EXCLUSIONARY METHODS AND MATERIALS TO PROTECT PLANTS FROM PEST MAMMALS--A REVIEW

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ABSTRACT: Protecting individual plants or small clumps of plants with some type of protective material or device represents a positive nonlethal approach to damage prevention that is often much less expensive than fencing an entire garden or crop or netting over the entire area to prevent damage by such species as deer (Odocoileus spp.), rabbits (Lepus spp., Sylvilagus spp.), and ground squirrels (Spermophilus spp.). This review article does not include fencing or the netting or screening of entire crops, which are subjects unto themselves.

Tree trunk guards or protectors include commercial tree wraps and other materials affixed directly to young tree trunks, wire cylinders for individual trees, and plastic-mesh tubing. The use of soil mounding or a layer of coarse gravel around the base of a tree is helpful against damage from meadow voles (Microtus spp.). Damage from pocket gophers (Thomomys spp., Geomys spp.), can be alleviated by planting in wire-mesh cylinders or baskets, although generally too expensive and impractical to be used for large commercial plantings. Tree bands and shields are particularly useful against ground and tree squirrels (Sciurus spp.) and certain other climbing mammals. For seeds and very young seedlings, domes, caps, and cones offer good protection during their vulnerable period. Where other materials are scarce, the use of prickly or thorny plant materials, such as holly or hawthorn branches, can provide protection to newly planted seed and young seedlings. This paper reviews these methods and provides references for those seeking further information.

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INTRODUCTION

Exclusionary methods and materials other than fences or full area enclosures have a long history of use in vertebrate pest control, particularly as a means of protecting young fruit and nut trees and tree seedlings for reforestation from deer (Odocoileus spp.), rabbits (Lepus spp., Sylvilagus spp.) and a variety of pest rodents. Some of these methods had very early use and are cited not only because of their past significance but because some of these early methods continue to have considerable merit. Some have been abandoned in favor of chemically oriented approaches to damage control but are now receiving renewed interest and use in organic and sustainable agriculture.

The methods include various materials wrapped or tied directly on the tree trunks, the larger loose-fitting protective cylinders or other individual exclosures, shields, or bands to prevent access to the upper tree portions via the trunk, mounding soil, or other materials around the base of trees to restrict feeding or to make the habitat less favorable to pest species.

TREE TRUNK GUARD PROTECTORS

Materials Affixed Directly on the Tree

Today we have a variety of trunk protectors (wraps) that are specially designed, manufactured, and sold for the purpose of protecting young orchard trees. They are manufactured of weatherproofed cardboard, plastic, aluminum foil, flexible aluminum mesh, and other types of materials (Baer 1980). Some are more cost-effective than others, especially as they relate to installation time.

In earlier times a variety of natural and discard materials were wrapped or tied around trunks of trees (especially young trees) to protect them from bark-gnawing mammals, particularly meadow voles (Microtus spp.) and rabbits. Natural materials of botanical origin that were locally plentiful and frequently used include cornstalks, yucca leaves, dried rushes, bamboo, and birch, juniper, and eucalyptus bark, closely spaced sticks or twigs, and ropes of hay. Plant materials were often also used as ties to attach the wraps to the trunks as well. Such natural materials are rarely used today in the U.S. because commercial wraps are available and natural materials are labor-intensive to collect and attach, but they continue to be used in developing countries where other resources are unavailable or costly and labor is relatively inexpensive.

Prior to 1940 discard materials, especially packaging materials (rags, burlap or jute sacking, cardboard, heavy paper, tar paper, newspaper) received much use as trunk protectors. Empty cement, feed, and fertilizer paper bags have also been used as trunk wraps.

Early wraps of natural materials, cloth or paper were often used as temporary protectors only and attached seasonally or during the winter months when most damage occurs. It was often recommended that these protectors be removed in spring or early summer and replaced in the fall, in part because many of these materials were inexpensive and not very durable, but also because they occasionally provided harborage for insect pests and/or physically injure the trees when left on throughout the year. Tar paper, in particular, has been implicated in injuring trees Contrarily, injury in the way of sunburning (scalding) or trunk scarring by implements may also occur when wraps such as tar paper, newspaper, and burlap are removed and the tender bark was exposed. White-washing of trunks of young trees assists in reducing sunburn or sun scald.

Efficacy--Although few of the sources reporting the use of these earlier used materials provided any detailed evaluation of their effectiveness, most indicated that the materials provided a degree of protection and/or that they were commonly used.

