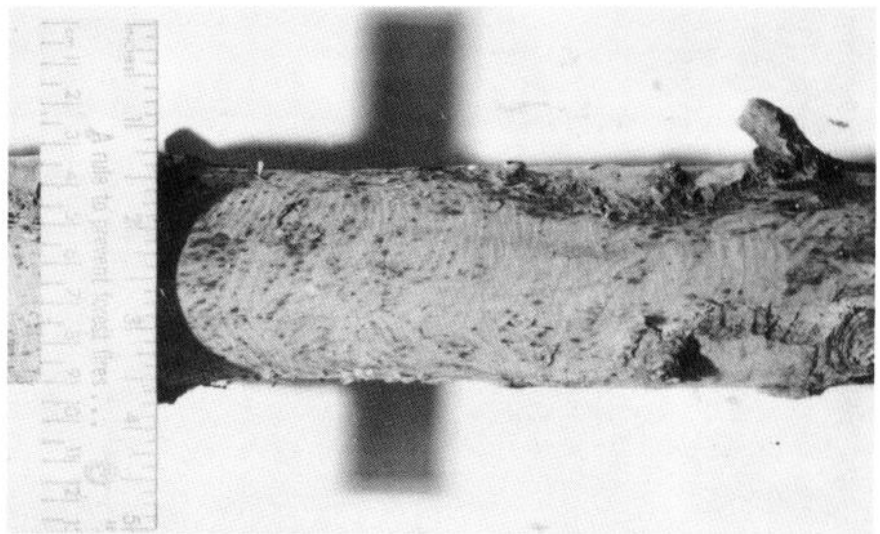


Figure 34—Porcupine damage, showing prominent horizontal and diagonal tooth marks.

Determining the need for damage management—Porcupine damage can occur throughout the porcupine's range, but it is most prevalent in stands with trees less than 18 inches d.b.h. The impact of damage on a stand depends on management objectives. Porcupine damage management probably should be considered in managed stands with 3 percent or more annual damage. Annual damage of less than 1 percent per year may be very conspicuous, but probably does not warrant the effort and expense of a porcupine control program.

Management methods—

A combination of techniques may be required to provide effective damage management. The most specific and effective technique is hunting during the winter, when the areas receiving damage can be visited and particularly depredating porcupines removed (see chapter 4).

Hunting—In snow country, daytime hunting is most successful on snow suitable for tracking during late fall, winter, and early spring. Porcupines usually are active after a snowstorm, and tracks and fresh droppings are easily seen.

Daytime hunting can be done in the early spring when vegetation begins to develop. Look for porcupines where they feed in meadows, along streams, and in open grass and weed-covered ridges in the early morning and late evening.

Night road hunting is recommended during the breeding season in late summer and early fall.

Trapping—Porcupines can be easily caught with a no. 2 jump trap or a Conibear 330 trap (see chapter 4). Many of the normal precautions used in making trap sets for furbearers, such as coyotes and bobcats, can be purposely omitted to avoid unwanted catches of these predators. Most large predators avoid a trap unless it is set with utmost care. If there is a risk of taking nontarget species, another control technique should be used or the trap should be left exposed.

Trap sets should be baited with a fetid scent. The scent should be deposited on solid objects close to the trap. Apples are an attractive bait.

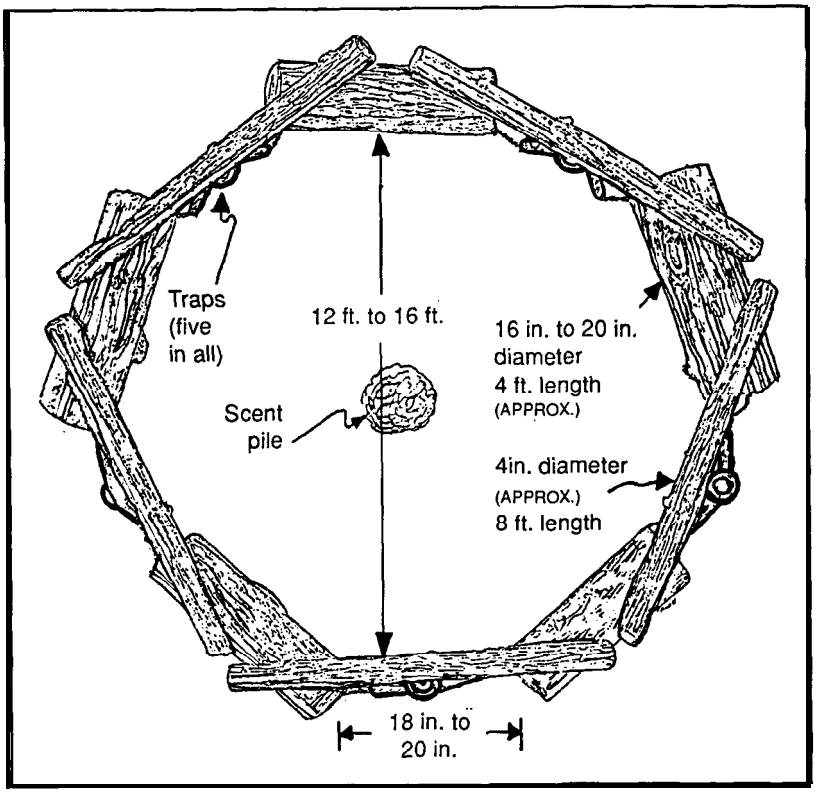


Figure 35-Traps set in a porcupine scent station set.

Scent station sets can be inconspicuously located in areas of concentrated damage (fig. 35). Any material with a fetid odor, such as rotted fish or meat, should be placed in the center of the station. The station is designed to reduce the chances of nontarget species being trapped, while attracting porcupines to enter the station.

Biological control--Fishers are natural enemies of porcupines and should be protected where they occur.

individual free protection--Plastic-mesh tubing can be used for protection of young seedlings (see chapter 4).

Porcupine-resistant signs-Porcupine-resistant signs, made with a special plywood, have been in use at some National Forests for several years, Generally, they have resulted in at least a 50-percent reduction in damage-where damage had been moderate. Damage continued to occur, however, in areas where damage previously was severe. Information on the availability of these signs may be obtained from the Equipment Development Center, USDA Forest Service, Missoula, MT. Resistant signs have been used in several regions of the Forest Service and have proven cost-effective. The price of the special plywood was about $1 per square foot in 1988.

Fencing-Woven wire or electric fencing may be used to fence porcupines out of an area, but high cost generally limits this method to small areas of high value. One of the most practical uses of fencing is to use wire-mesh drift fences or metal flashing as low as 24 inches to direct porcupines to traps set in openings at the ends of the fence (Dodge and Borrecco 1992).

Silvicultural modifications-Habitat changes resulting from harvesting and other silvicultural treatments may increase or decrease habitat suitability for porcupines, although data are lacking on the effects of these practices on porcupine populations, habitat use, and damage. Dodge and Borrecco (1992) note that several forest management practices, such as managing for greater species diversity, delaying thinning, maintaining higher stand densitites, and removing natural and artificial sites (log dumps, slash and other debris), have the potential for reducing porcupine problems.

References-

Anthony, R.M.; Evans, J.; Lindsey, G. 1986. Strychnine-salt blocks for controlling porcupines in pine forests: efficacy and hazards. In: Salmon, T.P.; Marsh, R.E.; Beadle, D.E., eds. Proceedings, 12th vertebrate pest conference; 1986 May 4-6; San Diego, CA. Davis, CA: University of California: 191-195.

Borrecco, J.E.; Black, H.C. 1990. Animal damage problems and control activities on National Forest System lands. In: Davis, L.R.; Marsh, R.E.; Beadle, D.E., eds. Proceedings, 14th vertebrate pest conference; 1990 March 6-8; Sacramento, CA. Davis, CA: University of California: 192-198.

Costello, D.F. 1966. World of the porcupine. Philadelphia, PA: Lippincott. 157 p.

Dodge, W.E. 1982. Porcupines. In: Chapman, J.; Feldhamer, C., eds. Wild mammals of North America: biology, management, and economics. Baltimore, MD: Johns Hopkins University Press: 355-366.

Dodge, W.E.; Barnes, V.G., **Jr. 1975.** Movements, home range, and control of porcupines in western Oregon. Leafl. 507. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 7 p.

Dodge, W. E.; Borrecco, J. E. 1992. Porcupines. In: Black, H.C. tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 253-270. Chapter 12.

Dodge, W.E.; Canutt, P.R. 1969. A review of the status of the porcupine ***(Erethizon*** dursatum) in western Oregon. Olympia, WA: U.S. Department of the Interior, Sport Fisheries and Wildlife; Portland, OR: U.S. Department of Agriculture, Forest Service. 25 p.

Evans, J. 1987. The porcupine in the Pacific Northwest. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 75-78.

Hooven, E.F. 1971. The porcupine in Oregon, its life history and control. Res. Pap. 10. Corvallis, OR: Oregon State University, School of Forestry, Forest Research Laboratory. 22 p.

Lawrence, W.H. 1957. Porcupine control: a problem analysis. For. Res. Note 16. Centralia, WA: Weyerhaeuser Timber Co., Forestry Research Center. 43 p.

Schemnitz, S.D. 1983. Porcupines. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Great Plains Agricultural Council and Nebraska Cooperative Extension Service: B71-B74.

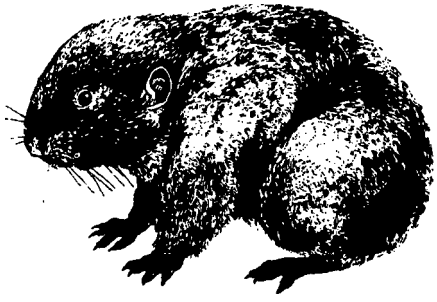
Sullivan, T.P.; Jackson, W.T.; Pojar, J.; Banner, A. 1986. Impact of feeding damage by the porcupine on western hemlock-Sitka spruce forests of north-coastal British Columbia. Canadian Journal of Forest Research. 16: 642-647.

U.S. Department of Agriculture, Forest Service. 1975. New porcupine-resistant signs. Equip. Tips 7571 2306. Missoula, MT: U.S. Department of Agriculture, Forest Service, Equipment Development Center. 1 p.

Yocum, C.F. 1971. Invasion of Humboldt and Del None Counties of northwestern California by porcupines. Murrelet. 52(1): 1-6.

Mountain Beaver
(Aplodontia rufa)

Description-Mountain beaver are about the size of muskrats; head and body length is about 14 inches. Adult mountain beaver weigh about 2 pounds. They have small rounded ears, small eyes, and short, stubby tails. Color is blackish brown all over, except for a whitish spot below the ear. There are five toes on each foot, with the reduced thumb lacking a claw. Size, color, and lack of a tail distinguish it from other mammals within its range.



Economic significance-Mountain beavers cause serious damage to Douglas-fir plantations during establishment, which may continue through the sapling and pole stages of development. They rarely cause damage to mature trees; however, lateral and terminal branches may be removed from trees up to 10 feet tall. Basal barking and undermining of tree roots frequently occur in young-growth stands. Root cutting also occurs. This damage often is not detected until after precommercial thinning; in some instances, thinning may stimulate damage. Plantations up to 4 years old and precommercially thinned stands 12 to 15 years old are particularly susceptible to damage. Burrowing activities of mountain beavers occasionally undermine road beds, irrigation ditches, and earthen dams.

Life history information-

Preferred habitat--Distribution is limited mainly to western Oregon and Washington, although the range of the species extends from southern British Columbia to central California. Mountain beavers are found in suitable forested habits throughout their range; mountain beaver populations thrive on suitable sites in cutover areas. Populations are most abundant near streams and on areas with deep moist soils.

Feeding habits--Mountain beavers are herbivorous and eat a wide variety of herbaceous and woody plants. Sword-fern and "bracken fern" comprise an important part of their diet throughout the year. Feeding is primarily at night, with foraging occurring within a few feet of a tunnel exit.

Activity--Most surface activity takes place at night, but movements within the extensive burrow system may occur either night or day. Although mountain beavers do not hibernate, their activities in many areas are restricted in the winter. Some burrowing may occur in the snow. Late spring is the season of greatest burrowing activity. The burrow system consists of extensive irregular tunnels, 6 to 8 inches in diameter. These tunnels form a network of passages from a few inches to several feet beneath the ground surface. There are many entrances and unrepaired roof openings. A typical burrow system occupies about 0.3 acre (range, 0.1 to 0.5 acre). Burrow systems may overlap. Each system is occupied by a single mountain beaver, except during the spring and summer when juveniles occupy a system with an adult female before dispersing. The nest is large (up to 2 feet in diameter) and a fairly elaborate structure containing numerous layers of packed leaves and other foliage. It usually is located under logs or stumps at a depth of 3 to 5 feet.

Reproduction--Breeding takes place once a year in late February or early March. From two to four young are born after a gestation period of 28 to 30 days. Females do not bear young until they are in their second year.

Damage problems and their management-

Identification--The presence of active mountain beaver burrow systems generally is evident. Clipping by mountain beaver leaves an oblique cut characteristic of rodents and lagomorphs, but it usually can be distinguished from clipping by other animals because of the multiple cuts, which leave a serrated cut end. On larger seedlings, the laterals are frequently clipped off, leaving 1- to 3-inch stubs (fig. 36). Basal girdling may occur on saplings and small pole-size trees. Superficially, the basal girdling may look like bear damage; however, mountain beavers do not leave any discarded bark at the base of the tree. Mountain beavers leave scattered horizontal and diagonal tooth marks, whereas black bears leave deep, vertical incisor marks when scraping the sapwood.

Determining the need for damage **management-Wherever** an active burrow system exists, the potential for clipping of young seedlings exists. When the population of mountain beavers exceeds two per acre, a high rate of clipping can be expected, unless some method of damage control is undertaken. If planting is planned in the immediate vicinity of active mountain beaver burrow systems, some method of damage prevention will be needed.

Management methods-

Baiting--No Federally registered rodenticides are available to control mountain beavers. A Special Local Needs (24-C) registration for pelleted strychnine bait may be in effect in some areas.

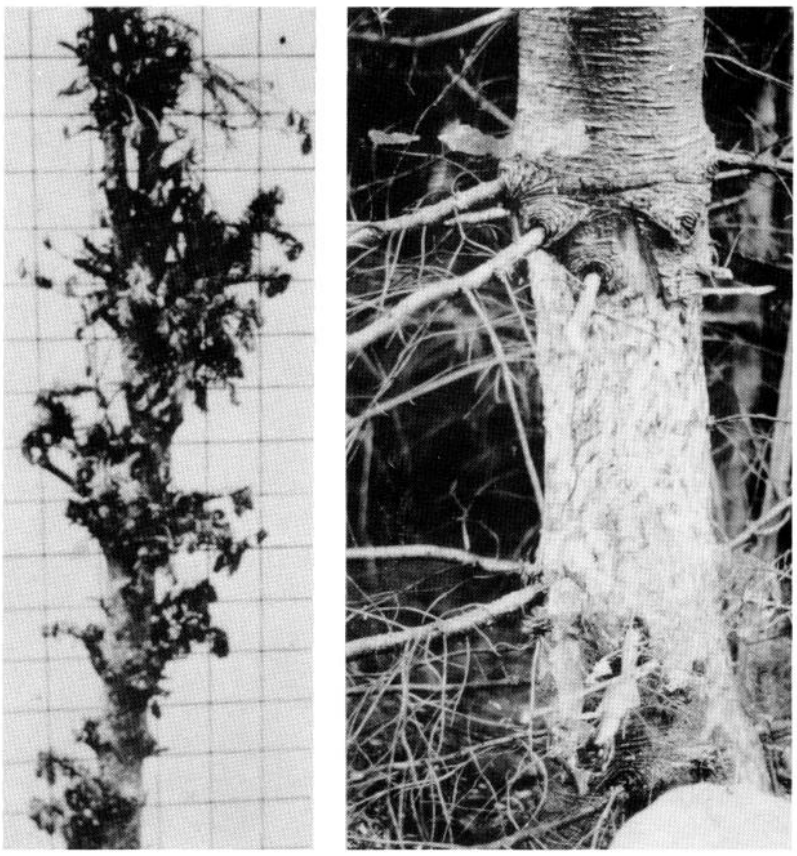


Figure 36—Clipping and barking damage caused by mountain beaver showing characteristic 1- to 3-inch stubs left after clipping limbs (left) and basal girdling (right).

Trapping—Trapping is the most effective method available for controlling mountain beavers (table 3). Conibear Model 110 traps set upright and at right angles to the underground runways are recommended (fig. 37). Traps should be set in a main runway of an active burrow. Before setting a trap in a burrow, be certain that the opening is not a lateral exit burrow used for pushing out soil or plant debris. Secure traps with stakes and chains (fig. 38). There is no need to conceal or cover traps. Check traps regularly, after the first trapnight, to remove any animals not killed outright, to reset as needed, and to ensure maximum effectiveness of traps.

Consider trapping on areas of 5 acres or larger; smaller areas needing buffer protection often are too expensive to trap. Set 3 to 5 traps per burrow system or 20 to 25 traps per acre (when four to five burrow systems per acre are found in typical mountain beaver habitat). One person can set 40 to 50 traps and check an additional 50 traps per day. Use a Conibear 110 trap set in a main runway. Nontarget species may constitute about 3 to 6 percent of the total catch.

Table 3-Estimated effectiveness of 3 control methods on an area with a moderate to high population (3 to 5 active burrow systems per acre) of mountain beaver

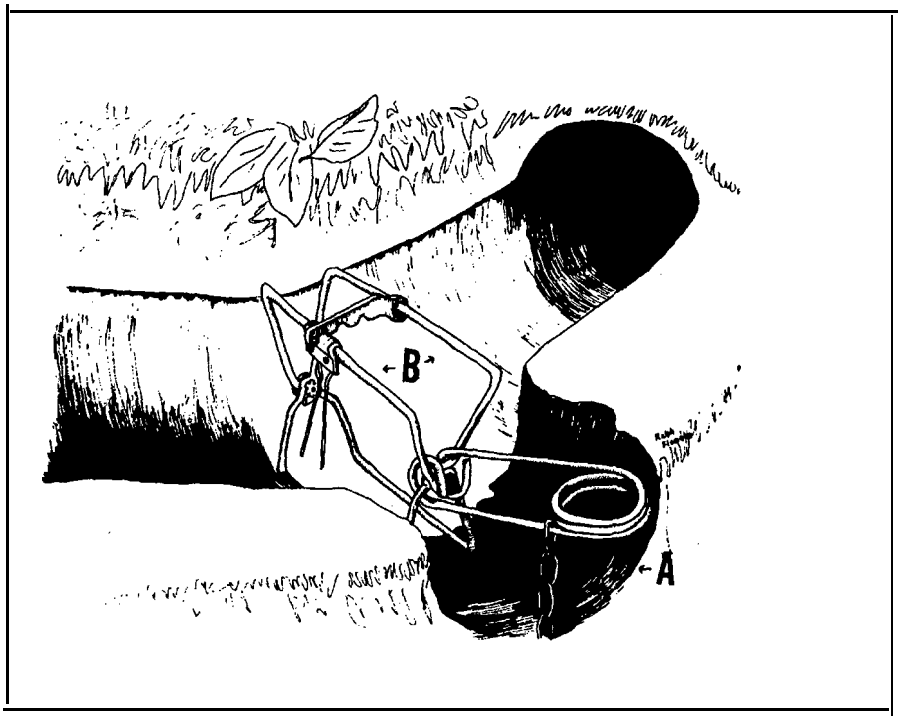
Control treatment	Expected terminal clipping 1 year after planting
	Percent
None	50-80
30-inch tubes	I-4
18-inch tubes	2-5
16-inch tubes	10-15
10-inch tubes	20-30
Broadcast burn	20-30
Trap	10-25
Trap and broadcast burn	4-8

Most animals (up to 90 percent) are caught in the first 1 or 2 days. Leaving the traps set for 4 to 5 days before removing them increases the chance of catching those animals that may have avoided traps or that do not encounter traps during the first part of the trapping period. During spring and summer trapping, juveniles are likely to occupy the burrow systems with adults. This necessitates an additional trap check, after the first day, to remove animals caught and to reset traps to catch mountain beavers remaining in burrow systems having multiple occupants.

During September and October, active mountain beaver sign may not be readily apparent. The lack of active sign can result in reduced trapping efficiency during this period. Scheduling of trapping operations should be delayed for at least 3 to 4 weeks after burning an area to allow development of new sign. If trapping is attempted immediately after burning, many-active mountain beaver burrow systems may be overlooked.

Trapping should be completed before planting, preferably as close to planting time as possible and no sooner than 6 months before planting. Where adjacent populations exist, a 300-foot-wide buffer strip may be trapped in occupied habitat to reduce reinvasion; however, this is of questionable operational value.

Individual tree protection--Plastic-mesh tubing should be considered as an alternative to trapping in areas of less than 5 acres. Use plastic tubing, 18 to 24 inches high, anchored with a single wire pin or wooden stake. For additional details see Campbell and Evans (1975; also reprinted in appendix 3).



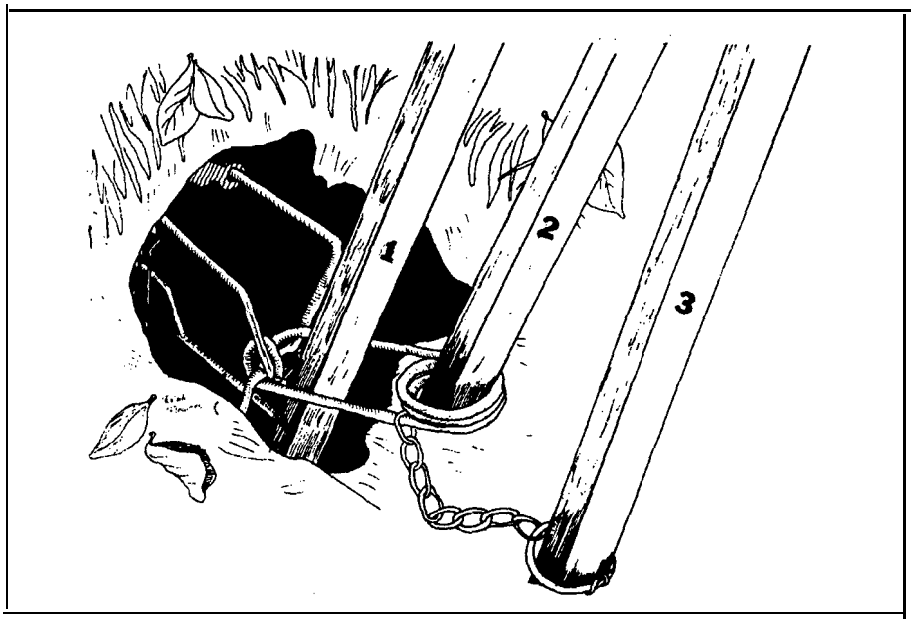


Figure 37—Mountain beaver (
main (B) runways and (bottom
trap spring, and (3) trap chain.

ibear set showing (top) placement in the lateral (A) and
) the position of the stakes used to anchor trap body, (2
ustrations courtesy Weyerhaeuser Company.)

Figure 38—Mountain beaver field set with two anchor stakes. (Photo courtesy Weyerhaeuser Company.)

References—

Borreco, J.E.; Anderson, R.J. 1980. Mountain beaver problems in the forests of California, Oregon and Washington. In: Clark, J.P., ed. Proceedings, 9th vertebrate pest conference; 1980 March 4-6; Fresno, CA. Davis, CA: University of California: 135-142.

Borrecco, J.E.; Black, H.C. 1990. Animal damage problems and control activities on National Forest System lands. In: Davis, L.R.; Marsh, R.E.; Beadle, D.E., eds. Proceedings, 14th vertebrate pest conference; 1990 March 6-8; Sacramento, CA. Davis, CA: University of California: 192-198.

Cafferata, S.L. 1992. Mountain beaver. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 231-251. Chapter 11.

Campbell, D.L.; Evans, J. 1975. "Vexar" seedling protectors to reduce wildlife damage to Douglas-fir. Wildl. Leafl. 508. Olympia, WA: U.S. Department of the Interior, Fish and Wildlife Service. 11 p.

Campbell, D.L.; Evans J. 1988. Recent approaches to controlling mountain beavers (*Apodontia rufa*) in Pacific Northwest forests. In: Crabb, A.C.; Marsh, R.E., eds. Proceedings, 13th vertebrate pest conference; 1988 March 1-3; Monterey, CA. Davis, CA: University of California: 183-187.

Evans, J. 1987. Mountain beaver damage and management. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension Service: 73-74.

Feldhamer, G.A.; Rochelle, J.A. 1982. Mountain beaver *(Aplodontia rufa).* In: Chapman, J.A.; Feldhamer, G.A., eds. Wild mammals of North America: biology, management, and economics. Baltimore, MD: Johns Hopkins University Press: 167-175.

Godin, A.J. 1964. A review of the literature on the mountain beaver. Spec. Sci. Rep., Wildl. 78. Washington, DC: U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife. 52 p.

Hooven, E.F. 1977. The mountain beaver in Oregon: its life history and control. Res. Pap. 30. Corvallis, OR: Oregon State University, Forest Research Laboratory. 20 p.

Johnson, S.R. 1971. The thermal regulation, micro-climate, and distribution of the mountain beaver, *Aplodontia rufa pacifica* Merriam. Corvallis, OR: Oregon State University. 164 p. Ph.D. dissertation.

Lovejoy, B.P. 1972. A capture-recapture analysis of a mountain beaver population in western Oregon. Corvallis, OR: Oregon State University. 105 p. Ph.D. dissertation.

Martin, P. 1971. Movements and activities of the mountain beaver *(Aplodontia rufa).* Journal of Mammalogy. 52(4): 717-723.

Motobu, D.; Jones, M. 1977. Trapping guidelines for mountain beaver. Tech. Rep. 042-4101/77/20. Centralia, WA: Weyerhaeuser Western Forestry Research Center. **28** p.

Motubu, D.T.; Jones, M. 1978. Effects of controlled slash burning on the mountain beaver *(Aplodontia* rufa). Northwest Science. 52(2): 92-99.

Mountain Beaver Subcommittee, Northwest Forest-Animal Damage Committee. 1979. Survey of mountain beaver damage to forests in the Pacific Northwest, 1977. DNR Note 26. Olympia, WA: Department of Natural Resources. 16 p.

Neal, F.D.; Borrecco, J.E. 1981. Distribution and relationship of mountain beaver to openings in sapling stands. Northwest Science. 55(2): 79-86.

Scheffer, T.H. 1929. Mountain beavers in the Pacific Northwest: their habits, economic status, and control. Farmers' Bull. 1598. Washington, DC: U.S. Department of Agriculture. 18 p.

Smutthwaite, D. 1986. Mountain beaver-the rodent that gets no respect. American Forests. 92(5): 45-50.

Voth, E.H. 1968. Food habits of the Pacific mountain beaver, *Aplodontia rufa pacifica* Merriam. Corvallis, OR: Oregon State University. 263 p. Ph.D. dissertation.

Woodchuck
(Marmota monax)

Description--Also known as ground hogs or whistle pigs, woodchucks occupy the Eastern United States from Canada to northern Alabama. They dig extensive ground burrows on farmlands and may be abundant in wooded areas adjoining open lands; excavated mounds of earth are at the main burrow entrances. The openings of the main burrows are about 10 inches in diameter. Woodchucks usually are brownish gray, and weigh 5 to 10 pounds.

Economic significance-Although woodchucks seldom cause extensive damage to trees, they frequently destroy young trees near their burrows. If trees are planted in woodlot openings or shelterwoods where woodchucks have established their burrow systems, the planted trees may be extensively damaged or destroyed, even though natural regeneration remains undamaged.

Life history information-

Preferred habitat-Woodchucks occupy open farmlands, hedgerows, brushy "islands," edges of woodlands, and woodland openings.

Feeding habits-Although legumes and grasses are preferred foods, a wide variety of plants is eaten.

Activity--Feeding and other aboveground activities are most common at dawn and dusk. Woodchucks hibernate during colder months, usually from about October to March, depending on latitude. New burrows usually are constructed during late summer.

Reproduction-Breeding occurs once a year, shortly after emergence from hibernation. Two to six young are born about 32 days later. They are weaned and soon thereafter leave the home burrow, in June or July.

Damage problems and their management-

Identification-Young trees may be clipped off or eaten. Older trees may be chewed or clawed extensively near ground level, particularly in spring or early summer. Damaged trees usually are near burrow entrances.

Status as game animals--Woodchucks are game animals in most states. Thus, it is important to check with the state wildlife agency, APHIS-ADC, or the Cooperative Extension Service for control recommendations.

Management methods-

Fumigants-Burrow fumigation cartridges may be available at farm supply stores and are sold by the Pocatello Supply Depot, USDA APHIS-ADC, 238 E. Dillon, Pocatello, ID 83201. Because they are ignited in use, the cartridges are a fire hazard-do not use them under buildings or when fire danger is high. The cartridges burn slowly to produce carbon monoxide and will not explode if properly used. Directions for use are on the label and must be followed precisely. Fumigation of burrows before the young emerge is especially effective, as is treatment of a large area at one time.

Where fire hazard exists, trapping with no. 2 steel traps or live-traps may be effective: check with your state wildlife officials to determine legality and restrictions. If equipped with telescopic sights, rifles may be effective in some areas, where legal and safe.

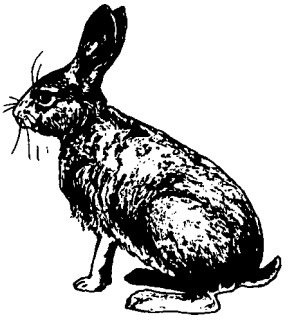
In recreation areas and other locations where individual high-value trees need protection, hardware-cloth tree guards may be helpful.

References-

Bollinger, R., **Jr. 1983.** Woodchucks. In: Timm, R.E., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension Service: B-153 to B-156.

Caslick, J.W.; Decker, D.J. 1981. Controlling wildlife damage in homes and gardens. Info. Bull. 176. Ithaca, NY: New York State College of Agriculture and Life Sciences, Cornell University. 28 p.

Snowshoe Hare
(Lepus americanus)



Description-Also known as the varying hare, most subspecies of this large-footed hare turn white during winter and dark brown in summer. The main distinguishing feature of the snowshoe hare is its coloring. Its ears are relatively short (3-1/2 to 4 inches) for a hare. Head and body length is between 13 to 18 inches.

Economic significance-Snowshoe hares provide a limited amount of sport hunting in parts of their range. The importance of this sport may increase in the future, as hunting pressure increases and habitat for other game species becomes limited.

Hares are food for large predators and, in this way, act as an important buffer species for other game animals.

In localized areas, hare damage to conifer plantations is more critical than that caused by big game. Clipping by hares or rabbits often results in loss of seedlings, especially small containerized stock, but suppression of growth generally occurs when seedlings are exposed to light to moderate injury.

Life history information-

Preferred habitats-Throughout their range, snowshoe hares occupy most commercial forest lands if there is an abundance of good protective cover provided by low-growing vegetation and dense brush.

Feeding habits-Hares prefer a woody diet of foliage, stems, and bark of shrubs and trees throughout most of the year, although herbaceous vegetation is their main food in summer.

Activity--Daily movements usually are limited to a small area. The period of greatest activity is from dusk to dawn. Snowshoe hares do not migrate, but they may shift their feeding activities to different vegetative types when deep-snow conditions exist in winter.

Reproduction-Snowshoe hares normally have three or four young per litter and may have up to four litters a year. Young are born from April through August. The gestation period is from 36 to 40 days. Newborn young are well developed and are soon able to move about.

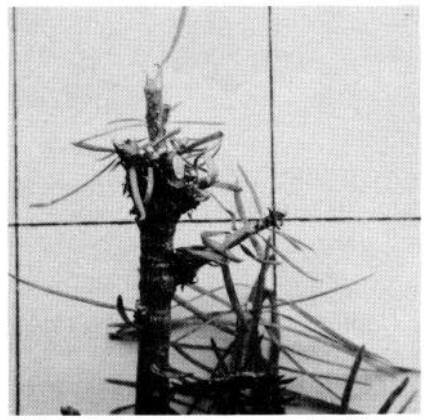


Figure 39—Hare clippings showing characteristic 45° angle of cut branch.

Damage problems and their management—

Identification—Snowshoe hares clip seedlings and limbs up to 1/4 inch in diameter. The stub remaining after clipping has an oblique cut on the end (fig. 39). Barking will occasionally occur during the winter on hardwoods and conifers when other vegetation is unavailable. Sublethal, partial girdling suppressed diameter growth of small trees in British Columbia but had little effect on trees with larger stems (Sullivan and Sullivan 1986). The fecal pellets of snowshoe hares are disc-shaped and about 3/8 inch in diameter.

Determining the need for damage management—Damage by snowshoe hares usually is localized. The most serious problems occur when an area is replanted that has been clearcut long enough (3 to 7 years) to allow a heavy buildup of vegetative cover and hares.

Management methods—

Baiting—No Federally registered toxicants are available to control hares.

Repellents (thiram)—Plant trees that have been treated with thiram animal repellent. Repeated applications of thiram in the field may be required after each growing season, until trees grow large enough to be out of danger. The repellent can be applied effectively with a backpack sprayer. The recommended dilution is 1 gallon of 20-percent thiram to 1 gallon of water (see chapter 4).

Individual tree protection—Plastic-mesh tubing 18 inches high can be used to protect individual tree seedlings. The tubes can be placed on newly planted or established seedlings and will provide protection of new and old foliage from clipping by hares. For additional details see Campbell and Evans (1975; also reprinted in appendix 3).

Fencing and other practices—Fencing, although expensive, may provide long-term protection to areas of high value, such as progeny test sites. Fences should be constructed of mesh or net wire with a weave of 2 inches across or less. A fence 4 feet high should exclude all rabbits and hares, except in areas with deep snow. Fences must be secured to the ground to prevent rabbits and hares from digging under them and, most importantly, must be maintained (Giusti and others 1992).

Installing raptor perches at nurseries and seed orchards is a common practice, although data are lacking on the effectivess of this procedure to control rabbits and hares (and pocket gophers).

Silvicultural practice--Disposal of fuel, brush, and accumulations of logging debris reduces the attractiveness of habitat for hares. When a serious hare-damage problem is anticipated, use large-diameter seedlings with a caliper width of 0.2-0.3 inches. Do not use containerized seedlings without plastic protectors.

Herbicides have been used to reduce herbaceous hiding cover to a low level, which tends to discourage occupancy of the area by snowshoe hares. Borrecco (1976) found a significant reduction in hare numbers and clipping (of conifer seedlings) on plantations where vegetation was controlled.

References-

Adams, L. 1959. An analysis of a population of snowshoe hares in northwestern Montana. Ecological Monographs. 29: 141-169.

Bider, J.R. 1961. An ecological study of the hare *Lepus americanus.* Canadian Journal of Zoology. 39: 81-103.

Borrecco, J.E. 1976. Controlling damage by forest rodents and lagomorphs through habitat manipulation. In: Siebe, C.C., ed. Proceedings, 7th vertebrate pest conference; 1976 March 9-11; Monterey, CA. Davis, CA: University of California: 203-210.

Broadhooks, H. E. 1965. Ecology and distribution of the pikas of Washington and Alaska. American Midland Naturalist. 73: 299-335.

Campbell, D.L.; Evans, J. 1975. "Vexar" seedling protectors to reduce wildlife damage to Douglas-fir. Wildl. Leafl. 508. Olympia, WA: U.S. Department of the Interior, Fish and Wildlife Service. 11 p.

Dolbeer, R.A. 1972. The snowshoe hare in the Western United States: its status and potential as a game animal. In: Proceedings, 52d annual conference of the Western Association of State Game and Fish Commissioners; [dates of meeting unknown]; Portland, OR. [Location of publisher unknown]: [publisher unknown]: 437-451.

Giusti, G.A.; Schmidt, R.H.; Timm, R.M. [and others]. 1992. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 289-307. Chapter 14.

Hartwell, H.D. 1969. Control of damage by snowshoe hares on forest plantations. In: Black, H.C., ed. Proceedings, symposium on wildlife and reforestation in the Pacific Northwest; 1968 September 12-13; Corvallis, OR. Corvallis, OR: Oregon State University, School of Forestry: 80-81.

Hartwell, H.D.; Johnson, L.E. 1983. Survival and height of large and small Douglas-fir seedlings in relation to animal damage six years after planting. DNR Note 38. Olympia, WA: Washington Department of Natural Resources. 20 p.

McKillop, I.G.; Pepper, H.W.; Wilson, C.J. 1988. Improved specifications for rabbit fencing for tree protection. Forestry. 1(4): 359-368.

Radvanyi, A. 1987. Snowshoe hares and forest plantations: a literature review and problem analysis. Info. Rep. NOR-X-290. [Location of publisher unknown]: Canadian Forestry Service, Northern Forestry Centre. 17 p.

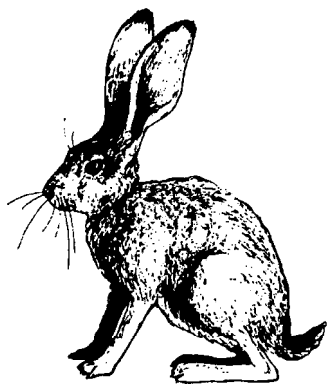
Sullivan, T.P.; Sullivan, D.S. 1982a. Barking damage by snowshoe hares and red squirrels in lodgepole pine stands in central British Columbia. Canadian Journal of Forest Research. 12(2): 443-448.

Sullivan, T.P.; Sullivan, D.S. 1982b. Influence of fertilization on feeding attacks to lodgepole pine by snowshoe hares and red squirrels. Forest Chronicle. 58: **263-266.**

Sullivan, T.P.; Sullivan, D.S. 1986. Impact of feeding damage by snowshoe hares on growth rates of juvenile lodgepole pine in central British Columbia. Canadian Journal of Forest Research. 16(5): 1145-1149.

Sullivan, T.P.; Sullivan, D.S. 1988. Influence of stand thinning on snowshoe hare population dynamics and feeding damage in a lodgepole pine forest. Journal of Applied Ecology. 25: 791-805.

Black-Tailed Jackrabbit
(Lepus californicus)



Description-The black-tailed jackrabbit may be found throughout the grasslands and open areas of the West. It also occurs in less abundance on forest land, especially in clearcuttings and partial cuttings. It is grayish dorsally, and nearly white beneath. Its conspicuous, large (6 to 7 inches), black-tipped ears and black streak on top of the tail distinguish it from all other hares.

Economic significance-The black-tailed jackrabbit occasionally clips Douglas-fir and other conifer seedlings in plantations adjacent to grasslands or shrub communities.

Life history information-

Preferred habitat--Grassland and sagebrush areas are the preferred habitat of the black-tailed jackrabbit.

Feeding habits--Forbs and grasses are dominant in the diet during spring and summer. During fall and winter, shrubs are dominant in the diet.

Damage problems and their management-

Identification--On shrubs and tree seedlings, obliquely cut stems and branches help identify clipping by black-tailed jackrabbits. The sighting of jackrabbits and occurrence of round fecal pellets are indications that black-tailed jackrabbits are in the area. On rangelands, forage cages can be used to determine forage use.

***Determining the need* for *damage* management-Damage** is localized and has been reported only sporadically. A study in Utah estimated that 5.8 jackrabbits consumed as much forage as one sheep on winter sheep range (Currie and Goodwin 1966). During periods of high population levels, several hundred jackrabbits may occupy an area of 1 square mile.

Management methods-

Repellents--Thiram is registered for use as a rabbit repellent. Repeated applications may be needed each year to ensure adequate protection (see chapter 4).

Individual free protection-Plastic-mesh tubing can be used to effectively prevent clipping. Tubes (30 inches high) should be placed over the seedlings when planting or replanting areas exposed to damage (see chapter 4). For additional details see Campbell and Evans (1975; also reprinted in appendix 3).

Fencing and other practices-Fencing, although expensive, may provide long-term protection to areas of high value such as progeny test sites. Fences should be constructed of mesh or net wire with a weave of 2 inches across or less. A fence of 4 feet in height should exclude all rabbits and hares, except in areas with deep snow. Fences must be secured to the ground to prevent rabbits and hares from digging under them and most importantly, must be maintained (Giusti and others 1992).

Installing raptor perches at nurseries and seed orchards is a common practice, although data are lacking on the effectivess of this procedure to control rabbits and hares (and pocket gophers).

Baiting-Special local registrations may exist for use of anticoagulant baits to limit damage by black-tailed jackrabbits.

Shooting and jackrabbit drives-Both drives and shooting may be used to reduce hare numbers, but they require a great deal of personnel time, and shooting may require special equipment such as night scopes or spotlights. State wildlife officials should be consulted regarding restrictions, laws, and permits that may be required.

Silvicultural practices-Use of seedlings over 24 inches in height may reduce clipping.

References-Also see the section on snowshoe hares for additional references on hares and rabbits.

Crouch, G.L. 1969. Jackrabbits injure ponderosa pine seedlings. Tree Planters Notes. 24(3): 15-17.

Currie, P.O.; Goodwin, D.L. 1966. Consumption of forage by blacktail jackrabbits on salt-desert ranges in Utah. Journal of Mammalogy. 30(2): 304-311.

Dunn, J.P.; Chapman, J.A.; Marsh, R.E. 1982. Jackrabbits. In: Chapman, J.A.; Feldhamer, G.A., eds. 1982. Wild mammals of North America: biology, management, and economics. Baltimore, MD: The Johns Hopkins University Press: 124-145.

Evans, J.; Hegdal, P.L.; Griffith, R.E., Jr. 1982. Wire fencing for controlling jackrabbit damage. Bull. 618. [Location of publisher unknown]: University of Idaho, Cooperative Extension Service. 7 p.

Giusti, G.A.; Schmidt, R.H.; Timm, R.M. [and others]. 1992. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 289-307. Chapter 14.

Knight, J.E. 1983. Jackrabbits. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Great Plains Agricultural Council and Cooperative Extension Service: D-75 to D-80.

Nuttall's (Mountain) Cottontail
(Sylvilagus nuttah)

Description-This small grayish rabbit has short ears. It rarely uses burrows; instead it makes runways through thick grass or other vegetation. It can be distinguished from the desert cottontail and the black-tailed jackrabbit by its smaller size. Length of the Nuttall's cottontail is about 14 inches compared with 11 inches for the desert cottontail and 22 inches for the black-tailed jackrabbit.

Economic significance-Nuttall's cottontail is of minor importance in providing hunting opportunities on National Forest lands. The dense habitat it occupies makes both hunting and viewing difficult.

Life history information-

Preferred **habitat-Dense** brush interspersed with openings provides ideal habitat. Distribution extends throughout western Oregon and California, to areas east of the Continental Divide, Montana, Wyoming, and Colorado.

Feeding habits-Buds, twigs, bark, grasses, and a wide variety of succulent forbs are eaten.

Activity--The main period of activity is from dusk to dawn. Movements are confined to very small areas.

Reproduction--Nuttall's cottontails normally have from two to four litters per year, with three to six young per litter. The young are born hairless and blind and spend more time in the nest than hares do.

Damage problems and their management-

Identification-Nuttall's cottontails clip seedlings and small limbs up to 1/4 inch in diameter, leaving an obliquely cut stem. (The appearance of clippings is similar to those made by snowshoe hares, as shown earlier in fig. 1.) Their fecal pellets are round and about 3/8 inch in diameter.

Determining the need for damage **managemement-Damage** is localized, with past experience being the best indicator of potential problems.

Management methods-

Silvicultural practices-Disposal of slash, brush, and accumulations of logging debris reduces the attractiveness of habitat for rabbits. Use of herbicides and other vegetation management practices to reduce food and cover also may alleviate rabbit damage to conifer seedlings. When a serious rabbit damage problem is anticipated, the use of seedlings 2 or more feet high will reduce damage.

Repellents (thiram)-In areas exposed to damage by rabbits, plant trees treated with thiram. Repeated applications of thiram in the field may be required after each growing season, until trees grow large enough to be out of danger. The repellent can be applied effectively with a backpack sprayer. The recommended dilution is 1 gallon of 20-percent thiram to 1 gallon of water (see chapter 4).

Individual free protection-Plastic-mesh tubing also may be used to protect individual tree seedlings. The tubes can be placed on newly planted or established seedlings and will provide protection of new and old foliage from clipping by rabbits. For additional details see Campbell and Evans (1975; also reprinted in appendix 3).

Baits-No poisonous baits are registered to control the Nuttall's cottontail.

References-Also see the section on snowshoe hares for additional references on hares and rabbits.

Chapman, J.A.; Hockman, J.G.; Edwards, W.R. 1982. Cottontails. In: Chapman, J.A.; Feldhammer, G.A., eds. 1982. Wild mammals of North America: biology, management, and economics. Baltimore, MD: The Johns Hopkins University Press: 83-123.

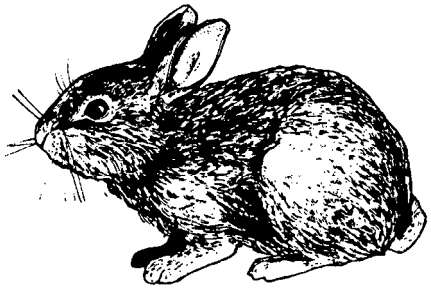
Giusti, G.A.; Schmidt, R.H.; Timm, R.M. [and others]. 1992. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 289-307. Chapter 14.

McKay, D.O. 1975. Dynamics of a population of mountain cottontail rabbits in central Oregon. Corvallis, OR: Oregon State University. 63 p. M.S. thesis.

Orr, R.T. 1940. The rabbits of California. Oct. Pap. 19. [Location of publisher unknown]: California Academy of Sciences. 227 p.

Brush Rabbit
(Sylvilagus bachmani)

Description-The small brown brush rabbit has short ears and tail. It rarely uses burrows; instead, it makes runways through thick grass or other vegetation. It can be distinguished from the desert cottontail and black-tailed jackrabbit by its smaller size. Length of the brush rabbit is about 13 inches compared with about 15 inches for the desert cottontail and about 22 inches for the black-tailed jackrabbit.



Economic significance-The brush rabbit is of minor importance in providing hunting opportunities on National Forest lands. The denseness of the habitat that it occupies makes both hunting and viewing difficult.

Life history information-

Preferred **habitat-Dense** brush interspersed with openings provides ideal habitat.

Feeding **habits--Buds,** twigs, bark, grasses, and a wide variety of succulent forbs are eaten.

Acfivity--The main period of activity is from dusk to dawn. Movements are confined to very small areas.

Reproduction--Brush rabbits normally have from three to four litters per year, with from three to six young per litter. The young are born hairless and blind.

Damage problems and their management-

Identification--Brush rabbits clip seedlings and small limbs up to 1/4 inch in diameter and leave an obliquely cut stem. (The appearance of clippings is similar to those made by other rabbits and hares.) Their fecal pellets (droppings) are round and about 3/8 inch in diameter.

Determining the need for damage **management-Damage** is localized; past history is the best indicator of potential problems.

Management methods-

Silvicultural practices--Disposing of slash, brush, and accumulations of logging debris reduces the attractiveness of the habitat for rabbits. Use of herbicides and other vegetation management practices to reduce food and cover also may alleviate rabbit damage to conifer seedlings. When a serious rabbit damage problem is anticipated, use of seedlings 2 or more feet high will reduce feeding damage.

Repellents--In areas exposed to damage by rabbits, plant trees treated with thiram. Repeated applications of thiram in the field may be required after each growing season until trees grow large enough to be out of danger. The repellent can be applied effectively with a backpack sprayer. The recommended dilution is 1 gallon of 20 percent thiram to 1 gallon of water.

Individual free protection-Plastic-mesh tubing also may be used to protect individual tree seedlings. The tubes can be placed on newly planted or established seedlings and will provide protection of new and old foliage from clipping by rabbits. For additional details see Campbell and **Evans** (1975; also reprinted in appendix 3).

Baiting-No poisonous baits are registered to control brush rabbits.

References-Also see the section on snowshoe hares for additional references on hares and rabbits.

Connell, J.H. 1954. Home range and mobility of brush rabbits in California chaparral. Journal of Mammalogy. 35(3): 392-405.

Hooven, E.F. 1966. A test of thiram on two rabbit-infested areas in Oregon. Tree Planters' Notes. 79: 1-3.

Mossman, A.S. 1955. Reproduction of the brush rabbit in California. Journal of Wildlife Management. 19(2): 177-184.

Orr, R.T. 1940. The rabbits of California. Oct. Pap. 19. [Location of publisher unknown]: California Academy of Sciences. 227 p.

Shields, P.W. 1960. Movement patterns of brush rabbits in northwestern California. Journal of Wildlife Management. 24(4): 381-386.

Birds

The consumption of conifer seeds by birds is a factor in reducing the efficacy of direct seeding (and regeneration by natural seedfall) or preventing its use for forest regeneration and bare-root nursery programs. During the 1950s and 1960s between one-third and one-half of the artificial reforestation in the Pacific Northwest was accomplished by direct seeding using seed treated with toxicants or repellents for rodent and bird management. In the 1970s direct-seeding was largely discontinued.

Birds also may damage terminal shoots by perching and may browse buds and needles.

Conifer tree buds are destroyed by many species of birds. Mature seeds are eaten by mourning dove, juncos, eastern meadowlark, robin, Clark's nutcracker, jays, crossbills, pine siskins, finches, woodpeckers, and nuthatches. Germinating seedlings are clipped by many species, especially if the seed coat is attached.

Drilling by sapsuckers may inflict injuries serious enough to result in log-quality degrade.

Birds may foul stored equipment, and their nests may constitute an electrical fire hazard around buildings.

References-

Bock, C.E.; Lepthien, L.W. 1976. Synchronous eruptions of boreal seed-eating birds. American Naturalist. 110: 559-571.

Eastman, W.R., Jr. 1960. Eating of tree seeds by birds in central Oregon. Res. Note 42. Corvallis, OR: Oregon Forest Research Center. 24 p.

Gashwiler, J.S. 1967. Conifer seed survival in a western Oregon clearcut. Ecology. 48: 431-438.

Gashwiler, J.S. 1970. Further study of conifer seed survival in a western Oregon clearcut. Ecology. 51: 849-854.

Hagar, D.C. 1960. The interrelationships of logging, birds, and timber regeneration in the Douglas-fir region of northwestern California. Ecology. 41: 116-125.

Noble, D.L.; Shepperd, W.D. 1973. Gray-headed juncos important in first season mortality of Engelmann spruce. Journal of Forestry. 71: 763-765.

Pank, L.F. 1974. A bibliography on seed-eating mammals and birds that affect forest regeneration. Res. Rep. 13. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 29 p.

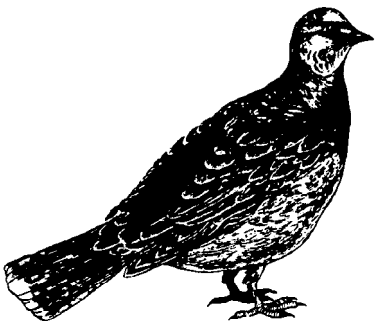
Shearer, R.C. 1987. Rodent and bird impacts on direct seeding and natural regeneration in the northern Rockies. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in the Pacific Northwest; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 65.

Smith, C.; Balda, R. 1979. Competition among insects, birds, and mammals for conifer seed. American Zoologist. [Vol. unknown]: 1065-1083.

Smith, C.F.; Aldous, S.E. 1947. The influence of mammals and birds in retarding artificial and natural seeding of coniferous forests in the United States. Journal of Forestry. 69: 361-369.

West, S.D. 1992. Seed-eating mammals and birds. In: Black, H.C., tech. ed. Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 167-186. Chapter 8.

Blue Grouse
(Dendragapus obscurus)



Description-Grouse are ground-dwelling, chickenlike birds. The blue grouse is dusky gray or blackish in color, with a light band at the tip of a black tail. Males have a yellowish-orange comb above the eyes. Females are grayish brown and barred with black, with a blackish tail. Coloration distinguishes the blue grouse from the ruffed grouse and the spruce grouse.

Economic significance-Blue grouse occur commonly from British Columbia to northern California. Although bud removal and clipping of needles occur sporadically, they are far more extensive than was realized in the past-bud clipping often has been overlooked or more often misidentified as deer browsing. Blue grouse usually remove only a few buds from each seedling, but the impact of bud clipping on small Douglas-fir seedlings may suppress height growth significantly (Black and others 1979).

Life History Information-

Preferred **habitat-Blue** grouse inhabit coniferous forests, particularly in the winter. This grouse nests and raises its young in nonforested areas, in native grasslands, or the early seral stages of a forest after logging or fire.

Feeding habits--Young grouse feed primarily on grasshoppers and other insects. In fall, berries, seeds, and succulent plant parts are eaten. During winter and early spring, the diet consists primarily of conifer buds and needles and occasionally of mistletoe.

Acfivity--Blue grouse are conspicuous in late spring when the males are “hooting” during the spring courtship period. During summer and fall, the females and broods are noticeable at mid and low elevations on mountain and ridge slopes. In winter and early spring, blue grouse usually are found concealed in heavy coniferous cover at high elevations; during this period they seldom feed on the ground.

Reproduction-Five to ten young are hatched per brooding female. The chicks stay with the hen through fall.

Damage problems and their management-

Identification-Buds are neatly plucked from the stem, leaving only the inconspicuous point of attachment. Needle clipping may result in the removal of the entire needle or only a portion of it. The combination of irregular needle clipping and clean removal of buds identifies the typical feeding of blue grouse (fig. 40).

Determining the need for damage **management-Light** damage to conifer seedlings can be tolerated without significant growth suppression. In localized areas with large grouse populations and with evidence of heavy damage on adjacent plantations, plastic-mesh tubing may be used to protect individual tree seedlings. This practice has not been thoroughly evaluated, however.

Figure 40—Typical blue grouse damage.

Management methods—

Planting large stock—Plant large stock with good caliper (stem diameter 0.2 to 0.3 inches) and internodal buds. Such seedlings can normally sustain considerable grouse bud clipping and still maintain good growth.

Individual tree protection—Plastic-mesh tubing (see chapter 4) may protect small seedlings. For additional details see Campbell and Evans (1975; also reprinted in appendix 3).

References—

Bent, A.C. 1932. Life histories of North American gallinaceous birds. New York, NY: Dover Publications: 91-120.

Black, H.C.; Dimock, E.J., II; Evans, J.; Rochelle, J.A. 1979. Animal damage to forest plantations in Oregon and Washington. Part I: a survey, 1963-1975. Res. Bull. 25. Corvallis, OR: Oregon State University, School of Forestry. 44 p.

Curtis, J.D.; Elder, F.S. 1965. Blue grouse feeding on planted ponderosa pine. Journal of Wildlife Management. 29(1): 199-200.

Fowle, C.D. 1943. Studies on methods for controlling grouse browse. [Location of publisher unknown]: British Columbia Forest Service; preliminary report. 15 p.

Halvorson, C. 1985. Influence of vertebrates on seed production. In: Proceedings, conifer tree seed in the inland mountain West, [dates of meeting unknown]; Missoula, MT. Fort Collins, CO: U.S. Department of the Interior, Fish and Wildlife Service, Division of Wildlife Research, Office of Information Transfer: 201-222.

Hatten, J. 1955. Problems in the management of sooty grouse in British Columbia. In: Proceedings, annual conference of the Western Association of State Game and Fish Commissioners; 1953 June 1-3; Long Beach, CA. [Location of publisher unknown]: [publisher unknown]. 35: 262-265.

Johnsgard, P.A. 1973. Grouse and quail of North America. Lincoln, NE: University of Nebraska Press. 492 p.

Otis, D.L. 1987. Birds and forest-related problems in the Pacific Northwest. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, symposium on animal damage management in the Pacific Northwest; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 63-64.

Pank, L.F. 1974. A bibliography on seed-eating mammals and birds that affect forest regeneration. Res. Rep. 13. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 29 p.

Bird Pests (Starlings and Sparrows)

Economic significance—Starlings and sparrows (shown) frequently take up residence in buildings and cause undesirable noise and droppings. These and many other avian species may cause significant damage to agricultural crops and may be hazardous to aircraft, especially at airports.

Damage problems and their management—Prevention is the best approach to damage. Ledges and small crevices 1-1/2 to 3 inches and larger supply nesting sites for these birds. Metal bands with prongs to prevent perching are commercially available. Holes around vents, gutters, and unboxed eaves provide nest sites that can be eliminated when building or repairing. Heavy screening can be placed on the outside of air vent holes before or after the nesting season is over. Netting can be effectively used to exclude birds from nursery beds (see chapter 4).

Many types of effective live-traps have been developed to control house sparrows around buildings. Before attempting to trap birds, consult with local representatives of the U.S. Department of the Interior, Fish and Wildlife Service, APHIS-ADC, or the state wildlife agency. Most birds are protected by both Federal and state laws.

References—

Fitzwater, W. 1983. House sparrows. In: Timm, R.M., ed. Prevention and control of wildlife damage. Lincoln, NE: University of Nebraska, Cooperative Extension: E-43 to E-51.

Geis, A.D. 1976. Effects of building design and quality on nuisance bird problems. In: Seibe, C.C., ed. Proceedings, 7th vertebrate pest conference; 1976 March 9-11; Monterey, CA. Davis, CA: University of California: 51-53.

Appendix 1:

Common and Scientific Names

Plant and Tree Species

Ponderosa pine	*Pinus ponderosa* Dougl. ex Laws.
Sitka spruce	Picea *sifchensis* (Bong.) Carr.
Western hemlock	Tsuga heterophylla (Raf.) Sarg.
Grand fir	*Abies grandis* (Dougl. ex D. Don) Lindl.
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
True firs	*Abies* spp.
Willows	*Salix* spp.
Aspen/Cottonwoods	*Populus* spp.
California black oak	*Quercus kelloggii* Newb.
Tanoak	*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.
Pacific madrone	*Arbutus menziesii* Pursh
Cypress	*Cupressus* sp.
Redstem ceanothus	*Ceanothus sanguineus* Pursh
Fireweed	Epilobium spp.
Pinegrass	*Calamagrostis rubescens* Buckl.
Geranium	*Geranium* spp.
Cheatgrass	*Bromus tectorum* L.
Tarweed	*Madia* spp.
Lupine	*Lupinus* spp.
Dandelion	*Taraxacum officinale* Weber
Alfalfa	*Medicago sativa* L.
Douglas lotus	*Lotus nevadensis* var. *douglasii* (Green) Ottley (L.d.)
Dutch white clover	*Trifolium repens* L.
Alsike (clover)	*Trifolium hybridum* L.
Yellow sweet clover	*Melilotus officinalis* (L.) Lam.
Subclover	*Trifolium incarnatum* L.
Red clover	*Trifolium pra tense* L.
Burnet	*Sanguisorba* spp.
Perrenial rye (grass)	*Lolium perenne* L.
Orchard-grass	*Dactylis glomerata* L.
Oatgrass	Danthonia spp.
Bitterbrush	*Purshia tridentata* (Pursh) DC.
Sword-fern	*Polystichum munitum* (Kaulf.) Presl

	Bracken	*Pteridium aquilinum* (L.) Kuhn.
	Mistletoe	*Arceuthobium* spp.
Animal Species	Mountain beaver	*Aplodontia rufa*
	Deer mouse	*Peromyscus maniculatus*
	California redbacked vole	*Clethrionomys occidentalis*
	Meadow vole	*Microtus pennsylvanicus*
	White-tailed deer	*Odocoileus virginianus leucurus*
	Snowshoe hare	*Lepus americanus*
	Beaver (American)	*Castor canadensis*
	Porcupine	*Erethizon dorsatum*
	Black-tailed jackrabbit	*Lepus californicus*
	Cottontail (rabbit)	*Sylvilagus floridanus*
	Red squirrel	*Tamiasciurus hudsonicus*
	Western gray squirrel	*Sciurus griseus*
	Dusky-footed woodrat	*Neotoma fuscipes*
	Unita ground squirrel	*Spermophilus richardsoni*
	Bobcat	*Lynx rufus*
	Coyote	*Canis latrans*
	Black-footed ferret	*Mustela nigripes*
	Black-tailed prairie dog	*Cynomys ludovicianus*
	Belding ground squirrel	*Spermophilus beldingi*
	Columbian ground squirrel	*Spermophilus columbianus*
	Black-tailed deer	*Odocoileus hemionus columbianus*
	Rocky Mountain elk	*Cervus elaphus nelsoni*
	Roosevelt elk	*Cervus elaphus roosevelti*
	Mule deer	*Odocoileus hemionus*
	Chickaree (Douglas squirrel)	*Tamiasciurus douglasi*
	Badger	*Taxidea taxus*
	Bushy-tailed woodrat	*Neotoma cinerea*
	Black bear	*Ursus americanus*
	Norway rat	*Rattus norvegicus*
	Golden-mantled ground squirrel	*Spermophilus lateralis*
	Brush rabbit	*Sylvilagus bachmani*
	Nutria	*Myocaster coypus*

	Pine mouse	*Microtus pinetorum*
	House mouse	*Mus musculus*
	Woodchuck	*Marmota monax*
	Nuttall's (mountain) cottontail	*Sylvilagus nuttalli*
	Pocket gophers	*Thomomys* spp. (and other genera)
	Shrews	*Sorex* spp.
	Moles	Scapanus spp.
	Chipmunks	*Eutamias* spp.
	Weasels	Mustela spp.
Birds	Barn owl	*Tyto alba*
	Great horned owl	*Bubo viginianus*
	Hawks	*Buteo* spp.
	Sparrow	*Zonotrichia* spp. (and other genera)
	Starling	*Sturnus vulgaris*
	Grouse	**Dendragapus sp.**
	Grosbeak	*Pheucficus* sp. (and other genera)
	Pheasant	*Phasianus colchicus*
	Quail	*Oreortyx* sp. (and other genera)
	Swallow	*Tachycineta* sp. (and other genera)
	Mourning dove	*Zenaida macroura*
	Junco	*Junco* spp.
	Southern meadowlark	*Sturnella* sp.
	Robin	*Turdus migratorius*
	Clark's nutcracker	Nucifraga columbiana
	Jays	*Cyanocitta* sp. (and other genera)
	Crossbills	*Loxia* spp.
	Siskin (pine siskin)	*Carduelis pinus*
	Finches	*Carpodacus* spp.
	Woodpeckers	*Dryocopus* spp. (and other genera)
	Nuthatches	*Sitta* spp.
	Sapsuckers	*Sphyrapicus* spp.
	Blue grouse	*Dendragapus obscurus*
Insects	Ants	Formicidae
	Grasshoppers	Acrindidae

Appendix 2:

Memorandum of Understanding

APHIS# 12-34-71-0017MU

FS# 93-SMU-118

MASTER MEMORANDUM OF UNDERSTANDING

between the

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

and the

FOREST SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

I. PURPOSE

The Animal and Plant Health Inspection Service (APHIS-ADC) and the Forest Service (FS) are agencies of the United States Department of Agriculture (USDA) concerned with animal damage management (ADM), and research.

The purposes of this Memorandum of Understanding are: (1) To identify responsibilities of the respective agencies and foster a partnership in discharging the Federal obligation under the Animal Damage Control Act of March 2, 1931, (46 Stat. 1468; 7 U.S.C. 426-426b), as amended, for the management of wild vertebrates causing damage on National Forest System (NFS) lands; (2) to establish general guidelines to assist field personnel in carrying out their ADM responsibilities consistent with policies of USDA FS and APHIS-ADC; and (3) to strengthen the cooperative approach to ADM on NFS lands through exchange of information and mutual program support.

II. INTRODUCTION

It is mutually recognized that the management of animal damage on NFS lands is important and may involve the control of individual animals, or local populations, to achieve land and resource management objectives. Further, it is mutually recognized that the tools and procedures available for managing populations must be used in a professional manner according to a plan developed in compliance with National Environmental Policy Act (NEPA), National Forest Management Act (NFMA), and Animal Damage Control Act.

Both agencies have a responsibility for limiting damage caused by wildlife, consistent with other multiple-use values. They also agree that in evaluating the need for, and in conducting ADM programs, multiple-use values must be considered.

It is also recognized that:

A. The FS is responsible for the management of land under its jurisdiction, including the identification of how those lands are to be used. The FS is also responsible for conducting routine ADM (nonpredator control) operations on NFS lands, including NEPA compliance on these activities.

B. APHIS-ADC is the agency with the authority and expertise under the Animal Damage Control Act of March 2, 1931, as amended, and pursuant to The Rural Development, Agriculture, and Related Agencies Appropriations Act of 1988 for providing ADM services. This includes maintaining technical expertise in the science of animal damage management, control tools and techniques, conducting ADM research, conducting management programs, and NEPA compliance on activities related to predator control.

C. All ADM programs on NFS lands will be coordinated with appropriate State and Federal agencies.

TO IMPLEMENT THE FOREGOING, the parties agree as follows where National Forest System lands are involved:

III. AGREEMENT

The Forest Service shall:

A. Provide for ADM activities to protect permitted livestock, forest resources and activities in Forest Land and Resource Management Plans.

B. Cooperate with APHIS-ADC in the development and annual review of Forest-wide ADM plans.

C. When requested, participate in APHIS-ADC NEPA processes.

D. Invite APHIS-ADC participation in NEPA training at the national, regional and forest levels.

The Animal and Plant Health Inspection Service shall:

A. In cooperatiion with the FS, state agencies, and permittees, evaluate ADM needs.

B. Develop and annually update ADM annual plans of work in cooperation with the Forest Service and appropriate State and Federal Agencies, permittees, and others. With the Forest Service, identify human safety zones and other areas where mitigation or restriction may be needed to comply with Forest Plans.

C. Inform the FS about ADM requests, management activities and results on a timely basis.

D. Provide the FS with technical information on recommended ADM tools and techniques.

E. When requested conduct ADM training sessions for FS personnel.

IV. BOTH AGENCIES AGREE TO:

A. Conduct ADM on NFS lands in accordance with the APHIS-ADC Policies. USDA policy on fish and wildlife and consistent with Forest Land and Resource Management Plans.

B. Form, as needed, State level interagency planning groups with appropriate State and Federal agencies, permittees, and other cooperators, to assure a mutual planning effort in each State for developing ADM annual plans of work.

C. Develop, as needed, State ADM agreements with the appropriate State and Federal agencies.

D. Ensure interagency coordination and concurrence on the effects of predator control activities on National Forest resources before NEPA decisions on predator control are signed. When BLM lands are also involved, NEPA decisions will be concurred by FS, BLM, and APHIS officials.

E. Evaluate the ADM program on an annual basis, with emphasis on its effectiveness in reducing damage by wildlife and meeting the objectives stated in this MOU.

F. Meet on a State or regional basis annually, or as needed, to coordinate ADM operations. Representation will be by the FS Regional Forester and the APHIS-ADC Regional Director, or their designated representatives.

G. Review and resolve problems regarding implementation of this agreement that arise and cannot be resolved at the field level by elevating to the next higher level for prompt action.

H. Conduct an annual meeting of the APHIS-ADC Deputy Administrator and the FS Deputy Chief for National Forest Systems, or their representatives, to coordinate ADM activities.

I. Cooperate on ADM research of mutual interest.

J. Nothing in this Memorandum of Understanding is intended to modify in any manner the present cooperative programs of either Agency with States, other public agencies, or educational institutions.

K. This MOU shall supersede all existing Federal MOUs, supplements, and amendments thereto relating to the conduct of animal damage control programs with the parties, with the understanding that all cooperative animal damage control programs now in progress, shall be incorporated and continued under this MOU if agreeable to both agencies.

L. This MOU is neither a fiscal nor a funds obligation document. Any endeavor involving reimbursement or contribution of funds between the Parties of this MOU will handled in accordance with applicable laws, regulations, and procedures including those for Government procurement and printing. Such endeavors will be outlined in separate agreements that shall be made in writing by representatives of the Parties and shall be independently authorized by appropriate statutory authority. This MOU does not provide such authority.

M. No member of, or Delegate to, Congress shall be admitted to any share or part of this MOU, or any benefits that may arise therefrom; but this provision shall not be construed to extend to this MOU if made with a corporation for its general benefit.

N. Nothing in this memorandum shall obligate the Forest Service to APHIS to expend appropriations or to enter in any contract or other obligations.

O. The principal contacts for this agreement are:

Robert Nelson
USDA Forest Service
4NW AUD WL&F
P.O. Box 96090
Washington, DC 20090-6090
(202) 205-1275

Donald Hawthorne
USDA Animal & Plant Health Insp. Svc.
P.O. Box 96464
Washington, DC 20090-6464
(202) 720-2054

V. EFFECTIVE DATE

This MOU may be modified or amended upon written consent of both parties or may be terminated with 30-day written notice of either party. Unless terminated, this MOU will remain in full force and effect until September 30, 1998, at which time it will be subject to review and renewal.

IN WITNESS WHEREOF, the parties hereto have executed this MOU as of the last written date below.

/s/ James C. Overbay	6-18-93
Deputy Chief, Forest Service	Date

/s/ Michael C. Gregoine	6-17-93
Acting Administrator, Animal and Plant Health Inspection Service	Date

Appendix 3:

Reprints of Technical Papers

[1] These papers are reproduced as they appeared originally.

Campbell, D.L.; Evans, J. 1975. "Vexar" seedling protectors to reduce wildlife damage to Douglas-fir. Wildl. Leafl. 508. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 11 p.

"VEXAR" SEEDLING PROTECTORS TO REDUCE WILDLIFE DAMAGE TO DOUGLAS-FIR

By

Dan L. Campbell and James Evans

U.S. Fish and Wildlife Service, Wildlife Research Center

Denver, Colorado 80225

INTRODUCTION

This leaflet describes uses of "Vexar" seedling protectors to reduce clipping and browsing damage to regenerating Douglas-fir *(Pseudotsuga menziesii)* by snowshoe hares *(Lepus americanus washingtonii),* rabbits *(Sylvilagus,* sp.), black-tailed deer *(Odocoileus hemionus columbianus)* and elk *(Cervus canadensis roosevelti).* The information was collected from 1968 through 1974 in a cooperative study with DuPont, Inc., to develop and evaluate "Vexar" as a conifer seedling protector in western Washington and Oregon.

ALLEVIATING ANIMAL DAMAGE WITH "VEXAR"

Clipping and browsing damage to Douglas-fir seedlings by hares, rabbits, deer, and elk is a major cause for delayed regeneration and occasionally reforestation failures in western Washington and Oregon. Protecting the main stem of newly planted seedlings or the terminal shoot of established seedlings for 3 to 5 years after planting, or until seedlings are 100 cm (40 in) tall, minimizes the damage. When main stems and terminal shoots are protected, clipping and browsing of lateral branching are usually not a limiting factor to growth or establishment of seedlings.

Other chemical and mechanical methods to alleviate clipping and browsing damage are not completely adaptable to all damage situations. Available repellents (Evans 1974), for example, are not always effective against deer; they are generally ineffective against elk, do not protect seedlings throughout the year, must be applied annually or semiannually to treat new growth, and must be registered for operational use. Mechanical bud protectors (Hines 1971) are not effective against summer browsing by deer or winter clipping by rabbits and hares. Exclosures of wire or nylon fencing (Jones and Longhurst 1958, Mealy 1969) are effective but costly and aesthetically displeasing.

"Vexar" protectors are relatively inexpensive, commercially available devices that reduce clipping and browsing nearly 100% and are considerably more effective than chemical repellents (Campbell 1969). In high damage areas (40% or more seedling damaged), seedlings protected with "Vexar" have produced 11 to 14 m (36 to 47 ft) more height growth per 100 seedlings per year than unprotected seedlings . In areas with less damage, "Vexar"-protected seedlings produce 8 m (26 ft) more height growth than unprotected seedlings. Our findings, demonstrations of Douglas-fir regeneration in critical damage areas by the U.S. Forest Service, and reports by other users (Anonymous 1972a, 1972b, 1973, Hunter 1972) have stimulated wide use of several types of "Vexar" protectors in the Pacific Northwest.

"VEXAR" SEEDLING PROTECTORS

"Vexar" polypropylene plastic netting formed into tubes (Fig. 1) has been extensively tested and used on Douglas-fir. Mesh patterns are diamond (rigid tubing) and twill (lay-flat tubing which is more flexible and compressed). Most current use is with the

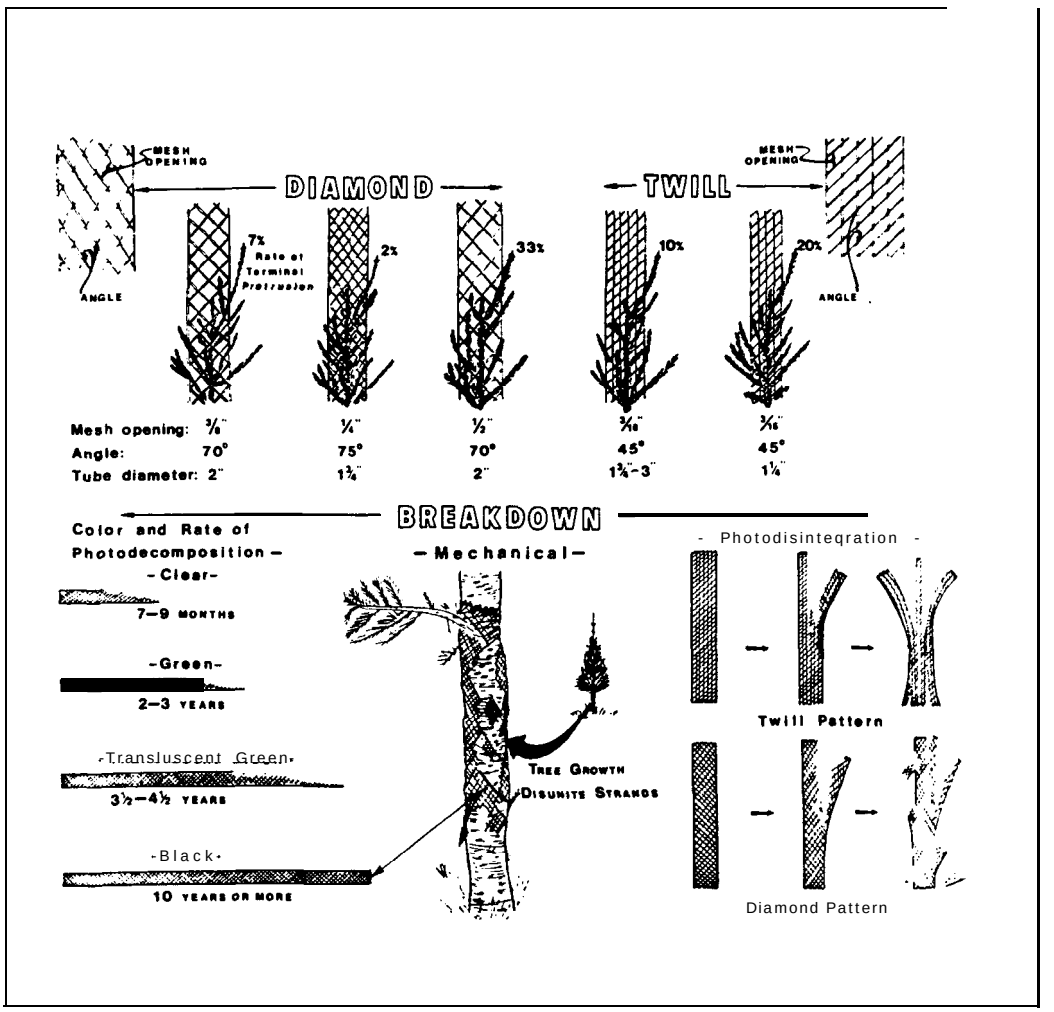


Figure 1- "Vexar" seedling protectors-polypropylene netting.

rigid variety. Mesh openings and angles are illustrated to show the different rates of protrusion by terminal shoots-the design with 7" terminal protrusion least affects lateral branch development during early stages of seedlings growth. Ultraviolet radiation degrades the different colors of "Vexar" netting at different rates (Fig. 1). The short-lasting clear material may be used on established seedlings where protection is needed for only one growing season; the green material gives 2 to 3 years of protection. The translucent green material protects newly planted and established seedlings for up to 4.5 years. As illustrated, breakdown of black material (durable for 10 or more years) occurs mostly when netting separates as the tree outgrows it. However, some trees have grown "around" portions of black netting before the strands have separated, but we do not believe this will lead to a long-term effect. Although the black protectors may be reused, the advantage of the clear, green, and translucent green materials is that they split (twill pattern) or degrade (diamond pattern) before tree growth breaks the netting.

RECOMMENDATIONS

The following recommendations on what, where, when, and how to use "Vexar' seedling protectors on Douglas-fir are based on the results of Fish and Wildlife Service studies,

What to Use

"Vexar" polypropylene plastic mesh rigid tubing is recommended over the lay-flat type. Dimensions with the least overall effect on seedling growth and form are:

Inside diameter: 5 cm (2 in)	Strand diameter: 1.5 mm (60 mils)
Mesh opening: 9 mm (3/8 in)	No. of strands: 1.3/cm (2/in)
Mesh angle: 70	Color: Translucent green: 5% UVI

The material is available through DuPont, Inc., Specialty Markets Division, Vexar Sales, Brandywine Building, 89247, Wilmington, Delaware 19898. DuPont's code for this tubing is 2-in ID 60-PDP-27, translucent green. Occasionally, finished products do not conform to the measurements given. Minimum-maximum mesh openings can be 6 to 9 mm (1/4 to 3/8 in), but other dimensions should be as listed above. Cost per 0.3 m (1 ft) of this tubing in 1974 was about $0.05.

Where and When to Use "Vexar"

"Vexar" seedling protectors can be used wherever browsing and clipping occur. We recommend they be used where: (1) severe damage occurs or is expected to occur, (2) damage occurs during all seasons or by several species of wildlife, and (3) restocking is necessary because of seedling loss to wildlife. If these conditions exist or are expected, "Vexar" tubes offer better short- and long-term protection than any available animal repellent.

How to Use "Vexar"

There are several ways of applying "Vexar" for protecting the main stem of Douglas-fir seedlings (Fig. 2). Most protectors are applied after the seedling is planted by fitting rigid tubing over the entire seedling. Position of lateral branches is not important as long as the main stem is approximately centered. On most newly planted 2-year-old seedlings, wire pins, staples, or a wooden lath should be used to anchor and support the protector; on sturdy seedlings, the lateral branches lend the necessary support. When elk are causing damage, protectors should also be secured with a twist-tie. Partially buried tubes are self-supporting and are used for "containerized" seedlings by fitting them inside the tubes for planting time. Twill or lay-flat tubing generally needs more support such as the double lath/twist-tie support as diagrammed (Fig. 2), although single lath support has been used in some instances.

Our recommended applications of "Vexar" rigid tubing on newly planted and established seedlings are shown in Fig. 3. Newly planted seedlings should be fitted with tubes 92 cm (36 in) long during or shortly after planting. Wire pins are recommended for support. *Vertical* placement of pins and tubing (kept rounded at the base) is essential to provide support and retention and to minimize terminal protrusion. The wire-pin/ridge-tube method reduces problems associated with other materials and methods of installation (Fig. 4).

Heavily browsed established seedlings usually need tubes only 46 cm (18 in) long placed over the terminal shoot. The tube is pressed down over the main stem to catch several lateral branches, then gently raised until about half of the tube clears the terminal as illustrated (Fig. 3). Where elk are a problem, twist-ties are recommended to secure the tube to one or more lateral branches. Tubes can be pulled upward for additional protection of terminals when needed. Tubes on established runt seedlings should be supported with wire pins.

COST OF USING "VEXAR"

The cost of using "Vexar" protectors will vary with the methods of installation, differences in seedling stocking rates (from 200 to 1,000 or *more* seedlings per acre), and differences in time and difficulty of installing "Vexar" in various terrain. However, in 1974, we made some material-labor cost comparisons between our recommended use and a commonly used double-lath support installation method under ideal conditions. Costs were as follows using 1 m long, translucent-green tubes ($0.15 each) and assuming labor costs of $5 per hour:

support Method	Material	Man-hours	Estimated Labor @ $5 per hour	Estimated Cost of Material + Labor
Wire pins	$20.00	1.0	$ 5.00	$25.00
Double lath/ twist-ties	$35.00	2.5	$12.50	$47.50

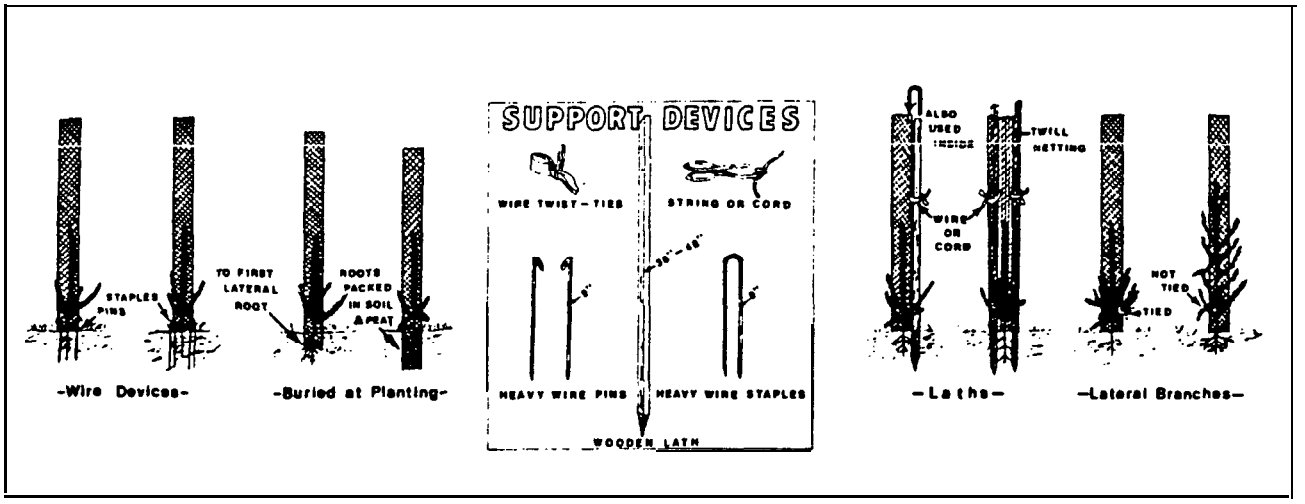


Figure 2-"Vexar" tubes-application/support methods.

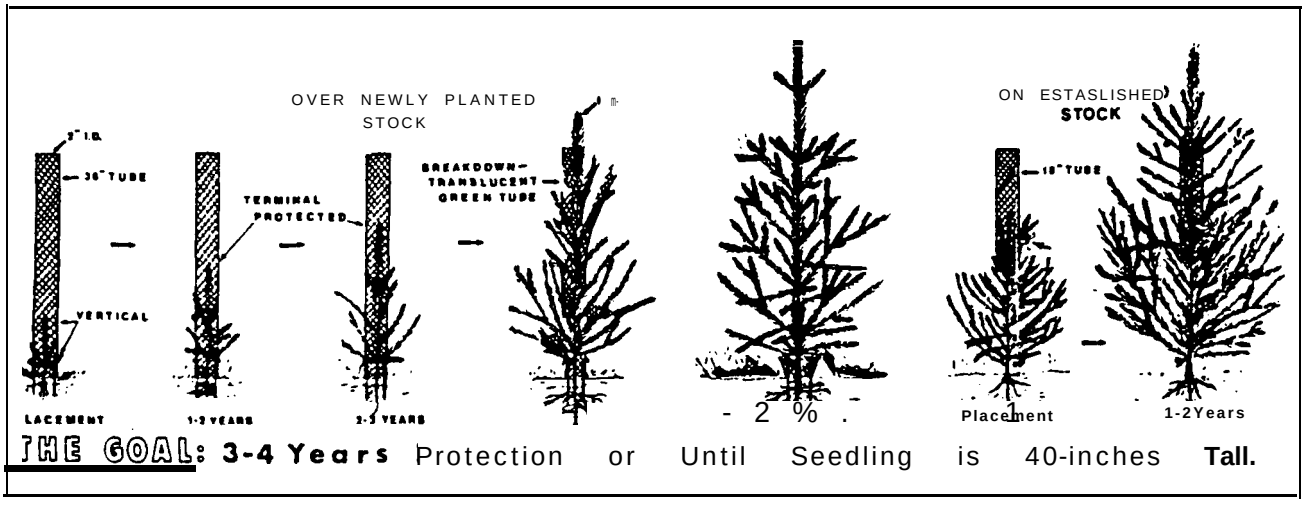


Figure 3-Recommended application on Douglas-fir.

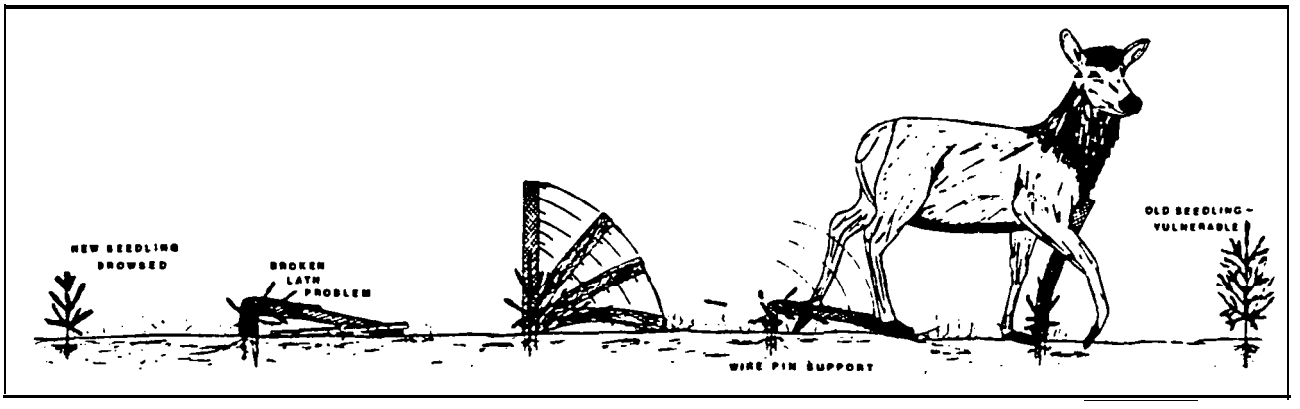


Figure 4-Pins/rigid tubes reduce many problems.

Costs for protecting 400 seedlings per acre would be about $100 for wire-pine/rigid-tubing compared to about $190 for double-lath/twist-tie/rigid-tubing. Cost of the short 46 cm (18 in) tube in 1974 was about $0.08 each. Labor for installing short tubes over terminals without twist-ties is estimated at $5 per 100, and with twist-ties about $7.50 per 100 seedlings. Total material-labor cost would be about $13.00 to $15.50 per 100 seedlings.

SOME OBSERVED PROBLEMS

Several problems that have developed with "Vexar" seedling protectors (Fig. 5) have been related mostly to improper installation or materials. These can be minimized or prevented by following our recommendations. Some problems such as tubes or seedlings buried by mud, or breakage by trampling, are unavoidable, but rarely occur. Installation during freezing weather should be avoided because "Vexar" becomes brittle and is easily broken.

MISCELLANEOUS INFORMATION

In this section, we attempt to answer questions that are regularly asked about the use of "Vexar" seedling protectors.

"Vexar" has been widely used in the Pacific Northwest and elsewhere, mainly on an experimental basis. However, one National Forest in Oregon has begun operational use with lath-supported tubing; others-as well as State and private organizations in the Pacific Northwest-are expected to begin operational use in the near future. Seedling protectors are being tried on other softwood and hardwood timber species in western, as well as eastern and southern forests, and in windbreak and fruit orchard plantings in several parts of the United States. Forest managers in other countries, including Russia and Poland, are experimenting with "Vexar." Polypropylene netting other than DuPont's "Vexar" is also being evaluated in the United States, but we have no information on effectiveness and costs of these products.

There are indications that "Vexar" is also effective in reducing damage to Douglas-fir by small rodents and mountain beaver *(Aplodontia rufa)* and to pines *(Pinus* sp.) by pocket gophers *(Thornomys* sp.). These potential uses are now being evaluated.

Environmental problems and hazards of using 'Vexar" appear minimal. The protectors are not an eyesore, and photodecomposition of materials (other than black) is quite rapid and complete following the designed life-span. There is no environmental contamination by polychlorinated biphenyls (PCS'S) in the breakdown of "Vexar' (DuPont, Inc., personal communication).

Biologically, "Vexar" protectors on individual seedlings benefit both Douglas-fir and wildlife. Seedlings are protected until they outgrow their plant and animal competitors, and access to areas by wildlife is not restricted. Vegetation immediately adjacent to protected seedlings is often browsed, reducing competition and the need for herbicide treatment.

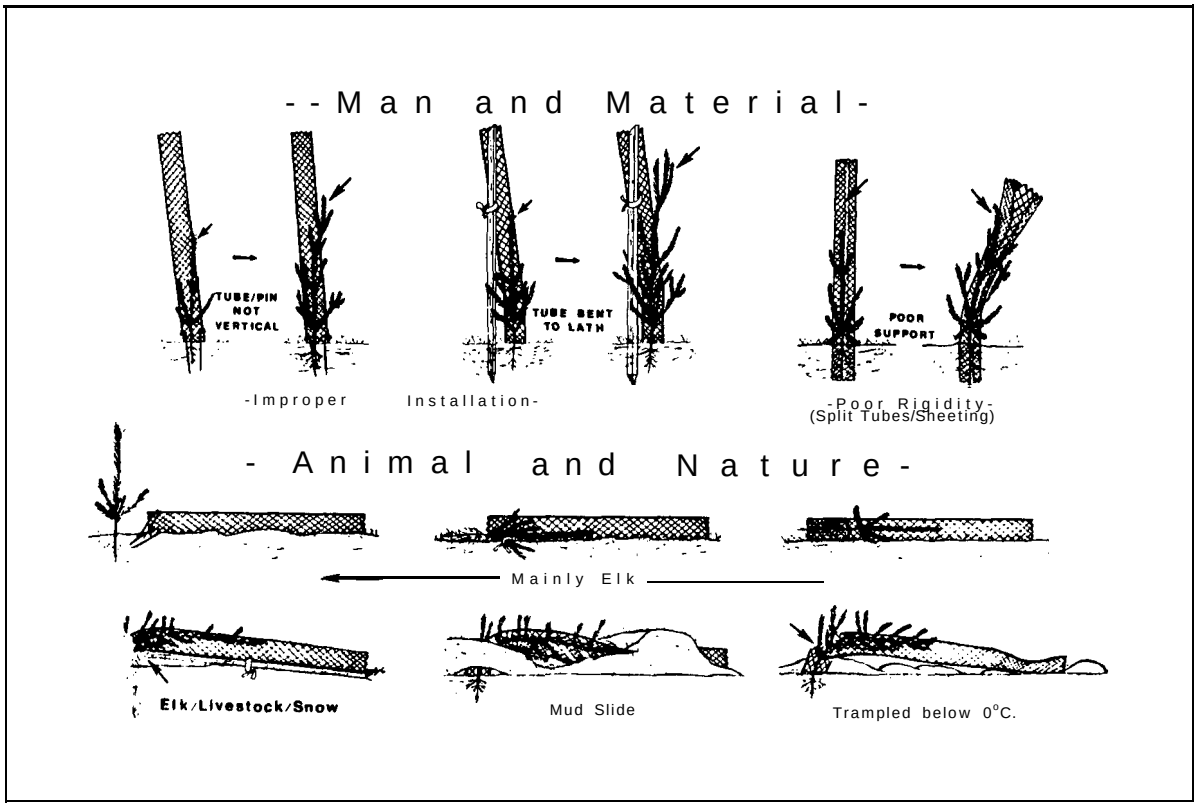


Figure 5-Some problems with "Vexar" tubes.

THE OVERALL EVALUATION OF "VEXAR"

In summary, "Vexar" protectors: (1) are an inexpensive and available method which greatly reduces clipping and browsing on dormant and growing Douglas-fir seedlings, (2) are made of photodegradable material which deteriorates in a few months to several years, (3) are designed so that seedling height growth and form are not impaired, and (4) are nonhazardous to the forest ecosystem, domestic animals, or man. "Vexar" seedling protectors fill the need to offset wildlife damage to regenerating Douglas-fir, and are being well accepted as a nonchemical and environmentally safe approach to forest-animal damage control.

ACKNOWLEDGMENTS

Cooperators, in addition to DuPont, Inc., included the State of Washington, Department of Natural Resources, particularly L.E. Johnson and H.D. Hartwell; personnel of the U.S. Forest Service on several National Forests and at the Equipment Development Center at Missoula, Montana; Weyerhauser Co.; Simpson Timber Co.; and Oregon State University.

LITERATURE CITED

Anonymous. 1972a. A new seedling protection device reduces seedling losses, enhances growth. Forest Industries, June 1972, p. 51.

Anonymous. 1972b. A new seedling protection device reduces seedling losses, enhances growth. World Wood. October 1972, p. 85.

Anonymous. 1973. Protection from browsing. For. Chron., April 1973, p. 62.

Campbell, D.L. 1969. Plastic fabric to protect seedlings from animal damage. Pages 87-88 in H.C. Black, ed. Wildlife and Reforestation in the Pacific Northwest, Symposium Proc., 1968. Oregon State Univ., School of Forestry, Corvallis.

Evans, J. 1974. Pesticides and forest wildlife in the Pacific Northwest. Pages 205-219 in H. C. Black, ed. Wildlife and Forest Management in the Pacific Northwest, Symposium Proc., 1973. Oregon State Univ., School of Forestry, Corvallis.

Hines, W.W. 1971. Physical versus chemical means of deterring browsing of Douglas-fir by black-tailed deer. Tree Planters' Notes 22(2):9-13.

Hunter, J.D., ed. 1972. Fending off foragers. DuPont Magazine, January-February 1972, 66(1):24-25.

Jones, M.M. and W.M. Longhurst. 1958. Overhanging deer fences. J. Wildl. Manage. 22(3):325-326.

Mealy, R.H. 1969. Nylon fencing to protect plantations from damage by big game. Pages 89-90 in H.C. Black, ed. Wildlife and Reforestation in the Pacific Northwest, Symposium Proc., 1968. Oregon State University, School of Forestry, Corvallis.

* * * * * * * * * * * * * * * * * * *

Additional information on the above topic is given in the following document:

Larson, J.; Campbell, D.; Evans, J.; Lindsey, G. **1979.** Plastic tubes for protecting seedlings from browsing wildlife. ED&T 2217. Missoula, MT: U.S. Department of Agriculture, Forest Service, Equipment Development Center. 19 p.

Where discrepancies exist between recommendations given by Campbell and Evans and those given in the Larson paper, follow the updated information given in the latter.

deCalesta, Davis S. 1985. Estimating cost-effectiveness of controlling animal damage to conifer seedlings. In: Bromley, P.T., ed. Proceedings, 2d Eastern wildlife damage control conference; 1985 September 22-25; Raleigh, NC. Raleigh, NC: North Carolina State University: [pages unknown].

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Estimating Cost-Effectiveness of Controlling Animal Damage to Conifer Seedlings

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Abstract

A model for determining the benefit-cost ratio of controlling damage by vertebrate pests to conifer seedlings requires knowledge of the amount, distribution, and duration of animal damage, reduction in damage associated with control, costs of control, methodology and value of trees at harvest. Because control costs occurring in the present must be compared with savings recovered decades later in the future, the model incorporates procedures for discounting or adjusting future monetary benefits into present net worth valuations. The model allows forest managers to evaluate a wide range of damage costs and savings accruing from use of various control techniques. The model clearly demonstrates that application of controls before damage occurs is more cost-effective than withholding application until it is established that damage will occur.

Introduction

Damage by vertebrate pests to conifer seedlings is a significant economic loss to the timber industry in the Pacific Northwest (Lawrence 1958, Swift 1960, Dimock and Black 1969, Brodie et al. 1979). The pests have been identified (Lawrence et al. 1961, US. Dept. Agric. 1978) and the frequency and distribution of damage, the percentage of trees killed, and the effect on subsequent tree growth have been reported (Munger 1943, Staebler et al. 1954, King 1958, Crouch 1968, Dimock 1970, Mitchell 1974, Black et al. 1979, Evans et al. 1981). There is only one report that provides guidelines for timing of application of controls to reduce or eliminate damages, and that concerned only bear damage to second-growth conifers (Schreuder 1976). One criterion that could prove useful in such decisions-and which we can model and which Schreuder (1976) used-is the benefit-cost ratio.

Benefit-Cost Ratio

We need two figures to estimate benefit-cost ratio: first, cost of control methods; and second, savings resulting from application of those methods. If the savings, in dollars, are higher than the costs, the benefit-cost ratio is greater than 1, and control methods will more than pay for themselves.

Costs of control are fairly easy to compute, as they are generated over a short time, usually less than two years; and they are obvious, usually including labor, travel, equipment and/or materials, and administration.

Savings are more difficult to estimate, because managers must predict how much damage will occur without control and how much damage the control method will eliminate. To avoid this difficulty, the control program may be delayed for a year. Rate of first year damage can be documented and assumed as that for subsequent years. For smaller pests permanently residing on regeneration sites such as mountain beaver (Aplondontia rufa), voles (Microtus sp.), and rabbits (Sylvilagus sp.), this may be a valid assumption. For larger pests such as deer (Odocoileus sp.), elk (Elaphus sp.), and bear *(Ursus* sp.), which may or may not include specific regeneration sites within a larger, annual home range, rate of damage one year may not be duplicated in following years.

Some conifer seedlings attacked by vertebrate pests die while others are set back in growth, so estimates of damage must include the value of trees destroyed and lost before commercial thinning or final harvest, and the value of reduced volume of trees damaged but not killed. More trees are planted on regeneration sites than are removed at final harvest; the remainder are removed at commercial thinning (for a commercial value), and by mortality factors including insects, disease, and vertebrate pests.

Thus, proportionate numbers of seedlings killed or damaged by vertebrate pests must be apportioned to precommercial thinning (no value lost) and commercial thinning (value lost representation of commercial thinning rather than final harvest) as well as to final harvest, and representative loss values assigned.

Usually, damage by vertebrate pests to conifer seedlings (and associated application of control methods) occurs 1-5 years after outplanting, but commercial thinning and final harvest occur decades later. Thus, costs of control in today's dollars must be adjusted for comparison with value of timber saved today, but harvested in the future and inflated in value above today's market prices. Adjustment and comparison of control costs and market values to reflect current comparable values is termed "present net worth valuation" or "discounting."

Conventional timber harvest economics dictate calculation of present net worth valuations on timber. Present net worth of timber harvested in the future is derived by compounding today's stumpage values for n years (numbers of years to harvest) at an expected inflation rate (i) and equating it to the value of an investment compounded at today's interest rates on conventional investments (r) to arrive at the stumpage value inflated n years into the future. For example, timber harvested in 60 years, worth $100,000 per ha today and inflated by an expected inflation rate of 5%, is worth $10,000 (1.05) = $1,867,920 per ha, 60 years in the future. This value must be reverse compounded 60 years back to the present at a current investment rate, say 8%. Letting X equal the present net worth value of the timber, $X\ (1\ .08)^{60} = \$1{,}867{,}920$; solving for X we arrive at the value of $18,447 per ha for the present net worth of the timber per ha.

Present net worth of the cost of animal damage control methods is calculated slightly differently. The value of control efforts is equated with that of any ordinary investment, and assigned the prevalent interest rates plus the current inflation rate, compounded forward for the period of expected damage (usually less than 5 years) and then back compounded at the prevalent interest rate. The following calculations, which demonstrate the process of estimating loss to vertebrate pests and determination of the benefit-cost ratio, are based on present net worth valuations.

The Model

Data required to arrive at the benefit-cost ratio include: a) amount, distribution, and duration of expected animal damage, b) reduction in damage associated with control, and c) value of trees at commercial thinning and at final harvest. The basic model for estimating benefit-cost ratios is represented by the equation:

$$\frac{\text{Value of preventable loss (\$)}}{\text{Cost of control (\$)}}$$

Value of preventable loss (V) may be calculated by multiplying number of trees projected as damaged or killed by pests and saved by control by the value of trees. Value of trees varies at several distinct periods. Trees harvested at precommercial thinning have essentially no market value, whereas trees harvested at commercial thinning have a value (V_c) which is considerably lower than that for trees cut at final harvest (V_f).

Trees killed or damaged by vertebrate pests must be assigned, proportionately, to precommercial thinning, commercial thinning and final harvest.

If K trees are killed or damaged, N_P (number of trees cut per ha at precommercial thinning) trees, divided by N_t (number of trees planted per ha) provides the fraction (N_p/N_t) of K trees killed or damaged assigned to precommercial thinning. By similar logic (N_c/N_t) equals fraction of K trees killed or damaged and assigned to precommercial thinning (N_C = number of trees cut per ha at commercial thinning) and N_f/N_t equals fraction of K trees killed or damaged assigned to final harvest (N_f = number of trees cut per ha at final harvest).

Number of trees saved by control (K) is a function of: 1) the area damaged (D) by the pest, expressed as a fraction of the total regeneration site; 2) the percent reduction in volume of trees killed or damaged by the pest (P) in an area of damage, expressed as a fraction; 3) intensity of damage (I) (number of trees attacked within area of damage), the number of years (N) damage occurs by the pest(s); and 4) efficiency of damage control methods (E) expressed as a fraction, reflecting the fact that control methods are rarely 100 percent effective.

The number of trees saved per ha by control of vertebrate pests (K) can be estimated by the formula: K = DxPxIxExN.

For the purpose of demonstrating the process of estimating cost-effectiveness, three periods of tree removal (precommercial thinning, commercial thinning, and final harvest) are utilized. If fewer or greater periods of tree removal occur on specific sites, calculation of values will include fewer or more steps, respectively.

If the corrective mode of control (wait until damage occurs before applying control methods) is utilized, number of trees killed or damaged the first year (K_t) will not be saved and subsequent calculations of value of control will be based on trees potentially saved in the second and succeeding years (K_2). Value (V) of the stand will be lower than when the preventive mode is used because there will be fewer trees left to harvest after the loss of K_1 trees.

Current value of trees saved by application of control methods is computed by summing the value of proportionate numbers of trees saved from commercial thinning [$K(N_c/N_t)$] and from final harvest [$K(N_f/N_t)$]. This summed dollar value is then converted to present net worth value via the discounting procedure described above.

Examples

Preventative Control

Assume damage is caused by mountain beaver to Douglas-fir seedlings: trees attacked suffer 90% reduction in volume (P), damage occurs over 30% of the area (D), within area of damage 50 trees per ha are attacked (I), and duration of damage is 3 years (N). Assume control method used is vexar tubing (protect seedlings by placing sleeve of rigid plastic mesh, 40 cm high, around them at planting) at 95% efficiency in reducing damages at the cost of $250 per ha.

Number of trees scheduled for commercial thinning represented by these 50 trees is determined by multiplying 50 by the fraction of all trees represented by those commercially thinned (470/10000 = 0.47, Table 1), which equals 50x0.47 = 23.5. Current value of these 23.5 trees saved by application of vexar tubing is: 23.5 trees [number of trees attacked] (I) in areas of damage] times 0.9 [reduction in volume (P) of trees attacked] times 0.3 [damage occurs over 30% (D) of area] times 0.95 (efficacy of control method used (E)] times 3 (number of years for which damage is expected) times $2375/470 (value of each tree saved for commercial harvest). This value is $91.38. Present net worth of this timber (X) saved by control, assuming commercial thinning occurs at 15 years and current interest rate on commercial investments is 8% is: $X(1 .08)^{15} = \$91.38(1 .05)^{15}$; X = $59.89

Number of trees scheduled for harvest at rotation represented by the 50 trees attacked per ha of areas receiving damage is determined by multiplying by the fraction of all trees represented by those harvested at rotation (180/1000 = 0.18) which equals 50x0.18 = 9.0. Current value of these 9 trees saved by application of vexar tubes is 9.0 trees [number of trees attacked (I) in areas of damage] times 0.9 [reduction in volume (P) of trees attacked] times 0.3 [damage occurs over 30% (D) of area] times 0.95 [efficiency of control method used (E)] times 3 [number of years for which damage is expected] times $9,000/180 (value of each tree saved for commercial harvest). This value is $346.28.

Present net worth of this timber saved by control, assuming interest and inflation rates given above and that final harvest is 60 years after planting is: $X(1 .08)^{60} = \$346.28(1 .05)^{60} = \$63.88$.

Table 1. Data set assumed for estimating losses of trees to vertebrate pests.

Trees/ha	At planting	At precommercial thinning (NP)	At commercial thinning (Nc)	At final harvest V W
Standing	1000	650	180	0
cut	0	350	470	180
Value	0	0	$2375	$9000

Present net worth of commercially thinned and final harvested timber, saved by application of control methods is $59.89 + $63.88 = $123.77 per ha.

Present net worth of vexar tubing is $X(1 .05)^3 = $250(1 .08)^3; X = $272.05. Benefit:cost ratio = $123.77/$272.05 = 0.45. This value is less than 1.0, so control of damages by vexar tubing, when damage is anticipated for 50 trees, is not cost effective. Multiplying the benefit:cost ratio of 0.45 by 2.2 yields a benefit:cost ratio of 1.0; multiplying any of the values used to compute K (D, P, I, E, or N) by 2.2 will result in a benefit:cost ratio equal to or greater than 1.0. Increasing the I value (50) by a factor of 2.2 (2.2 X 50 = 111) results in a number of trees saved that would be cost effective. Increasing the values of 2 or more of the values by factors whose product equals 2.2 will also result in a benefit:cost ratio greater than 1.0: If the D value is increased by 1.75 and the I value by 1.25 (1.75 x 1.25 = 2.2) resulting benefit:cost ratio is greater than 1.O.

Corrective Control

Using the same values as the above example, excepting that no controls are effected the first year of damage, 111 trees per ha will be lost the first year. These 111 trees will represent 111(470/1 ,000) = 52.2 fewer trees available for commercial thinning and 11(180/1,000) = 20.0 fewer trees available for final harvest.

Value of commercially thinned trees will decrease per ha by an amount commensurate with the reduction in number of trees left to save ($2,375 per ha x 417.8/470 = $2,111.2 per ha). Likewise, value of timber at final harvest will decline to $8,000 per ha. Thus, for the second year of damage fewer trees will be left to save and value of saving the 111 trees will be less. Indeed, present net worth of saving 111 trees the second year is $192.95 per ha. Present net worth of applying vexar tubing for 2 years is $192.59/264.49 = 0.73.

Thus, delaying implementation of control for one year, with a constant damage level, results in a benefit:cost ratio that is no longer cost effective; corrective control programs, which require waiting one year to assess level of damage before applying controls, are less cost effective than preventive control programs. The implication is obvious: if models were available that allowed prediction of damage by vertebrate pests of conifer seedlings, application of damage control methods would be more cost effective and savings would increase.

The increased use of personal computers, and spread sheet software, should make models such as this one tremendously useful to managers in planning animal damage control programs: multiple evaluations of benefit:cost ratios can be computed rapidly and cheaply so that upper and lower limits of parameters influencing benefit:cost ratios, such as efficiency of control method, or reduction in volume of trees damaged by a pest, can be evaluated to determine a range of damage characteristics within which animal damage control efforts will be cost effective.

Literature Cited

Black, H.C., E.J. Dimock II, J. Evans, and J.A. Rochelle. 1979. Animal damage to coniferous plantations in Oregon and Washington. Part 1. A survey. Res. Bull. 25, For. Res. Lab., Oregon State Univ., Corvallis. 45 p.

Brodie, D., H.C. Black, E.J. Dimock II, J. Evans, C. Kao, and J.A. Rochelle. 1979. Animal damage to coniferous plantations in Oregon and Washington. Part II. An economic evaluation. Res. Bull. 26, For. Res. Lab., Oregon State Univ., Corvallis. 24 p.

Crouch, G.L. 1968. Spring-season deer browsing of Douglas-fir on the Capital Forest in western Washington. Res. Note 84. U.S. For. Serv. Pac. Northwest For. Range Exp. Stn. 8 p.

Dimock, E.J. II, and H.C. Black. 1969. Scope and economic aspects of animal damage in California, Oregon and Washington. P.10-14 *in* Wildlife and Reforestation in the Pacific Northwest, Symposium Proc. (H.C. Black, ed.) School of Forestry, Oregon State Univ., Corvallis.

Dimock, E.J. II. 1970. Ten-year height growth of Douglas-fir damaged by hare and deer. J. For. 69:285-288.

Evans, J., D.L. Campbell, G.D. Lindsey, V.G. Barnes, Jr., and R.N. Anthony. 1981. Distribution of animal damage in southwestern Oregon forests. U.S. Dept. Interior Wildl. Leaflet 514. 12 p.

King, J.E. 1958. Development of a stand of coniferous reproduction and interplanted Douglas-fir. Northwest Sci. 32:1-8.

Lawrence, W.H. 1958. Wildlife-damage control problems on Pacific Northwest tree farms. Trans. North Am. Wildl. Conf. 23:146-151.

Lawrence, W.H., N.B. Kverno, and H.D. Hartwell. 1961. Guide to wildlife feeding injuries to conifers in the Pacific Northwest. West. For. Conserv. Assn. 44 p.

Mitchell, K.J. 1974. Height growth losses due to animal feeding in Douglas-fir plantations, Vancouver Island, British Columbia. For. Chron. 40:298-307.

Munger, T.T. 1943. Vital statistics for some Douglas-fir plantations. J. For. 41:53-56.

Schreuder, B.F. 1976. Economic decision making in black bear damage control. Washington For. Prot. Assoc. 1411 4th Ave. Bldg., Suite 1220, Seattle, WA. 98101. 43 p.

Staebler, G.R., P. Lauterbach, and M.W. Moore. 1954. Effect of animal damage on a young coniferous plantation in southwest Washington. J. For. 52:730-733.

Swift, L.W. 1960. Wildlife management and protection in the forests of the United States. Proc. World For. Cong. Seattle, WA. 5:1794-1800.

U.S. Department of Agriculture. 1978. Animal damage control handbook. U.S. Dep. Agric. For. Serv. Regions 5 and 6.

Horton, Alan J. 1987. Animal damage prediction models in conifer plantations. In: Baumgartner, D.M.; Hahoney, R.L.; Evans, J. [and others], eds. Proceedings, workshop on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 29-36. Available from: Coop. Extension, Washington State University, Pullman, WA 99164.

Animal Damage Prediction Models in Conifer Plantations

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Abstract

Animal damage prediction models are most effective when used by interdisciplinary teams composed of wildlife biologists, foresters, forestry technicians, and range conservationists. Foresters usually focus on seedling protection, wildlife biologists on animal habitat needs, food preferences, and population dynamics, while range conservationists are most knowledgeable about livestock herd movements and seasons of use. Together, these disciplines are applied in an *integrated* way to share risk, thereby reducing investments in seedling protection.

In south-central Oregon, we have site-specific models for predicting damage by pocket gophers, big game, and livestock. Pocket gopher and big-game protection has often exceeded a third of our total plantation establishment costs. Prediction models are based upon habitat, history/experience, population cycles, weather and disturbance factors (big game), use patterns and travel routes (big game and livestock), and available controls.

On districts that have implemented interdisciplinary animal damage management through the use of prediction models, plantation establishment costs have declined significantly. However, we have failed to accurately predict damage on a few plantations. Failures have been essential to testing the limits of the models. Ongoing refinement of the models is necessary, particularly in separating “high risk” from “moderate risk” conclusions. As interdisciplinary animal damage risk management has gained acceptance, we have experienced increasing needs for more frequent plantation monitoring.

Samples of animal damage prediction models along with names and addresses of some of our modelers follow this abstract.

DISTRICT _____ DATE _____

SALE _____ MULTIPLY YES'S X WEIGHT

SOIL TYPE	YES or NO	SCORE	WT.	SUB-TOTAL
1. SOILS FAVORABLE FOR BURROW SYSTEM DEVEL. (clay loams, granitics, pummies)		9	2	
2. SOILS WILL LIMIT BURROW SYSTEM DEVELOPMENT. (heavy clay %, seasonal drainage limitations)		3		
3. SOIL NOT FAVORABLE FOR BURROW SYSTEM DEVELOPMENT. (very heavy "gumbo" clays)		*NO GOPHER PROBLEMS ANTICIPATED		
• MUST FIELD-VERIFY BOTH UNIT AND PERIMETER AREA.				
VEGETATION TYPES				
4. SITE MESIC W/RHIZOMATOUS PLANTS AND SUCCULENT FORBS.		5	5	
5. SITE IS ADJACENT TO ABOVE HABITAT		3		
6.* MIXED CONIFER/SNOWBERRY/FORBS		10		
8.* MIXED CONIFER/SNOWBERRY/lWINFLOWER		10		
*PLANT ASSOCIATIONS				
SNOW ACCUMULATION				
9. ANNUAL SNOW ACCUMULATION < ONE FOOT.		1		
10. ELEVATION <4000 FEET AND SNOW ACCUMULATION > ONE FOOT.		3		
11. ELEVATION >4000 FEET AND SNOW ACCUMULATION > ONE PACK UNTIL MAY.		5 (01 USE IO)		
SLOPE			2	
1.>35%		1		
13. < 35%		3		
14. < 10%		10		
HISTORY OF POCKET GOPHER DAMAGE			10	
15. < 50% OF COMPARTMENT CUTOVER WITH HISTORY OF POCKET GOPHER DAMAGE.		2		
16. HISTORY OF POCKET GOPHER DAMAGE TO SEEDLINGS IN AREA.		5	10	
17. POCKET GOPHER DAMAGE PRESENT ON SITE OR ADJACENT AREA.		10		
18. SITE ADJACENT TO MEADOW/GLADE WITH GOPHER ACTIVITY.		15		

SITE PREPARATION		5
19. LITTER (DUFF, NEEDLES, ETC.) WILL COVER 50% OR MORE OF UNIT.	1	
20. SITE PREPARATION 100% VIA SCARIFICATION OR BROADCAST BURN.	5	
21. UNIT WILL BE SEEDED WITH FORBS/SUCCULENT GRASSES.	3	
REFORESTATION FACTORS	5	
22. REPLANT OR FILL-IN PLANT	5	
23. NATURAL REGENERATION *	8	
24. YEARS SINCE HARVEST OR BURN:		
	1-3	2
	3-5	5
	> 5	10

* UNLESS NATURAL REGEN. IS PREDICTABLE WITHIN THE FIRST 2 YEARS.

POCKET GOPHER PREDICTION MODEL RISK ASSESSMENT

TOTAL POINTS	DAMAGE POTENTIAL
<50	LOW POTENTIAL FOR MORTALITY/GROWTH LOSSES.
50-75	LOW TO MODERATE RISK OF DAMAGE. NEED TO MONITOR GOPHER POPULATIONS.
75-125	MODERATE TO HIGH RISK. NEED MORE EXTENSIVE SURVEYS. SEEDLING DAMAGE COULD BE HIGH IN SPOTS.
125-200	DAMAGE RISK HIGH. MORTALITY OF CROP TREES EXPECTED. NEED CLOSE MONITORING, DAMAGE CONTROL MEASURES LIKELY. NEED TO CONSIDER CUMULATIVE EFFECTS OF MORTALITY FACTORS.
200+	DAMAGE RISK EXTREMELY HIGH. INTEGRATED PEST MANAGEMENT SHOULD BE CONSIDERED, THAT IS, HERBICIDES, LOCATION OF UNIT, TYPE OF HARVEST, LEAVE RESIDUE/MINIMIZE FORBS AND GRASS, ETC.

EVALUATION OF DEER/ELK DAMAGE CONTROL NEEDS

(Use for existing plantations, recently cut units, preplanting.)

SALE _____ UNIT _____ DATE _____

Criteria	Score (circle 1)	District's Place your Score Values Here	How Useful is this Criterion to you? District's Value
1. Damage to Seedlings.			High _____
a) more than 35%	5	_____	
b) 10-35%	3	_____	
c) less than 10%	1	_____	
2. Stocking			High _____
a) 20% or more below recommended level.	5	_____	
b) Within 20% of recommended level.	3	_____	
c) Exceeds 20% recommended level.	1	_____	
3. Seedling Size			High _____
a) Under 18" tall.	5	_____	
b) 19" - 36" tall.	2	_____	
c) Over 36" tall.	1	_____	
4. Species			High _____
a) Mostly Douglas-fir	5	_____	
b) Mixed Conifer.	2	_____	
c) True Fir.	1	_____	
5. Amount of Sign			Medium _____
a) Abundant tracks, droppings.	4	_____	
b) Moderate.	2	_____	
c) Very little.	1	_____	
6. Accessibility			Low _____
a) Light slash/debris, few obstructions.	2	_____	
b) Moderate to heavy slash obstructions.	1	_____	

7. Isolation Factor			Low _____
a) People often present or pass by.	2		
b) People occasionally present or pass by.	1		
8. Stock Type (Only use for units planted within 1 yr.)			High _____
a)	Containers.	4	_____
b)	1-0 bare root.	3	_____
c)	2-0 bare root.	2	_____

Summary of Score Value

All Criteria Used	Criteria 1 - 7 Used	Evaluation. Recommendation
18+ points	(15+ points)	Damage will be extensive, control measures should be taken.
8-18 points	(7-15 points)	Damage control should be considered, especially if stocking level is low and trees are small.
0-8 points	(0-7 points)	Damage control is not recommended.

DEER/ELK ANIMAL DAMAGE PREDICTION MODEL

(Use in the sale planning phase)

SALE _____ UNIT _____ DATE _____

Criteria	Score (circle 1)	District's Place your Score Values Here	How Useful is this Criterion to you? District's Value
1. Unit is within migratory corridor.	4		
2. Unit is within summer range; bedding, feeding, movement areas present.	5		
3. Unit is within winter range.	1		
4. History of area reflects high to medium deer/elk densities.	3		
5. Evidence of browsing on natural regeneration.	3		
6. Evidence of browsing on nearby plantations.	5		
7. Abundance of tracks, droppings, trails.	4		
8. Disturbance to elk; area frequently used by people.	1		
9. Units have little to moderate slope.	1		
10. There are few obstructions to movement, light slash and brush.	1		
11. Snow recession coincides with spring, migration animals closely follow the snow line.	3		
12. Drainage is less than 30% cutover.	1		
TOTAL	(summary of circled numbers)		

EVALUATION	RECOMMENDATION
22+ points	Prescribe control measures, damage could be extensive.
16-22 points	Damage control may be indicated, damage is predicted.
10-16 points	Damage control should be considered, expect some damage.
0-10 points	Animal damage is not anticipated to be a problem, control is not recommended.

Black, Hugh C. 1989. Vertebrate pest management in Pacific Northwest forests. In: Protecting the health of Pacific Northwest forests through integrated pest management: a symposium for forest managers; 1989 January 17-18; Corvallis, OR. Corvallis, OR: Oregon State University: 1- 12.

Vertebrate Pest Management in Pacific Northwest Forests

Hugh C. Black

Introduction

Scope and Significance of Animal Damage

Animal damage is a significant and costly problem to stand establishment and management in the Pacific Northwest. It costs the forest industry millions of dollars annually (Brodie and others 1979), and is the leading cause of plantation failure in Oregon (Campbell and Evans.1984). A survey, in 1984, of four western Regions of the USDA Forest Service showed that animal damage was a serious problem to forest regeneration and other resources in the Regions surveyed (U.S Department of Agriculture, Forest Service, Timber Management. March 1984. Washington, DC. Unpubl. report.).

In 1984, these Regions conducted annual damage control on about 100,000 acres of plantations and young stands each year. Direct control costs exceeded $5.5 million per year. An additional 8,000 to 10,000 acres per year required replanting, principally because of animal damage, at an additional cost of $3.5 million per year.

Animals causing damage to regeneration in these Regions, ranked in order of importance, are pocket gophers, mountain beaver, deer and elk, and black bear. Pocket gophers (Thomomys sp.), which are the most destructive species, damage or destroy regeneration on hundreds of thousands of acres of forest land in the western United States each year (Crouch 1986).

Present animal damage control practices emphasize direct population control (baiting, trapping and snaring, and special hunts) and use of physical barriers (plastic mesh tubing and fencing). But these practices are limited in effectiveness, costly, and becoming increasingly restricted by regulations and the public's concerns regarding their use. Of particular concern is the potential impact on threatened and endangered species and other nontarget species, and concerns are growing regarding animal welfare. These latter concerns are expressed through restrictions on use of leg-hold traps, e.g., leg-hold traps are banned in New Jersey, and use of snares to take bears.

Reforestation Success

Animal damage may be receiving less attention from forest managers because of the overall success of reforestation in recent years. For example, over the last 5 years (1981-1986), an average of 88 percent of all reforestation on National Forest System (NFS) lands have met stocking objectives. In 1986 (the latest year for which data are available), success was 91 percent (USDA Forest Service 1988). This pattern of successful reforestation is also occurring on industrial, state, and other federal forest lands. The numbers of acres reforested each year is also growing because of increased timber harvesting and severe wildfire damage in the West in both 1986 and 1987.

In 1987, the USDA Forest Service reforested 394,000 acres of NFS lands-the highest number of acres reforested since 1981 (USDA Forest Service 1988). This increase in reforestation was outpaced by the increase in acreage needing reforestation. At the end of 1987, about 1.1 million acres of NFS lands needed reforesting. This increase (over previous years) occurred primarily because of record high timber harvesting levels, the extreme wildfire damage in California and Oregon (in 1987), and severe bark beetle infestions in northeastern Utah.

Current Pest Management Practices and Their Limitations

Current vertebrate pest management practices are limited for the most part to use of a small number of chemical toxicants and repellents, and physical barriers (mainly plastic mesh tubing), which have been available for many years. For example, hand-baiting with strychnine oat baits to control pocket gophers-the most commonly used practice today-was adapted directly from agricultural practices developed in the early 1900s (Lantz 1903, Crouch 1933). Use of burrow builders for control of forest pocket gophers, which was also adapted from agricultural uses, first occurred in the 1960s (Ward and Hansen 1962). Crouch (1986) observed that hand- and machine-baiting, with strychnine as the toxicant, is still the only effective control method for large-scale gopher control programs, and procedures have changed little over the past 80 years.

Tetramethylthiuram disulfide (TMTD or Thiram), one of the two most widely used foliar repellents for protection of conifer seedlings from clipping by hares and rabbits and browsing by deer and elk, was first used operationally for this purpose in the 1960s and became the "standard" for evaluation of other candidate repellent compounds (Kverno and others 1965). Use of this repellent has recently declined, however, because of possible human toxicity (Campbell and Evans 1984).

Big-game repellent (BGR) was developed more recently (Rochelle and others 1974). "Vexar" seedling protectors (plastic mesh tubing) also were introduced at about the same time (Campbell and Evans 1975). In the meantime, several chemicals (toxicants and repellents) that had been used operationally or experimentally to protect conifer seeds or seedlings from animal damage are no longer available for these purposes. Examples of seed protectants no longer available include Compound 1080 (sodium fluoracetate), endrin, mestranol, and thallium sulphate. Examples of seedling protectants no longer available include octamethylpyrophoroamide (OMPA) and Gophacide.

Among the reasons for the unavailability of these and other chemicals are failure to obtain EPA registration (OMPA), the compound is registered but commercially unavailable because of limited market (Gophacide), or use is restricted by the EPA, e.g., the recent temporary cancellation of all above-ground uses of strychnine for rodent control (Federal Register, Vol. 53, No. 193, October 5, 1988).

OMPA is a highly toxic compound that was successfully used operationally as the active ingredient in a toxic tracking foam to control mountain beavers in Washington (Oita 1969) and used experimentally as a systemic animal repellent (Rediske and Lawrence 1964). (A systemic repellent is a chemical applied to foliage, roots, or soil that is absorbed and translocated to all parts of the seedling, and limits feeding on the plant by animals; Rochelle 1973). It was not federally registered, however, because of its extreme toxicity and potential hazard to nontarget species.

Development of New Vertebrate Pest Management Tools

An array of vertebrate pest management tools is required because they often are most effective when used in combination, constraints may limit use of certain methods, or development of resistance to particular chemicals may require use of alternative techniques. But development of new pest management tools and techniques has lagged for several reasons (Spencer 1982): forest management requires only small amounts of chemicals and is considered a "minor use," it is becoming more and more time consuming and costly to register new pesticides (5 to 10 years and several million dollars), and lack of public support for development and use of pesticides.

Restrictions on Pesticide Use in Vertebrate Pest Management

Pesticide label restrictions-In 1982, in a paper on "Vertebrate pest management and changing times," Spencer (1982) emphasized the extent to which restrictive pesticide labeling to protect endangered species can impact vertebrate pest management. Among several examples, he cited the M-44 registration, which has 26 separate restrictions, and label restrictions on a rodent burrow fumigant.

M-44 (item 9): "The M-44 device shall not be used in areas where threatened or endangered species might be adversely affected. Each applicant shall be issued a map which clearly indicates such areas."

Endangered species considerations for a rodent burrow fumigant (Degesch - Mag-Disc) exclude its use within the habitat of six widely distributed endangered species (from the California condor to the Eastern indigo snake) and require consultation with FWS Endangered Species Specialists or contact with State Fish and Wildlife Departments before use of the product.

The pesticide label for pocket gopher bait for use in burrow builders, which was revised in November 1988 after the EPA temporarily cancelled all above-ground uses of strychnine (Federal Register, Vol. 53, No. 193, October 5, 1988), provides a further example of the pervasive influence of endangered species considerations in vertebrate pest management:

> Before baiting, the user is advised to contact the Regional U.S. Fish and Wildlife Service (Endangered Species Specialist) or the local Fish and Game Office for specific information on endangered species. Strychnine baits should not be used in the geographic ranges of the following species, except under programs and procedures approved by the EPA: California condor, San Joaquin kit fox, Aleutian Canada goose, Morro Bay kangaroo rat, gray wolf, grizzly bear, and salt marsh harvest mouse.

For the USDA Forest Service and other federal agencies, this requires formal or informal biological evaluations and consultations with the FWS and subsequent jeopardy or nonjeopardy opinions by the FWS before these products may be used within the geographic ranges of the endangered species listed.

EPA's Endangered Species Protection Program

In 1986, the U.S. Environmental Protection Agency (EPA) initiated an effort to comply more fully with the Endangered Species Act (ESA) with regard to regulation of pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Witt and others 1988).

The ESA, which is administered by the FWS, requires federal agencies to ensure that their actions do not jeopardize the continued excistence of any endangered or threatened species. Under the ESA, agencies are required to evaluate potential risk and, when potential effects are identified, to consult with the FWS. If a formal Section 7 consultation is used to obtain a biological opinion, and if **the** opinion establishes "jeopardy" to an endangered or threatened species, agencies are required to act to mitigate risks to the affected species.

Pesticide registration decisions by the EPA, which through the FIFRA registers all pesticides used in the United States, are based upon evidence adequate to demonstrate that a pesticide use will not pose unreasonable risks to people and the environment. Under the ESA, the EPA must ensure that the registered uses of pesticides within the range of endangered or threatened species will not place the species or their critical habitats at unreasonable risk. The registration of pesticides is considered an authorization for use, and thus is subject to the ESA.

As part of their program, the EPA identified clusters of pesticides that could potentially affect endangered or threatened species. This approach grouped similar-use pesticides into one cluster. For example, all of the pesticides used in the management of forest land were grouped into one cluster. In cooperation with the EPA, the FWS identified federally listed endangered or threatened species potentially at risk. Pesticide prohibitions and restrictions were then established by the EPA, under authority of the FIFRA, as amended. To supplement the proposed pesticide label changes for products in these clusters, the EPA created bulletins and range maps. These bulletins were to serve to alert pesticide users about counties within which specific pesticides were prohibited and the endangered or threatened species at risk. Range maps were intended to depict the currently occupied habitat, or potential habitat, of each endangered species by county for each prohibited pesticide.

If EPA's proposed Endangered Species Protection Program had been implemented, forest pesticide users would have been prohibited from using strychnine and other rodenticides or predacides (and other pesticides) in areas occupied by listed threatened or endangered species.

Recent Developments in Vertebrate Pest Management

New Chemicals and Toxicants, and New Bait Formulations

Selenium-In 1983, University of Washington scientists reported that a time-release, selenium-containing tablet, placed with a seedling when planted, caused the tree to exude a malodorous gas ("garlic breath") that repelled **deer** (Allan and others 1984, Boling 1984). The plant apparently metabolizes selenium by transforming it into dimethyl selenide gas (garlic contains selenium) and expels it through the needles, which may repel deer. Preliminary tests showed that this method could reduce deer browsing up to 80 percent, with no apparent effect on the tree's growth rate, and that it remains effective for three years. (The original concept for the selenium pellet came from an effort to develop a systemic insecticide to prevent shoot borers from attacking cedar trees in the tropics.)

Field tests of this systemic repellent in Washington, in 1983, failed to confirm adequate repellency of selenium-treated seedlings to deer. A pen study of deer browsing of selenium-treated Douglas-fir seedlings by the U.S. Fish and Wildlife Service was discontinued because seedlings failed to accumulate adequate levels of selenium. (Campbell, D.L.; Evans, J. 1984. A pen study of deer browsing of Douglas-fir seedlings treated with selenium deer repellent. Unpubl. Job Completion Report. Olympia, WA: U.S. Fish and Wildlife Service. 4 p.)

Although the use of systemic insecticides has been highly successful with numerous commercial applications, development of a systemic animal repellent has intrigued but, so far, eluded wildlife biologists. Systemic chemicals offer many advantages over contact repellents, including greater resistance to weathering, potential for protecting new growth, and potential for providing longer protection (Rediske and Lawrence 1964). Efforts to develop a systemic repellent with OMPA as the active ingredient (Rediske and Lawrence 1964) and selenium as the active ingredient (Campbell and Evans 1984) have not been successful.

Synthetic predator odors-Researchers at the Applied Mammal Research Institute in British Columbia, Canada (Sullivan and others 1988), demonstrated on an experimental basis that certain synthetic predator odors repelled the snowshoe hare (Lepus *americanus),* several species of voles (Microtus sp.), the northern pocket gopher (Thomomys talpoides), and the red squirrel (Tamiasciurus hudsonicus), and reduced damage to tree seedlings. Predator odors from the short-tailed weasel (Mustela erminea) and the red fox (Vulpes *vulpes)* originating from feces, urine, or anal scent gland secretions elicited a “fear” response when detected by prey species. Used as an area repellent, synthetic predator odors produced significant avoidance responses in the above-named pest species. (Compounds were dispensed in small capillary tubes attached to trees, which protected them from weathering, controlled the release of odors, and maintained the odor around the base of test trees.) Field tests of this new area repellent are currently in progress in forest plantations in British Columbia.

In a related study designed to assess the influence of predator odors on population density and survival of montane vole (M[icrotus] montanus) populations in natural grassland habitat, Sullivan and others (1988) found that vole populations declined in three consecutive winters on an area treated with predator odors. (They assumed that odors dispensed from the capillary tubes permeated throughout the treatment area.) They believed that these declines were caused by significantly lower survival in the treatment than in the control populations, and attributed this to increased predation, which may have resulted from the predator odors attracting additional predators to the study area.

Cholecalciferol-QUINTOX (cholecalciferol) is the trade name (Bell Laboratories, Inc., Madison, Wisconsin) for a new commensal rodenticide, which was registered by the **EPA** in December 1987 for controlling Norway rats, roof rats, and house mice (Brown and Marshall 1988). Cholecalciferol (Vitamin D3) has a different mode of action than conventional acute and chronic rodenticides. It metabolizes calcium from bone matrix to plasma, causing target animals to die from hypercalcemia. It differs from other acute rodenticides in that reportedly no bait shyness is associated with consumption and once the lethal dose is consumed all food intake ceases, although time of death may be delayed for 3 to 4 days. Preliminary studies indicate that cholecalciferol has potential as a rodenticide for controlling pocket gophers and ground squirrels.

Field-efficacy tests of QUINTOX (pelleted grain baits) on the Targhee National Forest, Idaho (Personal communication, Jack Amundson, Forest Silviculturist, Targhee NF, October 1988), were not promising: initial results showed **a** 35-percent reduction in pocket gopher activity on the QUINTOX-treated plot compared with a 75-percent reduction on the plot treated with strychnine oat baits. Preliminary tests on the Umatilla National Forest, Oregon (Bonar, R.E. 1988. Field test of cholecalciferol on the Heppner Ranger District, Umatilla National Forest, Heppner, Oregon. Unpubl. report.), were inconclusive. There are indications that poor bait acceptance may have adversely affected results of both tests.

Durable baits for pocket gopher control-In 1984, researchers at the University of California, Davis (Tuneberg and others 1984) developed a new concept in pocket gopher control, which was based on two behaviorial traits of gophers, i.e., their rapid invasion of unoccupied burrow systems, after the previous occupant has been killed by a rodenticide, and their use of existing food stores, including baits left by the previous gopher. They designed and used a long-lasting (i.e., durable) pocket gopher bait that would not deteriorate for several months in the burrow system. They anticipated that this approach would make it possible to control gophers with one bait or a single baiting, and would be well suited in control situations where it is difficult to locate all of the burrow systems during a hand-baiting operation, and where gopher invasion from surrounding untreated areas is a problem. Preliminary tests with cylindrical-shaped paraffinized wheat baits (3 cm x 10 cm) containing bromadiolone, a potent, second-generation anticoagulant (it produces death in many rodent species with one or two feedings, unlike the first-generation anticoagulants that require multiple feedings to be effective) were promising. Gophers moved most baits to the nest area for feeding, gophers that fed on the baits were killed, and other gophers rapidly invaded abandoned burrow systems and fed on the residual baits.

In 1987, J. T. Eaton and Co., Inc., Twinsburg, Ohio, applied this concept to the development of a paraffinized grain bait containing 0.005 percent diphacinone (a first-generation anticoagulant) for pocket gopher control. Preliminary field tests with this product, trade-named “Eaton’s Answer,” were promising and provided the basis for 24-C registrations in several states, including Oregon and Washington.

In 1988, the Rogue River National Forest, Oregon, used Eaton's Answer operationally for pocket gopher control on 5,800 acres of forest land (Bulkin, S. 1988. Preliminary results of gopher baiting using durable bait blocks [Eaton's Answer TM] containing 0.005% diphacinone. Unpubl. report. Medford, OR: U.S. Department of Agriculture, Forest Service, Rogue River National Forest.). Preliminary results showed excellent bait acceptance (95%) and 55 to 65 percent reduction in pocket gopher activity, based on open hole surveys 2 to 3 weeks after baiting. Baiting with durable bait blocks was less restricted by weather and soil-moisture conditions than baiting with strychnine oat baits, but twice as costly. Efficacy of baiting will be reassessed in the spring of 1989.

Animal damage prediction models-It has long-been recognized that correct identification of animal damage is the necessary first step in prescribing appropriate animal damage control methods. Efforts have intensified in recent years to assess more fully the nature of animal damage problems on a site-specific basis and to develop species-specific models to predict occurrence of damaging animals, the extent and distribution of damage, the effects of animal damage on growth, and the need for damage control. On NFS lands in the Pacific Northwest Region, an interdisciplinary approach has been followed in animal damage assessment and model development. In their simplest form, these models provide a framework for systematic problem analysis and evaluation, based on damage history, animal occurrence, abundance, and use patterns (big game and livestock), and related information on habitat and plant communities, physical characteristics of the site, site preparation, etc. Experience has shown that these models are providing better damage assessments and more efficient use of controls, and have reduced plantation establishment costs (Horton 1987). The Weyerhaeuser Company also has used detailed damage assessment for evaluating the need for damage control, together with damage prediction models, to reduce damage control expenditures and improve treatment effectiveness (Anderson 1987). Further refinement of existing models and development of better methods of predicting the extent of damage are needed, however.

Silvicultural Strategies for Vertebrate Pest Management

A team of specialists from Oregon State University, USDA Forest Service research and management, industry, and others has begun development of a compendium that will summarize what is known about the response of selected wildlife species (species that cause damage to forest stands) to limit animal damage. Silvicultural research needs related to animal damage management also will be identified. This document ("Silvicultural approaches to animal damage management in Pacific Northwest forests") is intended to provide a synthesis of current information to serve practicing foresters and others as a basis for sound, cost-effective, and environmentally acceptable decisions regarding animal damage management in the Pacific Northwest. It will provide a comprehensive process for developing silvicultural prescriptions that integrate responses of wildlife species, vegetation, and stand growth in a manner that leads to preventing or limiting animal damage. It is not intended to supplant conventional methods of animal damage management, but to emphasize prevention of damage, while meeting timber, wildlife, and other resource management objectives. The team is also compiling an annotated bibliography of animal damage and habitat relationships to provide a useful reference for forest managers and others concerned with animal damage management.

Vertebrate Pest Management Research

During the 1960s and 197Os, vertebrate pest management research was actively supported, particularly in the Pacific Northwest, by state and federal agencies, universities, the forest industry, and others. The U.S. Fish and Wildlife Service conducted an intensive chemical screening program to develop toxicants and repellents to control forest animal damage (Kverno and others 1965). But this effort and related research decreased over time because of reduced funding and changes in research priorities, which were influenced by two compensating trends: (1) the increasing cost and time required to register new toxicants and repellents, and (2) the growing success of artificial reforestation due to greatly improved regeneration systems.

The USDA Forest Service terminated their Animal Damage Control Research Project at the Pacific Northwest Research Station, Olympia, Washington, in 1975 (Crouch 1987). Although vertebrate pest management research is continuing, supported with National Agricultural Pesticide Impact Assessment Program (NAPIAP) funds and other funds, no comprehensive vertebrate pest management research has been conducted by the Forest Service since 1975. Currently, two cooperative projects, funded in part with NAPIAP funds, are both aimed at controlling pocket gophers: (1) "Field-efficacy tests of three concentrations of strychnine baits to control pocket gophers," in cooperation with the Animal and Plant Health Inspection Service (APHIS), Olympia, Washington, and (2) "Environmental exposure and fate of (durable) multi-kill strychnine gopher baits," in cooperation with the University of California, Davis. NAPIAP funding also will be provided to the APHIS, Olympia, Washington, in 1989, to continue field-efficacy testing of pocket gopher baits ("Field efficacy of burrow-builder baiting for pocket gopher control"). Each of the field-efficacy studies will provide data required by the EPA to maintain registrations of strychnine for below-ground use (hand- and machine-baiting) for pocket gopher control.

Funding and staffing of the USDI Fish and Wildlife Service (FWS) Animal Damage Control (ADC) Project at Olympia, Washington, had been decreased for several years before the project was closed in 1985. After transfer of the ADC program from the FWS to the APHIS in December 1985 (PL 99-130), the project was reactivated in 1986. The APHIS' present forest ADC research program (both at Olympia and at the Denver Wildlife Research Center, Denver, Colorado), now in a separate Science and Technology branch, is beginning to expand after a period of reorganization and rebuilding. The foremost objective of the research program at Olympia is to maintain current bait registrations for both pocket gophers and mountain beaver.

Recommendations for Future Action

We need to continue to improve currently available tools and techniques for vertebrate pest management and, at the same time, to improve how we use them. More emphasis on developing silvicultural prescriptions that integrate responses of damaging animals, vegetation, and stand growth, i.e., a silvicultural approach to animal damage management, will enhance this process.

James L. Stewart, Director of Forest Insect and Disease Research, USDA Forest Service, in a speech to the Western Forestry and Conservation Association's Pest Committee, in December 1988, made the following observations, which are pertinent to vertebrate pest management:

> I do not see the environmental community easing up in its role of challenging the use of current pest-control tactics. Currently registered tactics will continue to go unused or be employed too late to be effective in preventing extensive damage because their use excites controversy. Forest managers will simply not self-inflict the abuse that comes with trying to employ many of today's pest control tactics. Where they do, the delays brought on by appeals and court actions will defeat the objectives of effective pest management and the result will be extensive damage.

We have already seen indications of this in vertebrate pest management, especially in predator control, through restrictions on use of the M-44 and the toxic collar to control coyotes, and through restrictions on snaring or shooting of black bears damaging conifer plantations.

Stewart also observed that we need to increase the public's awareness for the consequences of not taking action with environmentally compatible control tactics, but he did not believe we will make much headway in eliminating the constraints. He observed that the public is not likely to accept routine use of chemicals on public (or private) forest lands.

Stewart concluded that "we need to give increased emphasis to developing new, innovative pest-control tactics and strategies that managers can use within the constraints under which they work. They must be ecologically based and environmentally and economically sound."

Literature Cited

Allan, G.G.; Gustafson, D.I.; Mikels, R.A. [and others]. 1984. The reduction of deer browsing of Douglas-fir *(Pseudotsuga* menziesii) seedlings by quadrivalent selenium. Forest Ecology and Management. 7 (1983/1984): 153-181.

Anderson, R.J. 1987. Animal damage prediction and assessment. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, workshop on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 27-28.

Boling, R. 1984. The pill for seedlings; time-release tablet turns a taste treat into a turn-off for browsing deer. American Forests. 56 (June): 32-32.

Brodie, D.; Black, H.C.; Dimock, E.J., II [and others]. 1979. Animal damage to coniferous plantations in Oregon and Washington. Part II: an economic evaluation. Res. Bull. 26. Corvallis, OR: Oregon State University, School of Forestry, Forest Research Laboratory. 24 p.

Brown, L.D.; Marshall, E.F. 1988. Field evaluation of QUINTOX (cholecalciferol) for controlling commensal rodents. In: Crabb, C. A.; Marsh, R. E., eds. Proceedings, 13th vertebrate pest conference; 1988 March 1-3; Monterey, CA. Davis, CA: University of California: 70-74.

Campbell, D.L.; Evans, J. 1975. "Vexar" seedling protectors to reduce wildlife damage to Douglas-fir. Wildl. Leaf. 508. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 11 p.

Campbell, D.L.; Evans, J. 1984. Wildlife-reforestation problems and seedling protection in western Oregon: review and current knowledge. Tech. Note OR-4. Portland, OR: U.S. Department of the Interior, Bureau of Land Managment. 46 p.

Crouch, G.L. 1986. Pocket gopher damage to conifers in western forests: a historical and current perspective on the problem and its control. In: Salmon, T.P., ed. Proceedings, 12th vertebrate pest conference; 1986 March 4-6; San Diego, CA. Davis, CA: University of California: 196-198.

Crouch, G.L. 1987. A bibliography of publications from Forest Service animal damage research in the Pacific Northwest, 1961-1986. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, workshop on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 9-14.

Crouch, W.E. 1923. Pocket gopher control. Farmers Bull. 1709. Washington, DC: U.S. Department of Agriculture. 21 p.

Horton, A.J. 1987. Animal damage prediction models in conifer plantations. In: Baumgartner, D.M.; Mahoney, R.L.; Evans, J. [and others], eds. Proceedings, workshop on animal damage management in Pacific Northwest forests; 1987 March 25-27; Spokane, WA. Pullman, WA: Washington State University: 29-36.

Kverno, N.B.; Hood, G.A.; Dodge, **W.E. 1965.** Development of chemicals to control forest wildlife damage. In: Proceedings, Society of American Foresters; 1965 October 24-28; Detroit, MI: 222-226.

Lantz, D.E. 1903. Destroying prairie dogs and pocket gophers. Expt. Sta. Bull. 116. Lawrence, KS: Kansas State Agricultural College: 147-163.

Oita, K. 1969. Development and use of toxic foam to control mountain beavers. Part II. a tracking compound of toxic foam. In: Black, H.C., ed. Proceedings, symposium on wildlife and reforestation in the Pacific Northwest; 1968 September 12-13; Corvallis, OR. Corvallis, OR: Oregon State University, School of Forestry: **84-85.**

Rediske, J. H.; Lawrence, W. H. 1964. Octamethylpyrophosphoramide (OMPA) as a systemic repellent for Douglas-fir seedlings. Forest Science. 10(1): 93-103.

Rochelle, J.A. 1973. Wildlife damage control with chemicals. In: Proceedings, forest pesticides and their safe use. A short course. Sponsored by Oregon State University and Washington State University, Cooperative Extension Service, and the U.S. Forest Service, Region 6. 10 p.

Rochelle, J.E.; Gauditz, I.; Oita, K.; Oh, J.H.K. 1974. New developments in big-game repellents. In: Black, H.C., ed. Wildlife and reforestation in the Pacific Northwest: Proceedings of a symposium; 1988 September 12-13; Corvallis, OR: Oregon State University, School of Forestry: 103-112.

Spencer, D.A. 1982. Vertebrate pest management and changing *times.* In: Marsh, R.E., ed. Proceedings, 10th vertebrate pest conference; 1982 February 23-25; Monterey, CA. Davis, CA: University of California: 2-5.

Sullivan, T.P.; Sullivan, D.S.; Crump, D.R. [and others]. 1988. Predator odors and their potential role in managing pest rodents and rabbits. In: Crabb, C.A.; Marsh, R.E., eds. Proceedings, 13th vertebrate pest conference; 1988 March 1-3; Monterey, CA. Davis, CA: University of California: 145-150.

Tuneberg, A.D.; Howard, W.E.; Marsh, R.E. 1984. A new concept in pocket gopher control. In: Clark, D.L., ed. Proceedings, 11 th vertebrate pest conference; 1984 March 6-8; Sacramento, CA. Davis, CA: University of California: 7-16.

U.S. Department of Agriculture, Forest Service. 1988. Report of the Forest Service: fiscal year 1987. Washington, DC: U.S. Department of Agriculture, Forest Service. 188 p.

Ward, A.L.; Hansen, R.M. 1962. Pocket gopher control with the burrow-builder in forest nurseries and plantations. Journal of Forestry. 60: 42-44.

Witt, S.; Contreras, G.; Ollieu, M.M. 1988. Effects of implementing EPA's endangered species program on National Forest System lands, In: Crabb, C.A.; Marsh, R.E., eds. Proceedings, 13th vertebrate pest conference; 1988 March 1-3; Monterey, CA. Davis, CA: University of California: 160-162.

Appendix 4:

Deer Fence Contracts-Examples

Examples of specifications used for contracting the construction of nylon and woven wire, game-tight fence, and specifications for contract purchasing nylon mesh fencing material.

Exhibit 1. Sample contract from the Suislaw National Forest, Oregon.

Deer Fence Contract

AWARD

Award will be made on an all or none basis to one contractor. Bids offering less than 10 days for acceptance by the government from the date set for opening will be considered nonresponsive and will be rejected.

CONTRACT PERIOD - DATE OF DELIVERY

The Government desires that delivery be made at the points specified within 45 calendar days after notice of award.

Bidder shall insert in the appropriate blank below a definite number of days within which delivery will be made. If the bidder does not insert a delivery time, the bid shall be deemed to offer delivery in accordance with the Government's desired delivery date above. Although time of delivery will not be a factor in determining award, any bid offering a delivery time which exceeds 60 days after notice of award will not be considered for award on the basis that the time for delivery offered is unreasonable.

BIDDER PROPOSED DELIVERY_____ days after notice of award.

DELIVERY TS

Delivery shall be made f.o.b. to the following points in the quantities shown:

Delivery Point	Yards	Sections
1. District Ranger, Alsea Ranger District, Alsea, OR 97324	4180	19
2. District Ranger, Waldport Ranger District, Waldport, OR 97394	2640	12
TOTAL	6820	31

BID SCHEDULE

Item No.		Per Section	Amount
1. Nylon Fence Netting to be in complete accordance with the terms and specifications of this bid invitation.	31 Sections (6820 linear yards)'	_____	$_____

_____

Signature of Bidder

Exhibit 1, Continued

SPECIFICATIONS FOR PURCHASING NYLON FENCING MATERIAL

1. Netting

1.1 The twine fiber shall be continuous filament bonded nylon. The twine shall have a tensile strengh of at least 115 pounds.

1.2 Netting Twine Size: 15 thread.

1.3 Mesh size will be 6 inch, stretched measure.

1.4 Width or depth: 8 feet, hung measure.

1.5 Selvage: single.

1.6 Weaving: the netting shall be woven with single knots.

1.7 Treatment: the netting shall be untreated.

2. Hanging

2.1 The netting shall be hung square or diagonally square, and it shall be full-out.

2.2 The netting shall be hung with 18 thread nylon twine with a tensile strength of 150 pounds.

2.3 The top line shall be five-sixteenth (5/16) inch polypropylene rope with a tensile strength of 2,100 pounds.

2.4 The bottom line shall be one-quarter (1/4) inch polypropylene rope with a tensile strength of 1,200 pounds.

2.5 The net shall be hung, top and bottom, at every second mesh.

2.6 The top and bottom lines shall extend two (2) feet beyond the netting ends to permit tying.

3. Section Length.

3.1 Each of the 31 sections of net shall be 220 yards in length, hung measure. Each section shall be packed separately and in such a manner that it may be removed from the package without tangling.

Buy American Act

Particular attention is directed to clause 4 of the General Provisions (reverse of page one).

Exhibit 2. Sample contract from the Deschutes National Forest, Oregon.

SPECIFICATIONS FRO SKELETON CAVE AND CAMP TWO FENCE CONSTRUCTION

SCOPE

Vendor to furnish all supervision, labor, tools, transportation, equipment, materials and supplies listed herein, to construct two fences in accordance with these specifications and attachments.

CLEARING

The right-of-way will be cleared to a width of sixteen (16) feet. The fence will be constructed near the center line.

MATERIALS

The following materials, prefabricated for constructing the fence, have been stockpiled near the construction area, and are government furnished:

1) Wooden posts
2) Steel post and clips
3) Wooden braces (contractor will cut to length)
4) Woven wire, 47-inch
5) Woven wire, 35-inch
6) Barbed wire
7) Telephone wire, #9 (for stays)

VENDOR-FURNISHED MATERIALS

The vendor shall furnish the following items:

2 ea. 12 ft. x 8 ft. metal gates, with all hangers, hinges, latches and supplies for complete installation.

Staples, fence

Nails, 40d

Wire for guy wire

Scab lumber for protection of trees used as posts

All other required material and supplies not listed as government furnished

Posts - Spacing of posts shall not exceed 1 rod (16-1/2 feet).

Wooden posts shall be set plumb and to a depth of not less than 30 inches into the ground. Material shall be firmly tamped around posts.

Posts in a straight line of fence shall have a minimum of 4 inches protruding above the top strand of wire.

Live trees over 6 inches in diameter at breast height may be used in place of posts, providing they are located not more than 1 foot out of line with the adjacent fence. Before fastening wire to trees, a scab at least 2 inches thick and 9 feet long shall be nailed securely to the tree. Staples shall be driven into scabs instead of trees.

Exhibit 2, Continued

Wooden Corner Posts - Live trees 12 inches in diameter at breast height will be used for corners when available. Corner trees shall be scabbed in the same manner as post trees. Wooden corner posts shall be set not less than 36 inches into the ground. Excavated material shall be firmly tamped around the post.

Corner posts shall have a minimum of 4 inches protruding above the top of any wire, anchor wire, or brace.

Anchor Posts - Corner posts shall be anchored as shown in Figure 1. The anchor post shall be located a distance from the corner post that is equal to the height of the corner post protruding out of the ground. (For example, if the corner post protrudes 9 feet out of the ground, the anchor post will be 9 feet from the corner post.)

The anchor post shall be the same diameter as the other fence posts and shall be set at the same depth as the corner post. It shall be placed at a point that will split the interior angle created by the two lines of the fence.

The anchor post shall protrude 4 inches above the top of the anchor wire and shall not protrude more than 24 inches above ground level.

The anchor wire shall be of the wire furnished for this purpose. The contractor shall make two loops around the anchor post and the top of the main fence post, twisting the wire in the center to tighten. The ends of the wire shall be wrapped around the anchor post and stapled securely.

Steel Posts - Steel post shall be driven into the ground so that the top of the anchor wing will be not less than 6 inches below ground level.

The top of the steel post shall protrude at least 4 inches above the top strand of wire.

The posts shall be set plumb and shall be firmly embedded into the ground.

Clips shall be used to fasten the wire to the post. The clips shall be attached to the post at the holding points, a maximum of 8 inches apart.

The posts may be driven with a hollow pipe driver. The posts shall be driven in a manner that does not bend the posts or the anchor wings.

Posts, General - Every fifth post shall be wood. Where rock is encountered and it is not feasible to use a steel post, an excavation shall be made and a wooden post used, set as prescribed for wooden posts.

Gate Posts - Gate posts shall be set in the ground a minimum of 48 inches. The post above the ground shall be at least 10' - 0", and protrude above the top of the gate 6 inches. Anchor posts for gates shall be set as described in that section and shall be set at right angles to the line of the gate when closed. Anchor posts will only be placed on the outside of the fence.

Gates - Two gates will be installed at points shown on the attached map.

Contractor may furnish aluminum of "lifetime" or equal quality, or may prefabricate the gates by using 1-1/4" galvanized pipe with cross bracing and cover one side with woven wire.

If the contractor elects to prefabricate the gates, he must obtain advance approval of the design by the Forest Service

Exhibit 2, Continued

Bracing - All gates will be braced as shown in Figure 4. All horizontal and diagonal brace poles will be notched into posts and spiked with two 40d nails on each end. Any split braces will be replaced.

All corner bracing will be installed as shown in Figure 1. Where trees are used for corners as specified, no bracing will be needed. All horizontal and diagonal brace poles will be notched into posts and spiked with two 40d nails on each end. Any split braces will be replaced.

Stapling - All horizontal wires shall be stapled firmly to the scab on every tree used as a corner and to every corner post.

In other posts, the staples shall be driven in a manner that will provide some play when undue stress is placed upon the wire. The staples should be placed at an angle over the wire, so they will not split the post when driven. See Figure 3 for spacing of staples.

Wire Arrangement - The wire shall be placed as shown on Figure 2, with the 47-inch woven wire placed on the bottom, 35-inch wire above it, and two strands of barbed wire spaced as shown on top.

After all 35-inch wire has been used, two rows of 47-inch wire will be used. Where two rows of 47-inch wire have been used, the two strands of barbed wire will not be used.

The two sections of woven wire shall be clamped together between posts with four evenly spaced hog rings.

Stays shall be made from the No. 9 telephone wire supplied. These shall be placed at third points between posts (two in each space between posts.) The stay wire shall be wound around the top strand of barbed wire, looped once around the lower barbed wire strand, and wound around the top strand of woven wire. Stays shall be tight and straight in line. The strands of horizontal wire shall not be pulled out of line.

The woven wire shall be stretched tight, with no sag. Stretching shall be done with a bar clamp or similar device. The wires shall not be kinked or otherwise damaged during installation.

The barbed wire shall be stretched tightly with no sag. Any method of stretching that does not kink the wire or damage the barbs will be acceptable.

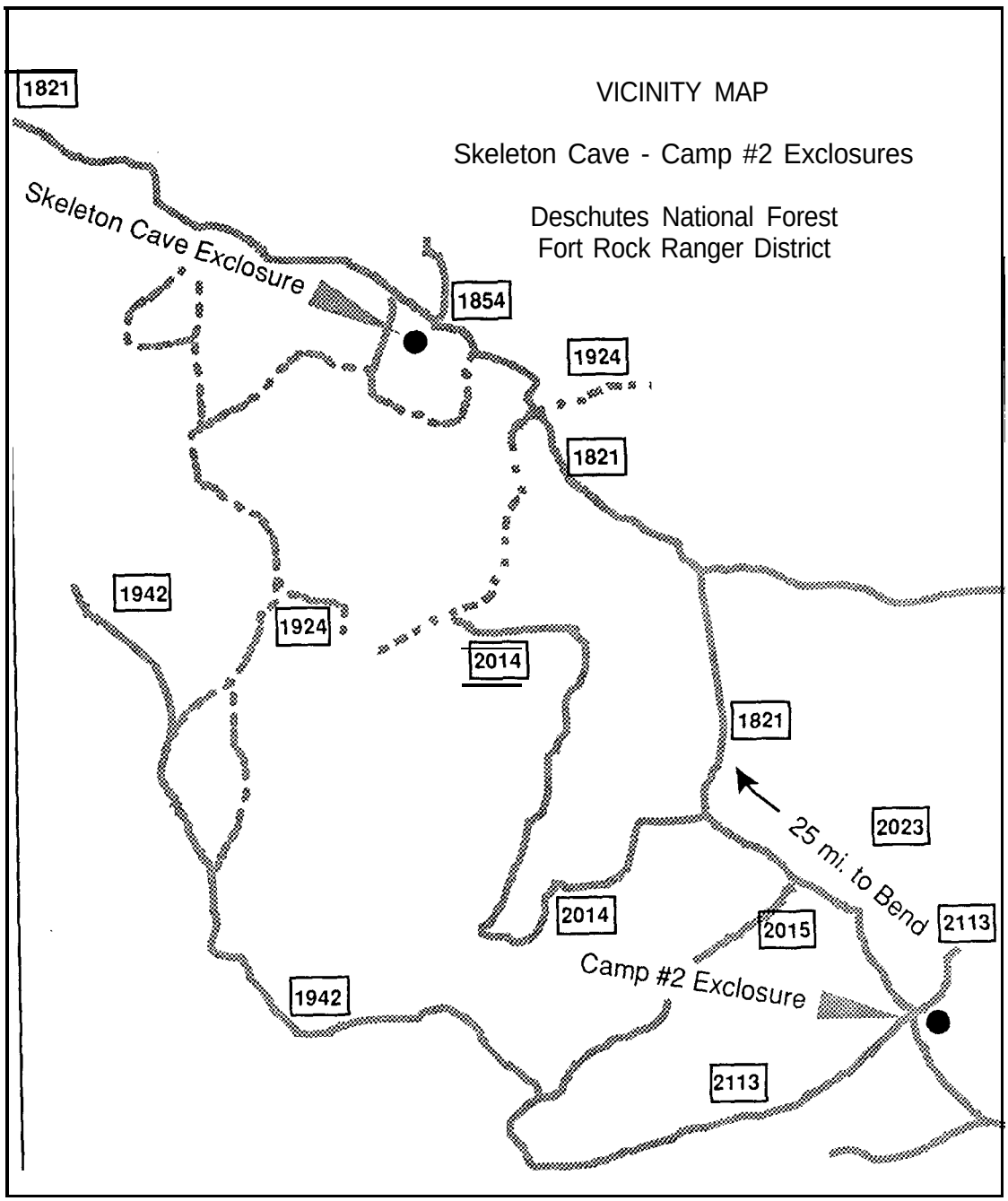
Attachments

Vicinity map; Skeleton Cave and Camp Two Enclosures
Schematic Drawings
Skeleton Cave Enclosure
Camp Two Enclosure

Figures 1 and 2: corner bracing and tangent bracing

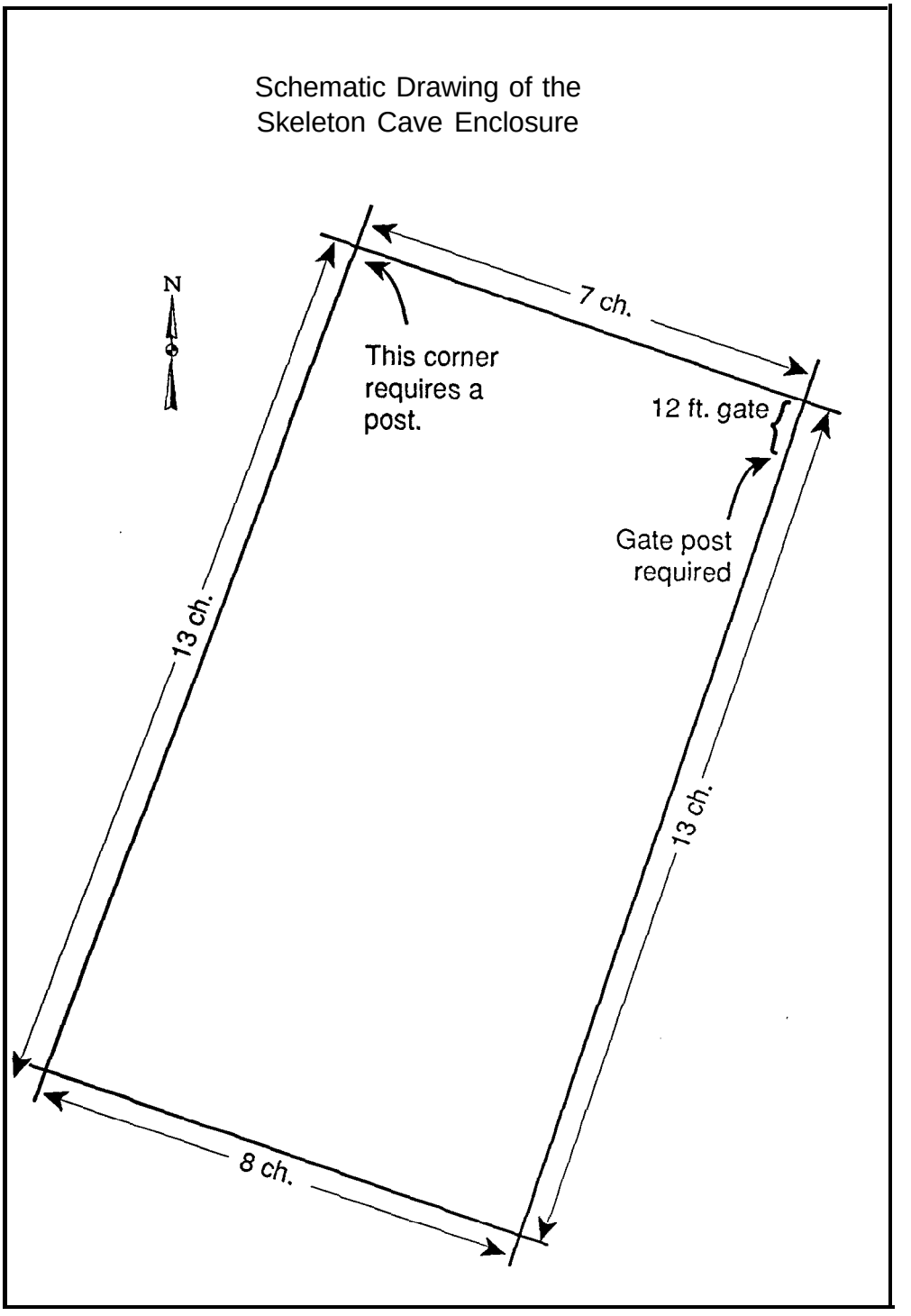
Figures 3 and 4: staples, height and gate bracing

Exhibit 2, Continued



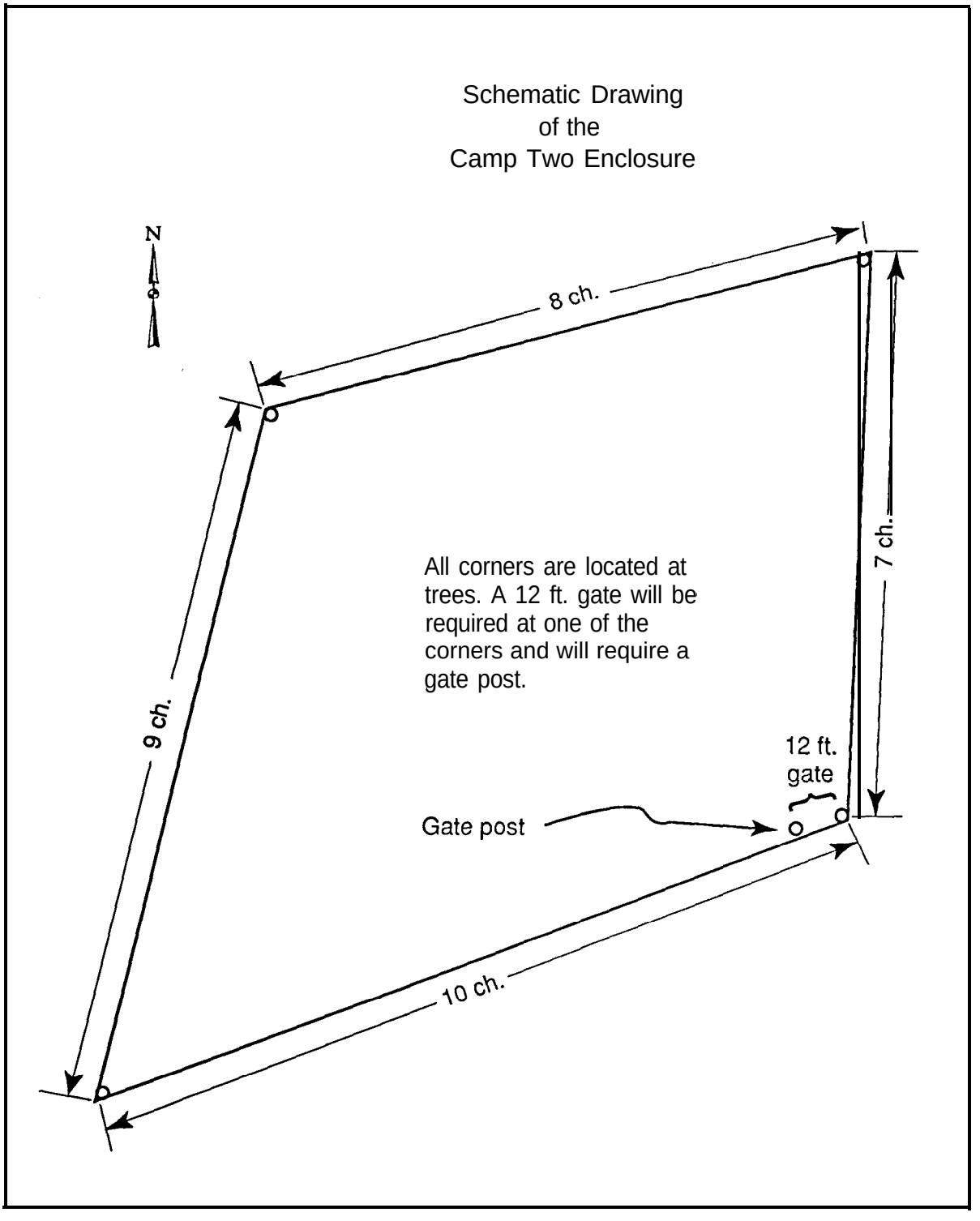
Vicinity Map

Exhibit 2, Continued



Schematic of the Skeleton Cave enclosure.

Exhibit 2, Continued



Schematic of the Camp Two enclosure.

Exhibit 2, Continued

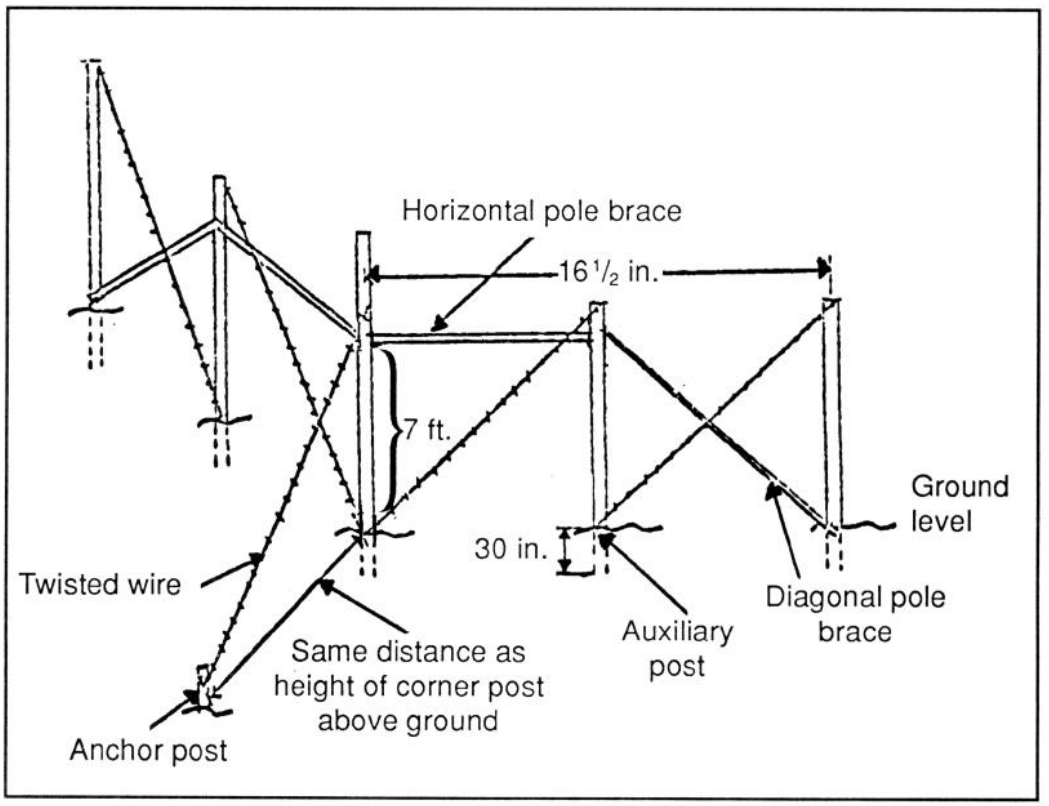


Figure 1 - Corner bracing.

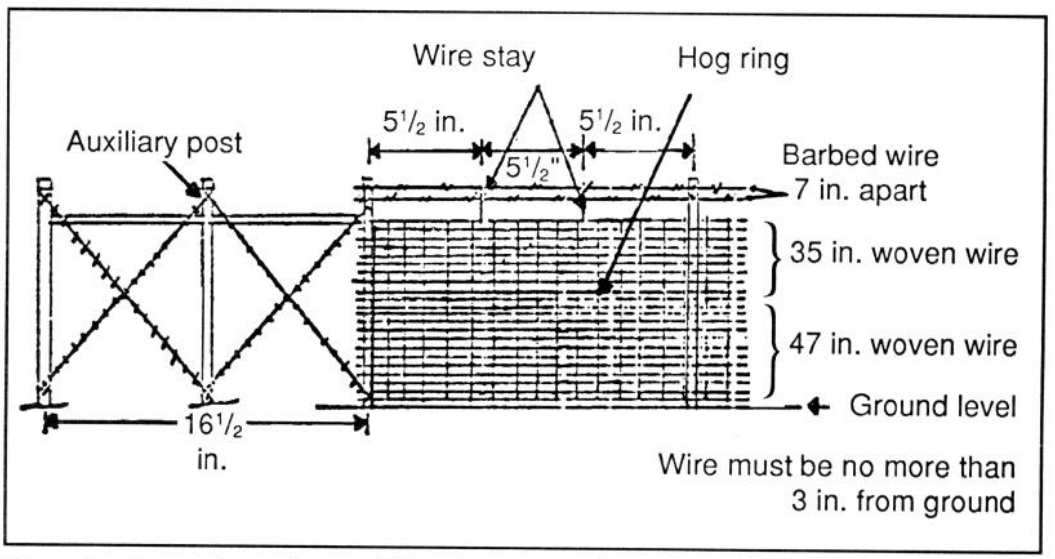


Figure 2 - Tangent Bracing and Wire Arrangement.

Exhibit 2, Continued

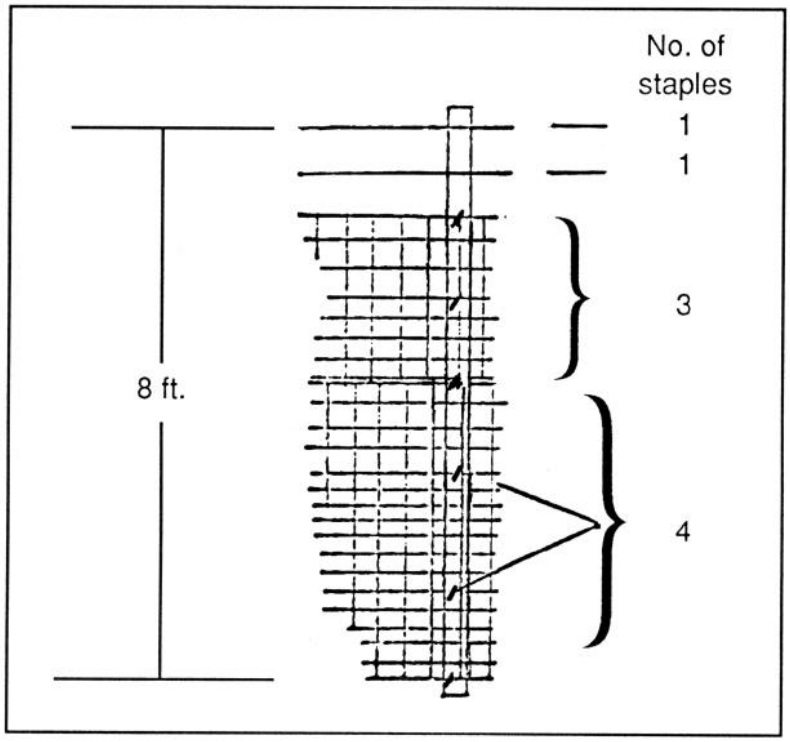


Figure 3 - Arrangement of staples and Total height of the fence.

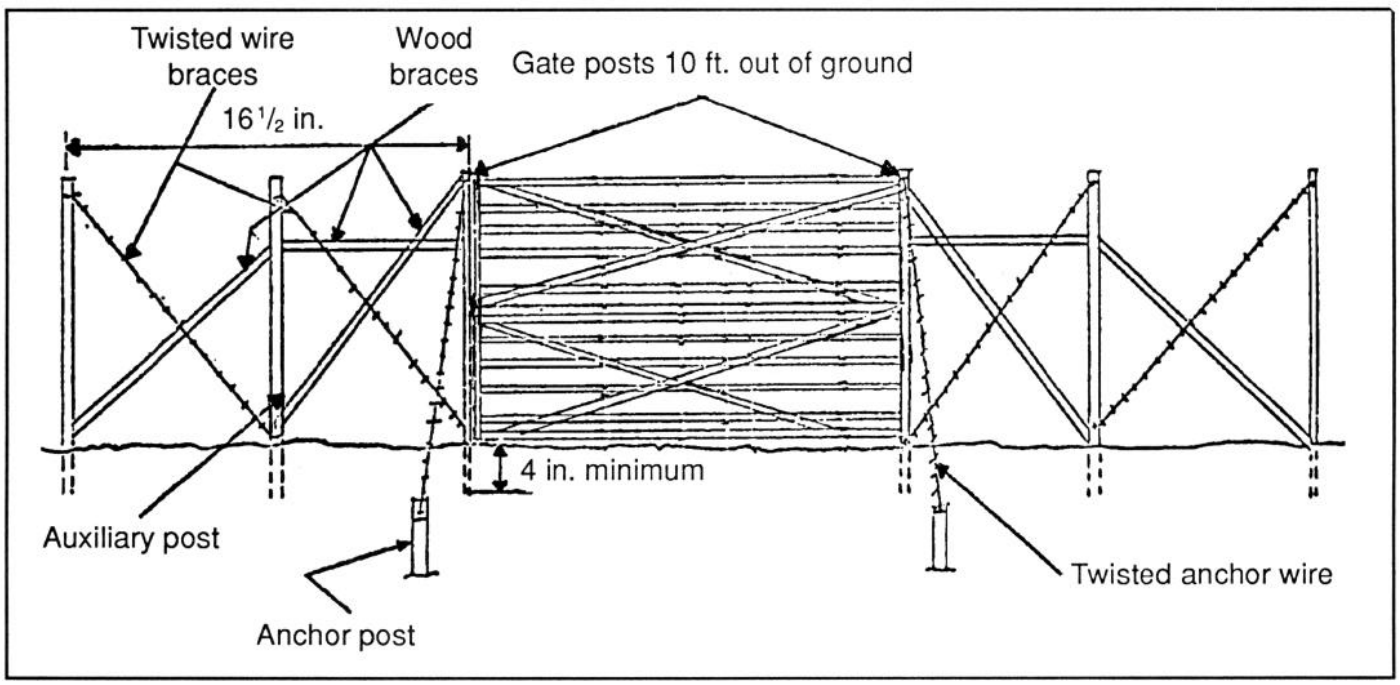


Figure 4 - Gate Bracing.

Exhibit 3. Specifications for installing woven wire fencing.

SPECIFICATIONS

1 Clearing a Trail for the Fence.

a. The fence location has been plainly marked with blue plastic flagging. This flagging shall serve as the centerline of the trail to be constructed.

b. The trail shall be cleared of all logs, limbs, brush, and debris to a minimum width of 4 feet, and all overhanging limbs, brush, vegetation and debris to a height of 10 feet over the cleared trail.

c. Snags or trees leaning over the cleared trail shall be felled before fence installation to prevent damage at a later date. These shall be designated by the COR.

d. All debris, logs, limbs, and brush shall be discarded to the side of the trail away from the unit being fenced.

2. Posts.

a. Posts will be installed at 12- to 20-foot intervals, as specified by the COR.

b. The posts shall be installed vertically and set 2 to 2-1/4 feet in the ground. Leveling the posts vertically will not be required. The posts should appear vertical.

c. All corner post shall be braced by the use of #9 wire and stakes or stumps (See Figure 2). Generally, one wire and stake per post will be sufficient; however, some posts may require two wires and stakes to stabilize the post. Line posts may require a brace, if the direction of the fence changes enough to place tension on the post.

d. Posts will be installed with the studded side facing out or away from the unit being fenced.

3. Fence

a. The fence must be constructed in such a manner that there are no openings large enough for a deer to pass through. The connections of one section of net with the next must be made carefully, and enough anchor pins must be used to keep the netting close to the ground.

b. Each section of net will be packed separately and in such a manner that the contractor may remove the net from the package without tangling. The COR will demonstrate how to unpack the net. Each section is 8 feet wide and 220 yards long.

c. The net shall be hung from top by a single clamp, and the clamp will be crimped with pliers to prevent vertical and horizontal slippage (Figure 2).

d. The net shall be fastened to the post at ground level by a single clamp, and the clamp will be crimped to prevent vertical and horizontal slippage (Figure 4).

e. The net shall be anchored to the ground with a minimum of three anchor pins, and more if unevenness of the ground requires it (Figure 4).

Exhibit 3, Continued

f. Each section shall be completed before connecting and fastening the next section, Sag in the net between posts shall not be less than 4 or more than 6 inches after the section is completed. Sag may be taken up at each post.

g. The net sections shall be connected by tying the rope ends in a square knot, or by laying the ends side by side and crimping two or three hog rings around them. Vertically, the nets shall be attached with crimped hog rings every 6 inches from the ground to the top. The sections must be connected at posts.

h. Trees may be utilized for posts, if they are available. The COR shall designate trees to be used, after the trail has been constructed.

i. Some splicing of netting will be required in areas where the fence crosses steep canyons. The COR will give additional advice on splicing when needed.“”

The following attachments form a part of this quotation and any resulting contract:

1. SF-19, General Provisions (except Clause 10a, which is replaced by the Contract Work Hours Standards Act).

2. AD-269, Contract Work Hours Standards Act.

3. Federal, State and Local Taxes.

4. Vicinity Map.

5. Project Map (Figure 1).

6. Fence Building: Figures 1 through 6, and a diagram of a post-driving tool.

U.S. Forest Service-Project Map (10 1/4” to 8 1/4”)

Exhibit 3, Continued

Type of Project Deer Fencing, Nylon Quote No. 66-36 Horn Creek #1 Unit C

Project Layout By J. Strickfaden Bid Item No._____ Unit No.

Date Oct. 11. 1985 Scale: 4" = 1 mile T. 4S. R. 10W Sec. 4

1. Project Area
2. Unit Boundary
3. - area shown within legend
4. Do not - strip - wide along - _ edge of unit.
5. (DEER FENCE INSTALLATION) marked by Forest Service
6. Completed Unit:
7. Dirt Spur Road
8. Gravel Road

Figure 1

Exhibit 3, Continued

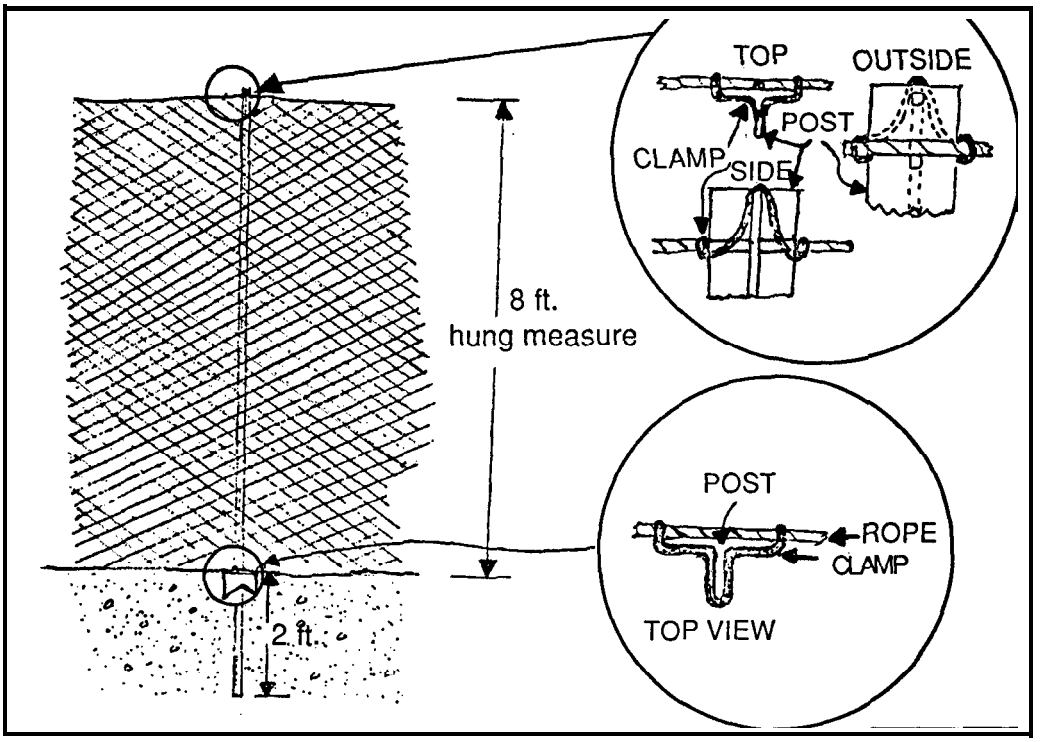


Figure 2 - Typical section (post).

Exhibit 3, Continued

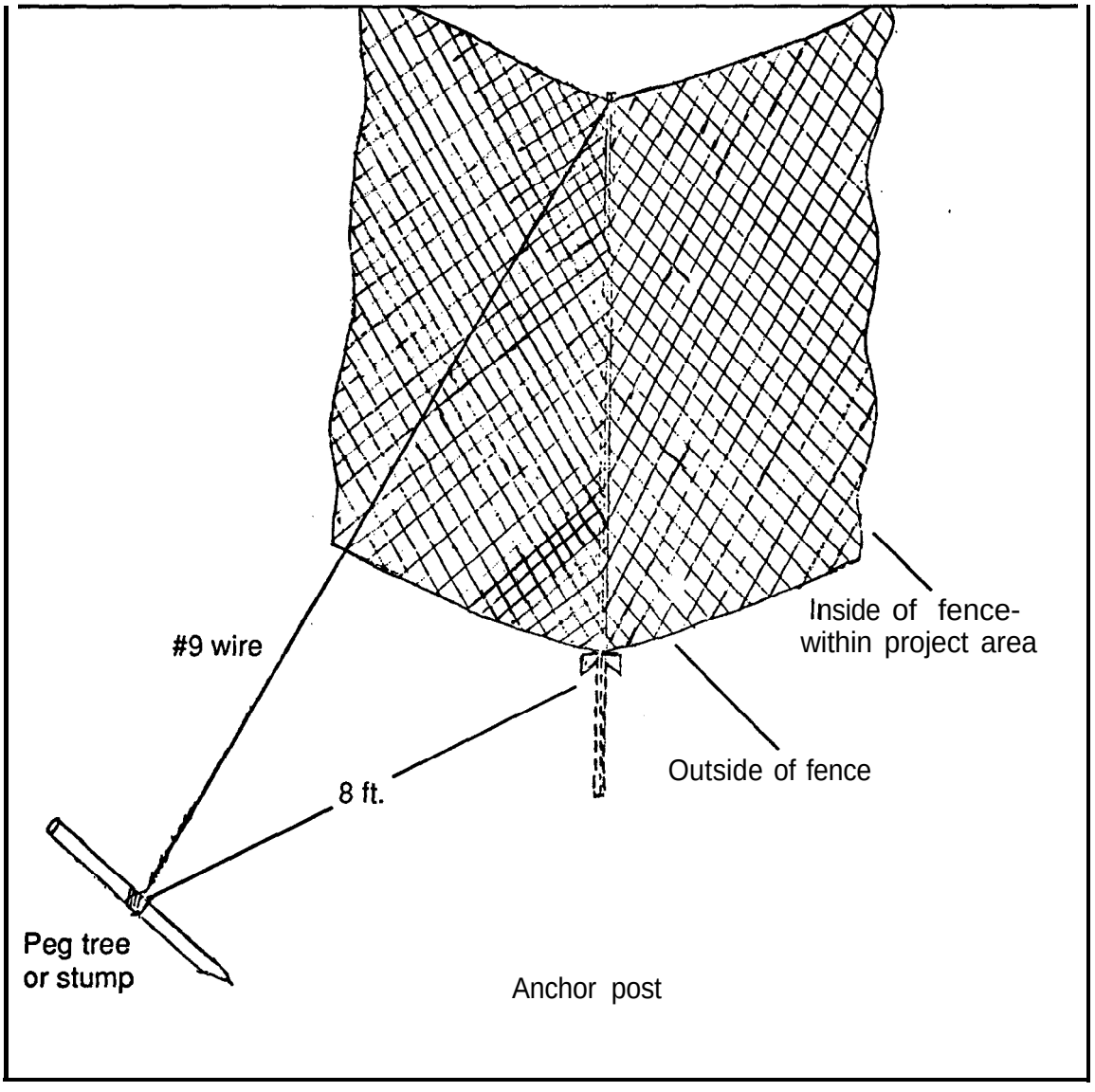


Figure 3 - Installation of anchor post.

Exhibit 3, Continued

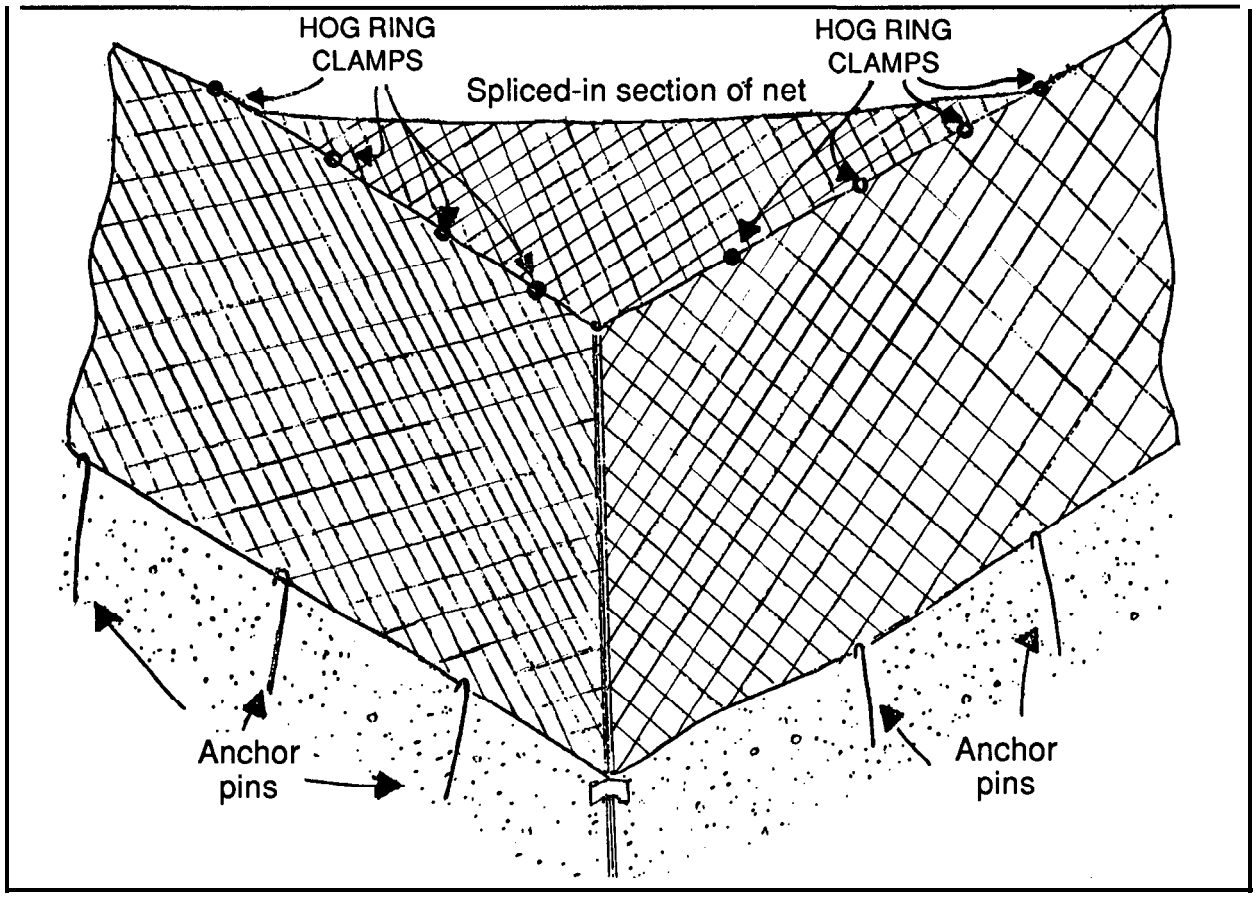


Figure 4 - Securing wire at fence corner.

Exhibit 3, Continued

Hebo Post Pounder

for 10' steel posts

Approx. 35 lbs.

Main pipe is 3 inches, outside-diameter. Handles are of 1 inch, inside-diameter pipe. Plug in top is 1/4-inch plate welded into pipe. Lead can be added to plug, to lessen jar on impact.

The post pounder is best operated by two people; one to steady the pounder while the other provides the up and down motion.

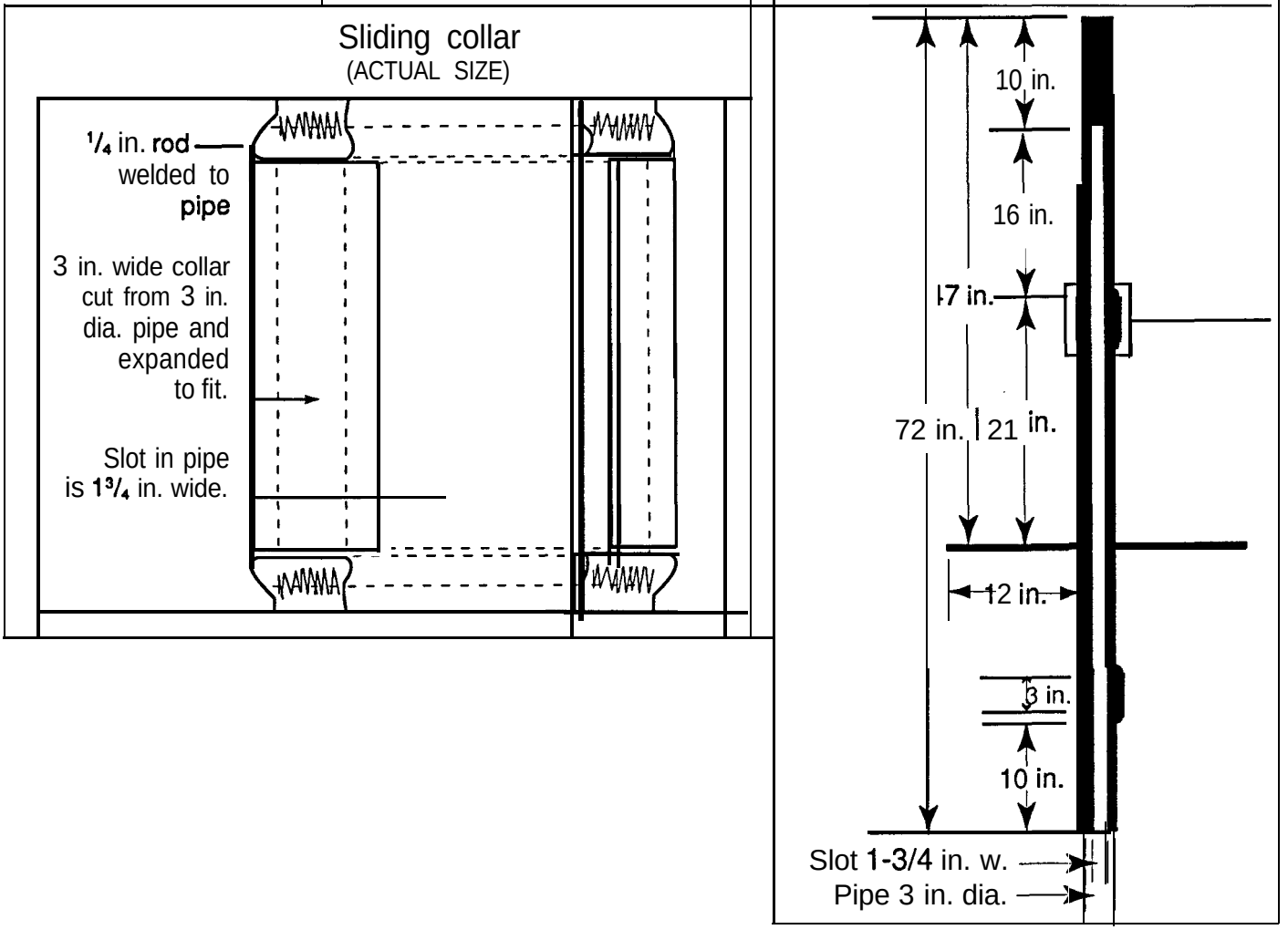


Figure 5 - Hebo post pounder.

Exhibit 3, Continued

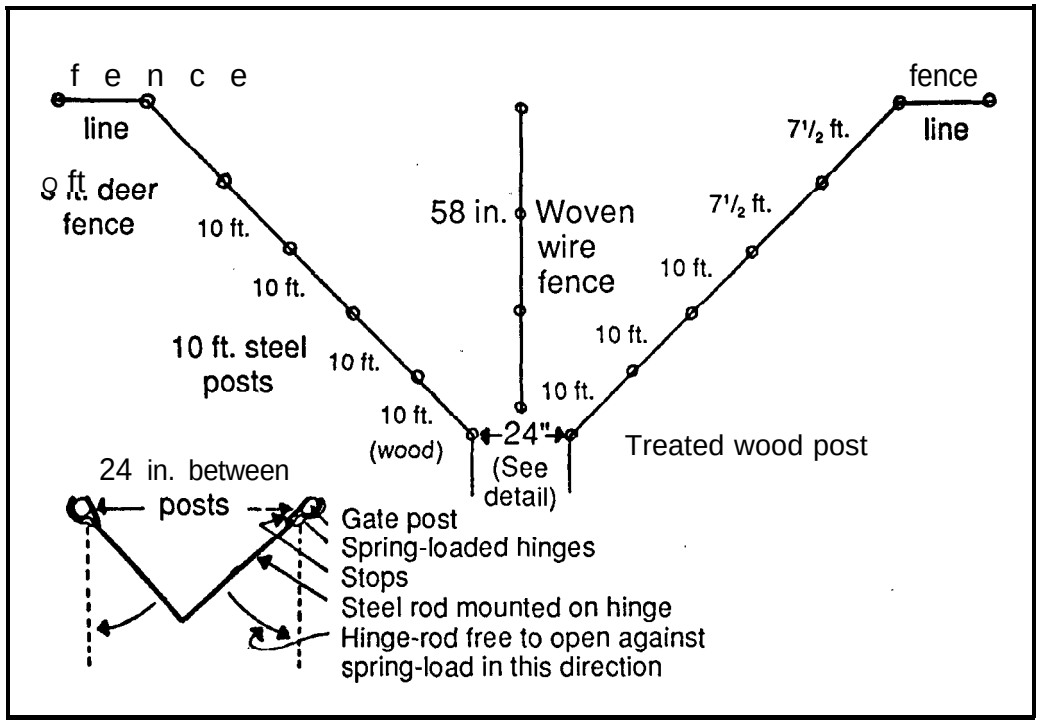


Figure 6 - Device to permit deer to escape from within fenced enclosure.

APPENDIX 5:

Gopher Baiting Probes and Forest-land Burrow Builder

Gopher Baiting Probes

There are at least four acceptable types of gopher probes, all of which can be constructed easily in Forest or District shops (Crouch 1933)[1].

For limited use in light sandy soil, or any soil that is not too hard, a satisfactory probe can be made of a broom, fork, or shovel handle, as shown in **A** and **B. One** end should be bluntly pointed, and a foot rest may be attached to aid in probing. For use in hard soil, an iron rod may be inserted in one end, as illustrated in **A** to be used as a "seeker," the handle being bluntly pointed for enlarging the opening through which the bait is to be placed.

For extensive use in relatively soft soil, a durableprobe may be made of 3/4-inch galvanized pipe: one piece 30 inches long and one piece 14 inches long. The 30-inch piece is threaded at both ends and the other pieces at one end only. A piece of 1/2-inch round iron about 2 inches long is welded into the unthreaded end of the 14-inch pipe and bluntly pointed. The pieces are then arranged and fitted together with two 3/4-inch T-joints, as shown in C.

For use in hard soil, the probe may be made of the following materials:

1 piece of 1/2-inch galvanized pipe, 34 inches long

1 piece of 1/2-inch galvanized pipe, 5 inches long

1 1/2-inch galvanized T-joint

1 piece of 1/2-inch round iron, 2 inches long

1 piece of highly tempered steel, 3/8-inch in diameter and 28 inches long

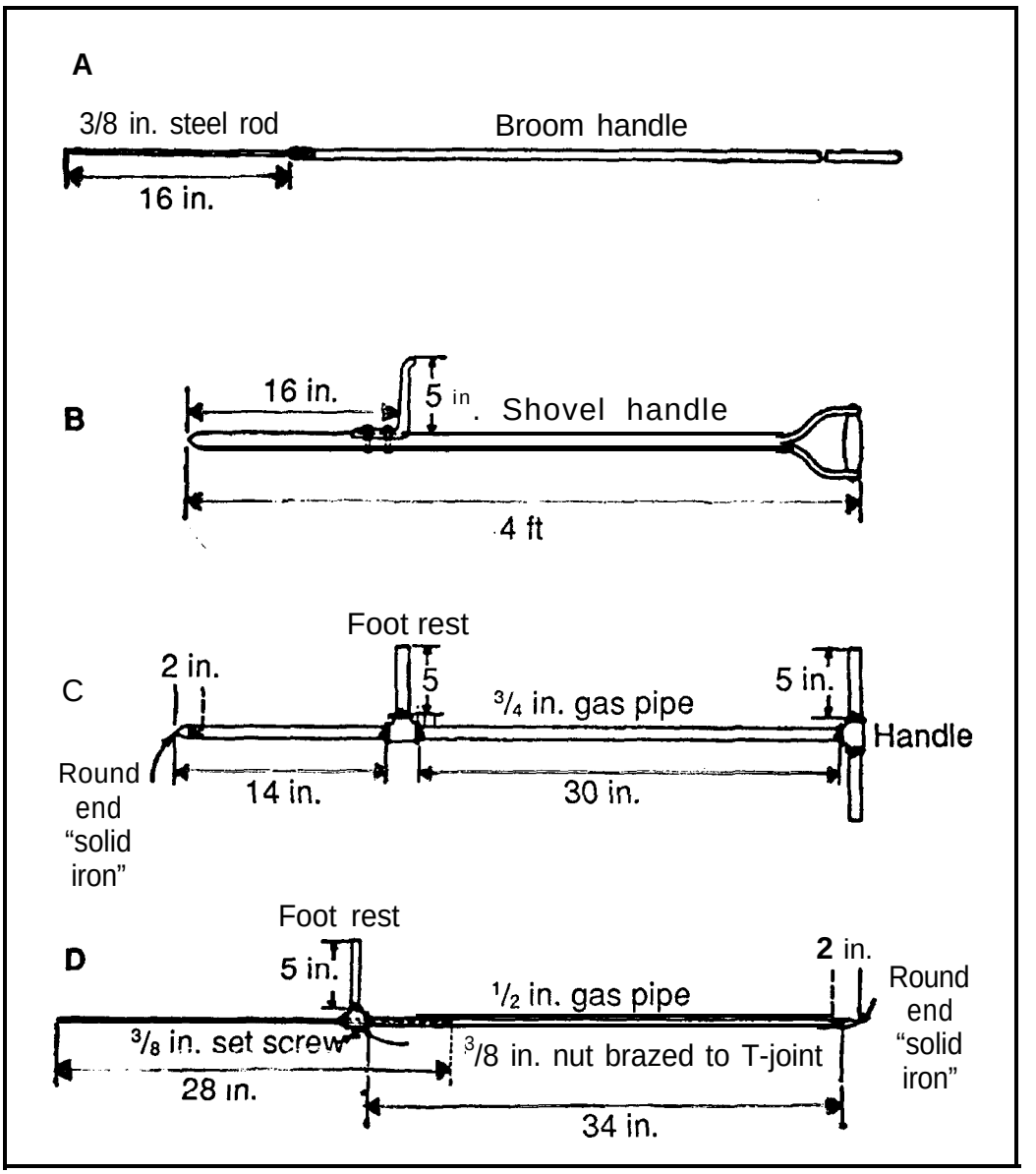
1 3/8-inch set screw, 1 inch long

1 3/8-inch nut

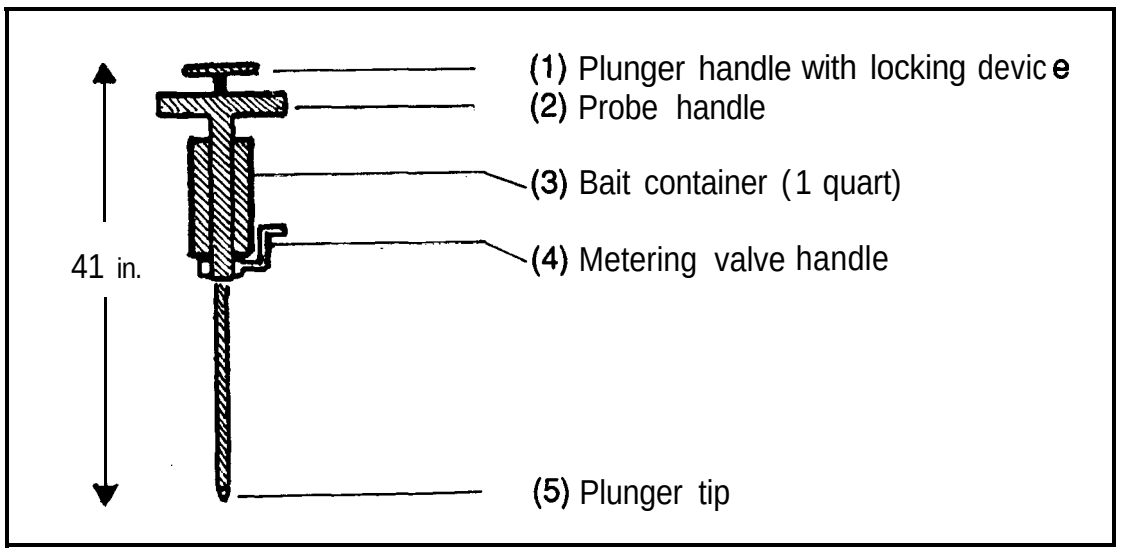
1 reducer, 1/2-inch to 3/8-inch

The two pieces of pipe are each threaded at one end. The piece of round iron is welded into the unthreaded end of the 34-inch pipe and bluntly pointed. A 3/8-inch hole is bored in the T-joint, and the 3/8-inch nut is brazed over this hole to accommodate the set screw. The piece of highly tempered steel is sharply pointed on one or both ends and held in place by the set screw. The pointed end of a hayrake tooth cut 28 inches long would serve well for this piece. These materials are then assembled as shown in **D.** The runway is located with the sharp end of the probe, and the blunt end of the probe is used to enlarge the hole to admit the poisoned bait.

[1]Crouch, W.E. 1933. Pocket gopher control. Farmers Bull. 1709. Washington, DC: US. Department of Agriculture, Bureau of Biological Survey. 21 p.



Gopher Bating Probes



Leppert Bait Probe

The Heavy-Duty Bait Applicator is designed to deposit a metered amount of bait into pocket gopher burrows, with safeguards for both the operator and the nontarget species. Any spillage or contact with the bait by the operator is eliminated by using preloaded bait containers, and by the addition of a locking device.

(1) Plunger handle with locking device
(2) Probe handle
(3) Bait container (1 quart)
(4) Metering valve handle
(5) Plunger tip

Operation Instructions

Step #l Attach the bait container. Hold the applicator upside down and screw the container (3) into place.

Step #2 Turn the handle (4) one complete revolution. This places about 5 grams of bait into the lower tube above the plunger tip (5).

Step #3 Locate the main runway of the gopher's burrow system by probing 6-12 inches from the horseshoe-shaped mounds.

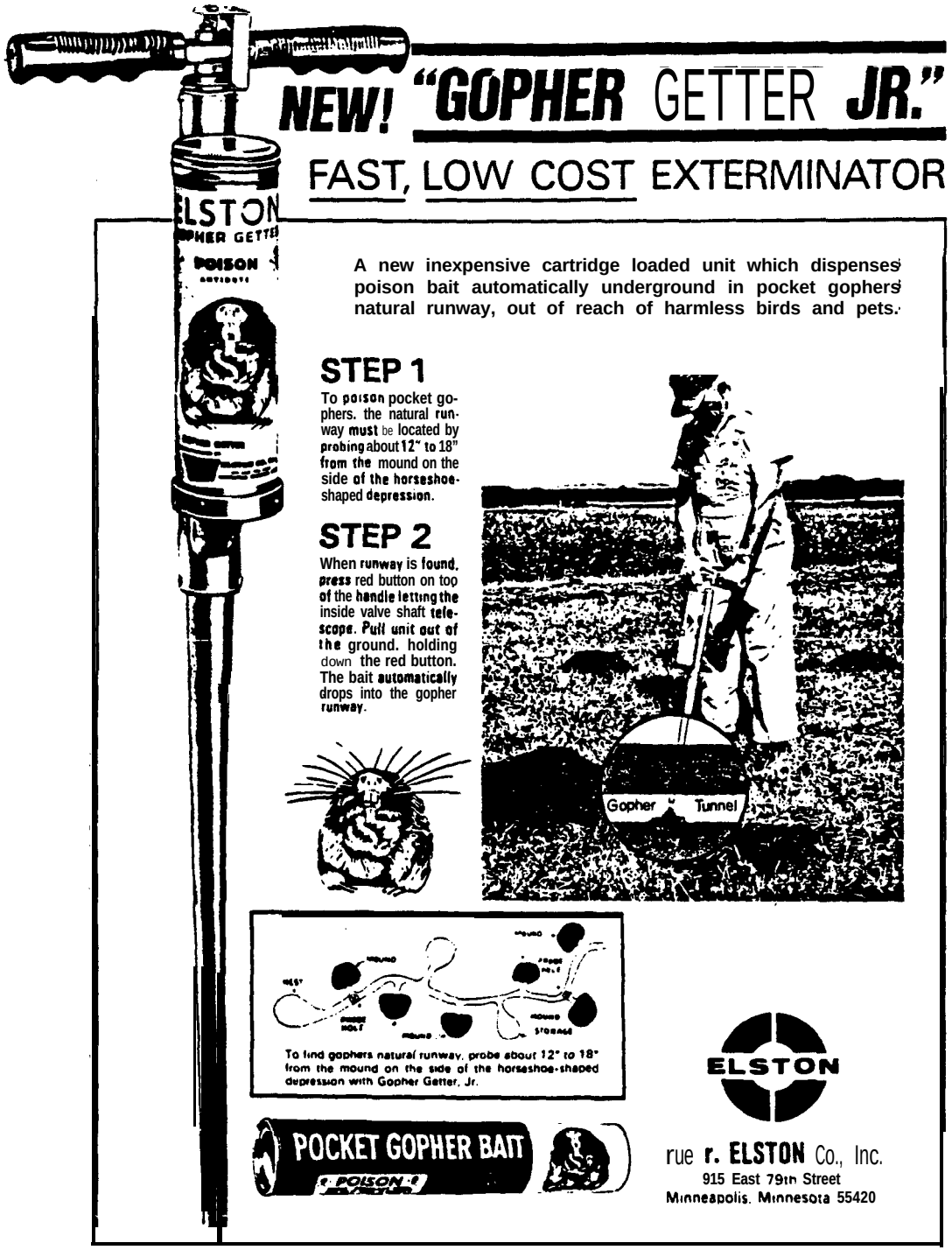
Step #4 When the runway is located, pull the applicator up so that the plunger tip (5) is in the center of the runway; unlock and **quickly** depress the plunger handle to let the bait fall into the runway. (It may be necessary to repeat this step, depending upon soil moisture condition.)

Step #5 Extract the bait applicator from the burrow carefully, so that soil does not cover the bait.

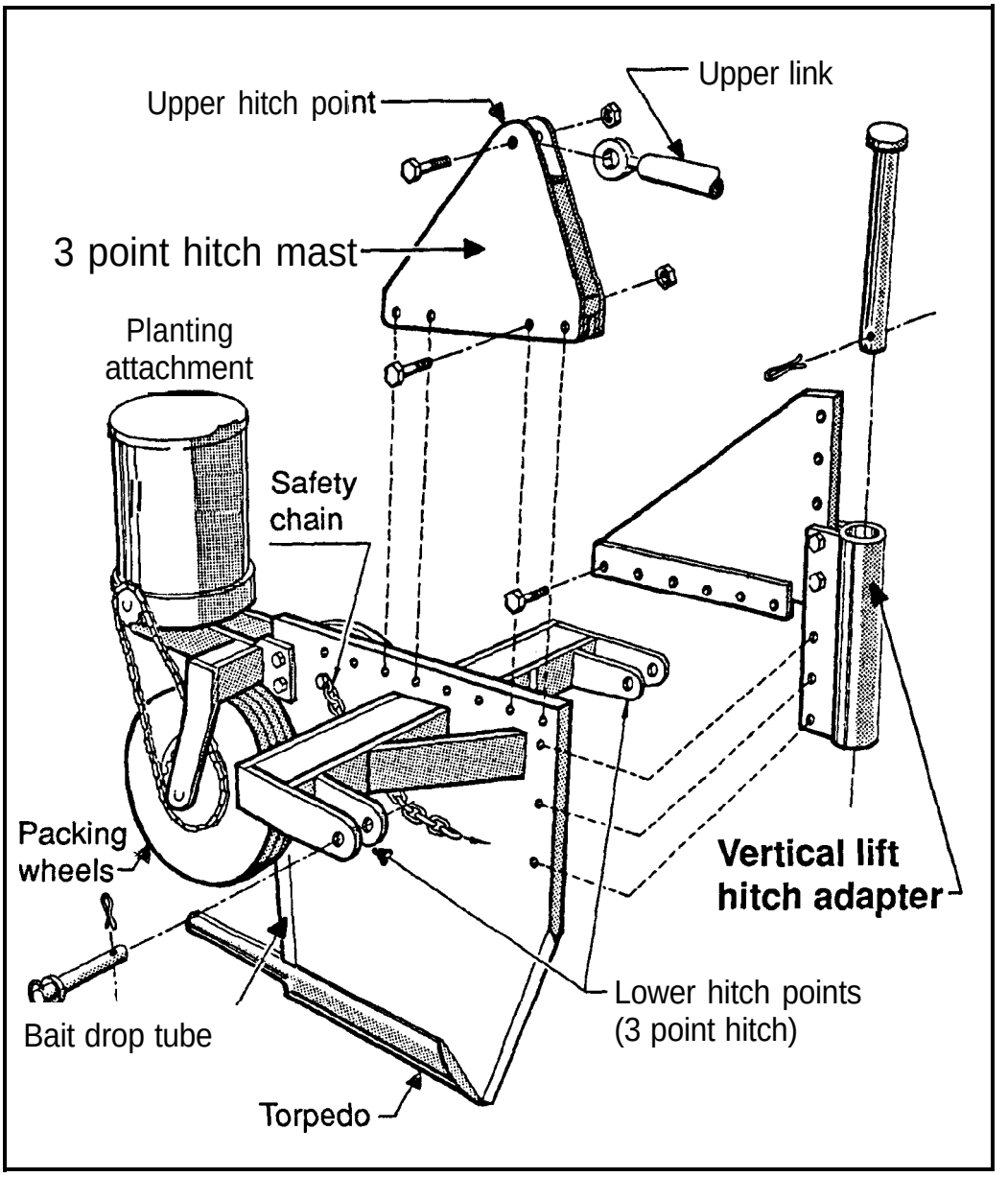
After each day of use, remove the container of bait by reversing step #l, replace its cap and store both the container and applicator in a safe place. Caution should always be used when handling pocket gopher bait.

Manufacturer: Leppert Machine and Welding
5635 South Sixth Street
Klamath Fa!ls, Oregon 97601
Telephone: (503) 884-9131

Approximate Price: $75.00 FOB Klamath Falls, for one applicator and five bait containers; $1.OO for each additional bait container.



Elston Bait Probe



Forest-land Burrow Builder

The Missoula Equipment Development and Testing Center (U.S. Department of Agriculture, Forest Service) and the U.S. Fish and Wildlife Service developed a heavy duty, gopher-burrow-building and baiting machine. This equipment constructs and automatically baits artificial burrows. It is capable of operating under conditions that prohibit use of other commercially available burrow builders, In addition to its rugged construction, the machine is designed to lift out of the ground when heavy obstructions are encountered.

Machine baiting functions are relatively simple. The torpedo moves through the ground, wedging and shaping a round burrow approximately 2- inches in diameter. The top of the burrow is immediately closed by packing wheels that are located above the rear of the torpedo. The packing wheels also control torpedo depth and meter the bait.

The baiting mechanism is a Dempster planter. When activated, it feeds teaspoonful amounts of bait into a bait-drop tube, which leads directly to the bottom of the new burrow. The Dempster planter is calibrated to drop bait at approximately 5-foot intervals. About 450 bait drops are made per acre. With a rhoplex-treated oat bait, this amounts to about 1 pound per acre.

Construction plans are available upon request from the Missoula ED&T Center. Fabrication costs in 1978 were about $700-$800.

Continued machine use in abrasive soils will wear away the leading edge of the shank and torpedo. Under normal use these parts should be rebuilt annually. Eutectic Cromcarb 6006 should be sprayed on the worn surfaces, using a Eutalloy Model B torch. If this torch is not available locally, the hard surfacing material should be put on with an arc welder and ground smooth. Grinding is an important step, because rough or irregular surfaces on the torpedo or shank will interfere with their operation.

A major advantage of the burrow builder is that it provides a means for one person to treat large areas rapidly. Acres treated per hour, at various tractor speeds, when burrows are spaced 20 feet apart are as follows:

Tractor speed (mph)	Area treated per hour (acres)
1.0	2.4
1.5	3.6
2.0	4.8
2.5	6.1
3.0	7.3
3.5	8.5

The Region 4 (USDA Forest Service, Intermountain Region) vertical-lift hitch is recommended for use with the Burrow Builder, because it also can be used for mounting other common forest land equipment such as the Holt Plow and Rocky Mountain Tree Planter. The Burrow Builder can be adapted quickly to fit category I and II three-point and Holt Timber Hitches. All of these hitches will perform satisfactorily with proper adjustment.

The Forest-land Burrow Builder was designed to operate under the wide range of site conditions likely to be encountered on forest and range lands. Many acres can be treated rapidly with a minimum of manpower. However, there are several factors that control the effectiveness of machine operation, and it is important to recognize these limitations.

Operational Limits

The following paragraphs describe acceptable and unacceptable operating conditions:

Acceptable Operating Conditions

Slope-The best results are obtained on flat or gentle topography, but slopes up to 20 percent can be treated effectively. Steeper slopes may be machine-baited, provided they have first been terraced. Tree-row spacing on terraced strips must be adjusted to allow a tractor to move between planted rows.

Obstructions-The burrow builder will perform satisfactorily through moderate amounts of subsurface material such as rocks or large roots. It will usually produce satisfactory gopher control, if 50 percent or more of the burrows are properly formed, baited, and evenly distributed in the treated area.

The ground surface should be reasonably free of l-inch or larger limbs and dense brush. Removal of surface obstructions to allow burrow-builder use is often possible, if it is included in the initial project planning. For example, slash on timber sale areas may be windrowed or bunched to provide an unobstructed travel lane, with proper spacing for gopher control. Brushfield site-preparation plans can also provide for clearings wide enough to allow machine travel between planted tree rows.

Soil texture-Burrow construction is possible in a wide range of soil textures, although fine-textured soils are most suitable for burrow construction.

Satisfactory burrows can be built in sandy or coarse pumice soils, provided other site conditions are favorable.

Soil moisture-Soils should contain enough moisture to make them moderately cohesive. This permits them to hold the form created as the torpedo passes through the soil. Soil moisture is usually adequate for burrow construction in spring and fall.

Unacceptable Operating Conditions

Slope-Suitable burrows cannot be constructed on sparsely vegetated slopes exceeding 20 percent, when the machine is operated on the contour. Increased slope angle causes uneven packing wheel pressure, which in turn results in poor burrow closures. Operation up and down slope is not recommended because of the possibility of starting gully erosion.

Obstructions-Large amounts of rock, large spreading roots, or a hardpan will seriously interfere with burrow construction, because the machine will continuously be forced out of the ground. Surface obstructions, such as logs, large limbs, large rocks, or dense brush, interfere with machine operation. The machine should not be used if obstructions prevent its proper operation at least half the time.

Soil texture-Soils containing large amounts of gravel often have insufficient fine material to bind particles together. Burrows cannot be formed properly in this situation.

Soil moisture-When soils become dry, they lose much of their cohesiveness. The degree of this loss is largely dependent on the structure and texture of the soil, and the number of fine roots in the profile. Sandy and other coarse soils, such as pumice and sugar granite, represent the low end of the operational scale and cannot be treated when dry; Clay soils often become difficult to work when saturated with water. They become sticky and plug the bait-drop tube. Packed snow or frozen soils also prohibit burrow-builder use.

Hitching Instructions

The Forest-land Burrow Builder is designed to operate with a Category I, three-point, free-link hitch; a Category II, three-point hitch; the R-4, Vertical-lift King Pin Hitch; and the Holt Timber Hitch (FSH 2409.26b). Instructions for mounting the burrow builder to these hitches follow:

R-4 and Holt Vertical-life Hitches

1. Check hydraulic controls on the R-4 hitch to ensure that frame-tilt and lift cylinders can be activated independently.

2. Make sure that hydraulic-lift cylinders on either hitch have a float valve. The valve must be in float position, while the burrow builder is in the ground. This allows the machine to seek the proper operating level and to rise out of the ground when it hits a large obstruction.

3. Place vertical-lift hitch adapter on the burrow builder and hook to tractor. The adapter may be adjusted vertically on the burrow builder to compensate for different hitches and to allow the machine to operate at proper depth.

4. Attach safety chains. The burrow builder should not be lifted from the ground before safety chains are attached, because the machine can swing freely to either side and could cause a serious injury.

5. Adjust hitch so that the roller-frame assembly is vertical and the burrow builder torpedo is horizontal when the machine is at operating depth. An exact vertical alignment is necessary to permit proper burrow construction.

The R-4 hitch may be adjusted hydraulically to a vertical position, whereas shims must be used with the Holt Hitch for vertical alignment.

Three-point Hitches

1. Check the hydraulic-hitch-lift system to ensure that it has a float valve, and that the valve operates properly.

2. Place three-point hitch mast on burrow builder.

3. Hook burrow builder to the tractor. Do not attempt to lift machine until all three points have been secured. When attaching the burrow builder to the category II hitch, bushings will have to be placed on the hitch pins to increase their size.

4. Level the torpedo by adjusting the length of the upper hitch link. Additional adjustment is possible by moving the mast to any one of three alternative positions, or by turning it around.

The torpedo must be adjusted to a horizontal position with the ground surface, when at working depth. This adjustment is critical, because the burrow will not be satisfactory if the torpedo moves through the ground at an angle. A spirit level is attached to the burrow builder to aid in this adjustment.

Burrow Builder Adjustments

The packing wheels control the working depth of the torpedo and are the only point of adjustment of the burrow builder. They may be adjusted vertically, at 2-inch intervals, to obtain the desired burrow depth.

Tractor Selection

The choice of tractor for most field operations should be limited to one developing 30-drawbar horsepower or more. Either wheel or crawler tractors are suitable, but the crawler type is more versatile in rough terrain. This is sometimes important in traveling between areas on a project.

Tractor Operating Instructions

- Check soil moisture to be sure that it is sufficient to allow the soil to hold the form created by the burrow builder. A simple soil-moisture test can be made by squeezing a handful of soil taken from the depth at which the burrow is to be constructed. If the soil forms a fairly tight ball, the burrow builder will operate satisfactorily.

These procedures should be carried out before moving machinery into a project area. This will prevent lost time in the event that soil moisture is unsuitable for burrow construction.

- Determine the average depth of natural gopher burrows. This should be done by opening and measuring the depth of several gopher systems in the area to be treated.

- Adjust the packing wheels to give the proper burrow depth. It is difficult to construct shallow burrows when vegetation is sparse. Under these conditions, it is better to set the machine deep enough to allow good burrow formation.

- Fill the bait hopper with strychnine-Rhoplex treated oats, and secure the hopper lid.

- Put the tractor in forward motion and slowly lower the burrow builder into the ground.

- Put the lift valve into float position after the torpedo has reached operating depth.

- Construct 20 feet of burrow, then excavate sections to determine if the burrow is properly formed at the selected depth, and if the bait is being metered at the rate of about one teaspoonful every 5 feet. Also, check to see that the packing wheels are completely closing the burrow.

- Make final burrow builder and hitch adjustments.

- Space burrows approximately 20 feet apart.

- Check frequently to ensure that the bait is flowing freely through the bait drop tube.

- Never reverse the tractor when the burrow builder is in the ground, because soil will be forced into the bait-drop tube.

- Do not exceed 3.5 mph operating speed, because burrows are often poorly formed at higher speeds.

- Do not allow debris to accumulate on the lead edge of the burrow builder. These accumulations will interfere with burrow construction. Most debris can be removed by momentarily raising the machine while the tractor is in motion.

- Open artificial burrows periodically to make sure that they are being properly formed. This is a very important step, especially when the burrow builder has just been fitted to a new hitch or when starting to bait a new area.

- Grease the burrow builder once a day.

Glossary

Acceptance-Refers to the palatability of baits and toxicants.

Acute rodenticide-Toxic compound specifically formulated to kill rodents from a single feeding.

Adult-Sexually mature; an animal that has contributed or is capable of contributing new individuals to a population.

Age composition-The arrangement of age classes in a population, which describes the relative size of the age classes; synonym, age structure.

Animal damage-In simplest terms, the result of any kind of animal activity interfering with resource management goals or objectives. (In the past, the emphasis had been on animal activity that causes economic losses by reducing or delaying forest yield.)

Animal unit-A measure for relating forage consumption by various animals (deer, elk, sheep and so forth) to the forage resources, based on the equivalent of the forage required by a mature cow of about 1,000 pounds.

Avicide-Generally, a lethal agent used to kill birds, but it also refers to other materials or means of repelling birds.

Avoidance behavior-Behavior that postpones an aversive event and thus provides escape from conditioned aversive stimuli.

Barking-The removal of bark from a stem. Bark may be stripped off as by a bear, abraded by deer or elk polishing their antlers, or gnawed away by a porcupine.

Bioassay-Determination of the relative strength or specificity of a substance (a contact repellent, for example) by comparing responses of test animals.

Biological control of vertebrates-An attempt to reduce the population density of a pest species (that is, increase mortality, reduce natality, or cause a significant emigration), by increasing predation, manipulating the conditions of the habitat, introducing or stimulating epizootics, or applying antifertility agents.

Bole-The trunk or stem of a tree.

Broadcast burn-Intentional burning of debris on a designated unit of land by allowing fire to spread over an entire area where debris has not been piled or windrowed.

Browse--Palatable twigs, shoots, leaves, and buds of woody plants; a term often used to describe a category of deer food.

Browsing-Feeding on woody vegetation by deer and elk that leaves a ragged, splintered break where a shoot is removed. These animals cause this type of injury because they lack upper incisors.

Budburst-Opening or flushing of vegetative buds, or beginning of shoot and foliage growth.

Bud clipping-The removal of buds, as in grouse injuries to seedlings.

Buffer crops-Crops purposely planted to take the feeding pressure of wildlife and other animals away from commercial crops.

Carrying capacity-The maximum density of a particular species of animal that can be maintained in a given ecosystem on a sustained basis without degrading the habitat; that is, the number of individuals that a habitat can maintain in a healthy condition.

Chemical toxicant-Any chemical substance that when ingested, inhaled, or absorbed or when applied to or injected into the body in relatively small amounts may cause significant bodily malfunction, injury, or death to animals or humans by its chemical action.

Chemosterilant-A chemical substance that causes sterilization or prevents effective reproduction; although much researched for applications in animal damage management, no chemosterilants are available for this purpose.

Clearcut method-A regeneration method that removes all trees over areas at least 2 acres or larger; generally with the objective of producing an even-aged forest by either natural seeding or artificial regeneration.

Clearcutting-SilvicuItural system in which the entire standing crop of trees is cleared at one time over a considerable area followed by regeneration efforts to produce an even-aged forest. In practice, much unsalable material may be left standing.

Clipping-Smooth, oblique cuts caused by rodents and rabbits feeding on woody shoots. These animals possess prominent chisellike incisors and must tilt their heads to the side to clip a stem.

Commensal rodents-Wild rats, especially of the genus Radius, mice (Mus), and other wild rodents that live in association with humans, eat the same food as humans, and adapt well to most human-made environments.

Contact repellent-A material applied as an external coating to the foliage and stems of seedlings to repel animals.

Control-In wildlife management, the process of managing populations of a species to accomplish an objective. The term usually is used in the sense of reducing population numbers of a wildlife problem species to prevent or decrease the impact of that species.

Cover-A general term used to describe vegetation and topography. Vegetative cover is divided into three categories: the overstory of trees; the midstory, composed mainly of large shrubs and small trees; and the understory that includes small shrubs, grasses, and forbs.

Crash-The period of severe mortality following the peak of a cycle.

Cutting--Gnawing by rodents to sever a large stem (as when beavers fell trees, for example). Cutting leaves multiple teeth marks on the cut surfaces.

Damage to buildings and grounds-Animal use that causes unacceptable health hazards or excessive maintenance costs.

Debarking-See "barking."

Direct seeding-Manual or mechanical sowing of tree seed on an area, either in spots or broadcast.

Droppings-The fecal material (especially pellets) of animals are useful, supplemental field signs in the identification of animal-caused damage.

Edge-The place where plant communities meet or where successional stages or vegetative conditions within plant communities come together.

Efficacy-Effectiveness as a rodenticide or other pesticide; ability of a product to control the specified target species or to produce the specified action.

Endangered species-A species whose prospects for survival and reproduction are in immediate jeopardy because of the loss of habitat, change in habitat, overexploitation, predation, competition, use of pesticides, or disease.

Even aged-Term for a forest in which all trees are nearly the same age (+ 10 percent of their age at maturity). Trees in even-aged stands may be quite different in size.

Even-age management-The application of a combination of actions that results in the creation of stands in which trees of essentially the same age grow together. Cutting methods producing even-aged stands include clearcut, shelterwood, or seed tree.

Environment-All the organic and inorganic features that surround and affect a particular organism or group of organisms; that is, both the biotic and physical factors of the habitat.

Eradicate-Often used to imply the local extermination of a species (best stated as "local eradication").

Exterminate--Often used to imply the complete extinction of a species over a large contiguous area such as an island or a continent. Not a good term for animal damage management, because it may imply making a species extinct. Animal damage management attempts to limit damage, not to exterminate animal species.

Forage-All browse and herbaceous food available to birds or mammals.

Forage damage-Animal use that causes a downward trend in the abundance of desirable plant species, or prevents maintenance of range in good condition.

Forb-Any herbaceous plant other than grasses or grasslike plants.

Forest pest-As defined by the Pacific Northwest Forest Pest Action Council, this term included any animal that impairs the economic or aesthetic management of forest resources. Some people prefer not to apply this term to big game and other wildlife species because of the value accorded them by the public for sport hunting, viewing, and as valued components of the forest ecosystem.

Formulation-Active ingredient packaged with various other materials produced by a manufacturer of pesticides.

Fumigant-Substances producing toxic or suffocating gases.

Fur bearer-Any animal sought for its fur.

Girdling-The more or less continuous removal of bark around a stem as by a porcupine or pocket gopher.

Group selection-A harvest-regeneration method used in uneven-age management. Trees are removed from small areas ranging from 0.25 to 2 acres.

Habitat—The sum total of environmental conditions of a specific place occupied by a wildlife species or a population of such species.

Habitat modification—Alteration of habitat primarily to limit damage to seedlings either by reducing suitability of habitat or by providing alternate (buffer) forage species for the problem species of wildlife.

Herbicide—A chemical capable of killing plants or suppressing their growth and development.

Home range—The area over which an individual animal habitually travels while engaged in its daily activities.

Housekeeping-type pesticide—Any pesticide used for purposes of general maintenance of human and animal health and comfort in or around all structures, vehicles, or grounds associated with offices, laboratories, dwellings, and areas of concentrated human activity. Included are garages, warehouses, special equipment or facility buildings, vehicles, offices, houses, mobile homes, dormitories, bunkhouses, lawns, gardens, patios, kennels, stables, hutches, aviaries, ponds, noncommercial greenhouses, and garbage disposal or receiving sites. (Subslab treatment or deep-soil injection of insecticides for termite control, building fumigation, fire-hazard reduction around buildings with soil sterilants or other herbicides, pest control in food handling areas and storage buildings, or the use of pesticides that require applicator certification are not considered housekeeping-type pesticide uses.)

Integrated control—A management system, within the area of associated environments and population dynamics of the wildlife problem species, that uses all suitable techniques and methods compatibly to maintain populations of problem species at levels below those causing economic injury.

Irruption—An unusually high population density of either a cyclic or noncyclic species.

Limiting factors—Any environmental factor limiting the distribution or the size of a population.

Model—Formal description that represents a system or process.

Multiple-dose bait—Poisonous bait that requires a sustained dosage over a period of time to produce death; for example, an anticoagulant.

Natural control—The maintenance of a comparatively stable population density, with certain definable upper and lower limits over time, by the combined actions of abiotic and biotic (relating to life) elements of the environment.

Natural regeneration—The renewal of a tree crop by natural seeding or sprouting.

Nontarget species—Any species not the target of a control program.

Palatability—How well an animal eats or "likes" a food.

Pesticide—A substance or mixture of substances intended for repelling, destroying, or mitigating any vertebrate or invertebrate pest, or preventing the species from becoming a pest.

Phytotoxic—Injurious and sometimes lethal to plants.

Plant association-The stable or unchanging plant community that occupies (or eventually could occupy) a site after completion of the successional process.

Pole-A still-young tree from the time its lower branches begin to die until the time when the rate of height-growth begins to slow down and crown expansion becomes marked.

Prescribed burn-The controlled application of fire to wildland fuels in either their natural or modified state to reduce the total amount of fuel and achieve other designated objectives.

Rangeland damage-Grasslands and meadows are subject to three general types of animal damage: plant destruction, soil compaction, and erosion.

Recreation area-In the context of pesticide labeling and use, it includes designated areas of concentrated public use and sites developed for recreational use, such as campgrounds, picnic areas, and other recreational facilities. This term does not include primitive hunting, hiking, and fishing camps or undeveloped areas used only occasionally by recreationists.

Reforestation-The natural or artificial reestablishment of a tree stand on forest land.

Regeneration-Young trees on an area that represents the early stages in the renewal of a forest stand.

Regeneration (harvest) method-The type of cutting or harvest method used to obtain a new stand (even-age management) or new trees (uneven-age management).

Regeneration survey-Any effort (particularly a planned and organized one) made to assess the amount, distribution, and condition of regeneration present on a specified area.

Release-The removal of plants by any of several means to free chosen trees from immediate competition that is overtopping or closely surrounding them.

Repellent-A substance so obnoxious to animals as to deter them from attacking the seed or plant to which it has been applied.

Residual vegetation-The decimated vegetation remaining after the main stand of vegetation has been removed through harvest or other means.

Rodenticide-A pesticide applied as a bait, dust, or fumigant to destroy or repel rodents and other animals, such as moles, rabbits, and hares.

Root clipping-The cutting or clipping of roots (as by pocket gophers, for example).

Rotation-The planned number of years between the formation or regeneration of a crop or stand and its final cutting at a specified age of maturity.

Sapling-Loose term for a tree no longer a seedling but not yet a pole.

Scarification (of soil)-Disturbing the forest floor and topsoil in preparation for natural regeneration, direct seeding, or planting.

Seed-tree harvest (cutting)--Removal of mature trees from an area in one cut, leaving a small number of seed bearers or seed trees singly or in small groups.

Seed-tree method-A regeneration method that in one or more thinning or harvest operations removes mature trees from an area and leaves a small number of high-quality seed trees singly or in small groups. The primaryfunction of the residual trees is to provide seed.

Seedling-In general, a young tree grown from seed, from germination to the sapling stage.

Secondary poisoning-Poisoning that occurs when a chemical toxicant is retained in a target animal in such a manner and quantity that its chemical action will cause significant bodily malfunction, injury, illness, or death to nontarget animals or to humans when the body part retaining that chemical is ingested.

Selection cutting-The cutting method in which individual trees or small groups are removed annually or periodically from an uneven-aged forest.

Selective pesticide-A pesticide that, while killing the pest, spares much or most of the other fauna, including beneficial species, either through differential toxic action or through the manner in which the pesticide is used (formulation, dosage, timing, and so forth).

Shelterwood harvest (cutting)-Regeneration cutting in a mature stand to establish a new crop under the protection of the remaining stand. Trees are removed in several stages to establish a new, even-aged crop under the protection of the older stand.

Shelterwood method-A regeneration method that in one or more thinnings or harvest operations removes mature trees from an area and leaves enough trees to affect the site environment for establishment of seedlings. The function of the residual trees is to modify the environment near the ground.

Silviculture-The art and science of managing forest stands to meet resource objectives.

Silvicultural system-A process whereby forests are tended, harvested, and replaced to result in production of crops of distinctive form. Systems are classified by the method of felling that removes the mature crop with a view to regeneration.

Single-feeding (single-dose) bait-A toxic bait that produces death from one dose; also called “acute toxic bait.”

Single-tree selection-A harvest-regeneration method used in uneven-age management in which trees are removed either on the basis of their individual maturity or to promote growth and maturity of neighboring trees. The objective is to produce a stand with trees of all sizes and ages within areas less than 2 acres in size.

Site preparation-preparing an area of land for regeneration establishment.

Soil compaction-Adverse changes in soil properties, which reduce water and air capacity and movement, and root penetration capacity. Soil compaction can occur when excessive numbers of big game or domestic livestock use areas of heavy clay soils saturated with water. Areas damaged by compaction have a dimpled appearance; animal hoofprints are discernible if the trampling is recent.

Soil damage-Animal use that leads to deterioration of the soil structure or to accelerated erosion.

Stand-A plant community, particularly of trees, sufficiently uniform in species composition, arrangement of age-classes, and condition to be a homogeneous and distinguishable unit.

Stand establishment-Developing a tree crop to the stage at which the young trees may be considered established (safe from normal adverse influences).

Stocking-With reference to forest stands, a more or less subjective indication of the number of trees as compared with the desired number. More precisely, a measure of the proportion of the area actually occupied by trees (as distinct from their stand density), or the percentage of area stocked as compared with either maximum or normal tree densities.

Stock type-A class of nursery stock produced by one or more of the basic production methods over a particular length of time.

Succession-The gradual replacement of one plant community by another until ecological stability is attained or until disturbance reinitiates the cycle.

Systemic repellent-A chemical applied to foliage, roots, or soil (at the root zone) that is absorbed and translocated to all parts of the seedling (or tree) and that limits the plant's acceptance as food by animals.

Target species-Primary object of control; species against which efforts are directed to control damage either by direct population reduction (trapping, baiting, or shooting) or by using mechanical or chemical barriers to protect forest resources from depredation by a particular species.

Thinning-A felling made in an immature stand primarily to accelerate diameter growth; also, a selection made to improve the form of the trees that remain.

Threatened species-A species or subspecies that, although not presently threatened with extinction, is in such small numbers throughout its range that it may be endangered if its environment worsens. A "status undetermined species or subspecies" is one that may be rare or endangered but for which more information is needed (see "endangered species").

Tolerance-An organisms' ability to endure a pesticide or drug without ill effect; for example, the state of its innate resistance or acquired immunity.

Toxicity-Poisonous quality, especially its degree or strength.

Translocation-The movement of dissolved substances through the vascular tissue of a plant.

Trapnight-One trapnight equals one trap set for one night.

Tree damage-Animal use that delays regeneration, or that reduces the number of desired trees below an acceptable stocking level.

2-0 seedlings-Seedlings aged 2 years in the seedbed and none in the transplant bed.

Uneven aged-A term for a forest composed of intermingled trees that differ widely in age and size.

Uneven-age management-The application of a combination of actions needed to simultaneously maintain continuous, high-forest cover, recurring patches of regeneration of desirable species, and the orderly growth and development of trees through a range of diameters or age classes. Cutting methods that develop and maintain uneven-aged stands include single-tree selection and group selection.

Vertebrate control objectives-To accomplish the desired effect with a maximum of safety to humans and to forms of life useful or of neutral value to society, and that is carried out with a minimum of disturbance to the biotic community. It is the alleviation of the problem to a tolerable level, not the destruction of vertebrates.

Vertebrate pest-Any native or introduced, wild, or feral species of vertebrate animal that is currently troublesome locally or over a wide area, to one or more persons, by being a health hazard, a general nuisance, or by destroying food, fiber, or natural resources. A pest to one person may, at the same time, have aesthetic or recreational value to others.

Definitions included in this glossary are from the following sources:

Black, H.C., tech. ed. 1992. Silvicultural approaches to animal damage in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 422 p.

Cummings, M.W. 1973. Study guide for agricultural pest control advisers on vertebrate pests. Davis, CA: University of California, Division of Agricultural Sciences.

Salmon, T.P.; Lickliter, R.E. 1984. Wildlife pest control around gardens and homes. Oakland, CA: University of California, Division of Agriculture and Natural Resources. 90 p.

Thomas, J.W., tech ed. 1979. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. Agric. Handb. 553. Washington, DC: U.S. Department of Agriculture, Forest Service. 512 p.

Metric Equivalents

When you know:	Multiply by:	To find:
Inches	2.54	Centimeters
Feet	0.31	Meters
Yards	0.91	Meters
Miles	1.61	Kilometers
Miles per hour	1.61	Kilometers per hour
Chain (22 yards)	5.03	Meters
Acres	0.41	Hectares
Square feet	0.09	Square meters
Square mile	2.59	Square kilometers
Gallon	3.79	Liters
Pound	0.45	Kilograms
Ton	0.91	Metric tons
Tons per acre	2.24	Metric tons per hectare
“Fahrenheit	5/9(^{o}F-32)	Celsius

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Black, Hugh C., tech. ed. 1994. Animal damage management handbook. Gen. Tech. Rep. PNW-GTR-332. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 236 p.

This handbook treats animal damage mangement (ADM) in the West in relation to forest, range, and recreation resources; predator management is not addressed. It provides a comprehensive reference of safe, effective, and practical methods for managing animal damage on National Forest System lands. Supporting information is included in references after each chapter and in the appendices.

Keywords: Animal damage management, integrated forest protection, wildlife problem species, damage identification.

The **Forest Service** of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

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