Natural materials such as cornstalks, bark strips, ropes of hay, etc., were effective to varying degrees, but they were time consuming to collect or prepare and labor-intensive to attach (Waugh 1917). The collection of certain botanical materials for protectors may damage the source plants. In

Pakistan, for example, stripping juniper bark for tree wrap sometimes damages the juniper trees (Khan and Smythe 1980).

Special considerations--Protectors wrapped or tied around the trunk are particularly suited for use on trees having a clean bole rather than those that branch at or near the ground. In general, wrappings or other protective materials should be attached to a height of 18 to 24 inches, and in some cases higher. Some recommend extending the material several inches below the soil as well for added protection, especially against meadow voles.

While in most cases protective materials are closely fitted to the trees, when protecting trees against ground squirrels Bailey (1911) and Wickson (1889) recommended allowing the top few inches (4 in) of the newspaper wrapping to extend loosely. Supposedly the paper rattles when the squirrels try to climb over it, frightening them away. It is unclear whether this technique was effective. Another species that is difficult to exclude with wraps or tied-on materials is the pine or woodland vole (M. pinetorum). Although pine voles (referred to as pine mice in early times) resemble other voles in appearance, materials that to a degree exclude surface-active meadow voles, such as wood veneers, paper protectors, and burlap, are ineffective against deeper burrowing pine voles because they normally burrow and feed much lower on the trees in the upper root zone and this generally occurs well below trunk protectors. Other vole species sometimes also get under such exclusionary materials, and some agriculturists consider trunk protectors relatively useless for any vole species. Deer mice (Peromyscus maniculatus) were found in one situation to have gained entry to cardboard-type trunk protectors and girdled the young citrus trees with the protectors providing them concealment and seclusion.

Deep or drifting snow reduces the effectiveness of protective wraps. If snow depth exceeds the height of the wrappings, animals may gain access to unprotected portions of the trees by burrowing up through the snow or, in the case of rabbits, feed on exposed parts above the snow and cause damage. In some situations it may be advisable to clear snow away from the tree trunks to alleviate this problem (Wilkinson 1945, Stebbins and Walheim 1981), or in areas that regularly receive a great deal of snow, wrap trees to a greater height to minimize the possibility of this problem occurring.

Cost--Early protectors of natural or discard materials were made of readily available and relatively inexpensive materials. Now several types of specially designed and inexpensive trunk wraps/protectors are available commercially (Fig. 1). Commercial tree protectors commonly used today are designed to be left on young trees year-round, at least for the first couple of years when the trees are most vulnerable to animal damage, providing they are not so tight as to restrict growth. As the trunk grows in diameter and the bark thickens, it is less prone to severe kinds of damage such as from rabbits and ground squirrels.

Cylinders for Individual Trees

Cylinders encircling trees/tree trunks form another category of exclusionary devices and are often used to protect young trees. Although these may be constructed from a variety of materials, hardware cloth and poultry netting are the most commonly used. Plastic netting and ready-made net-style (Vexar® type) tubes are currently extensively used for protecting forest tree seedlings from girdling, gnawing, clipping, and/or browsing damage by rabbits and deer but also sometimes used against ground squirrels and pocket gophers. These plastic-mesh tubes will be discussed separately.

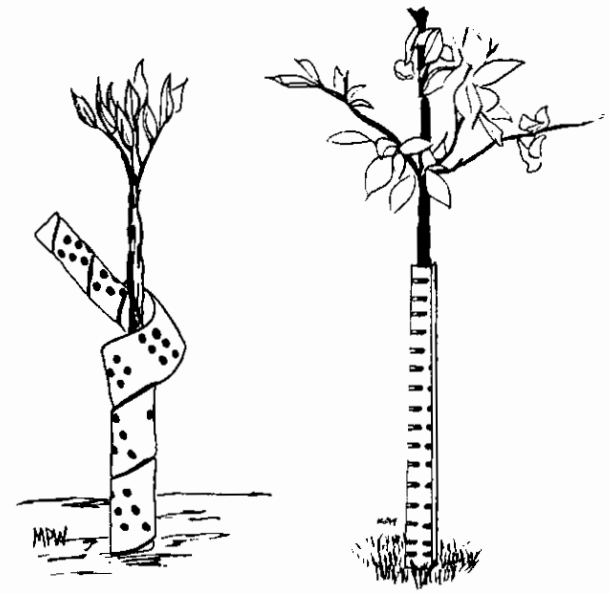

Figure 1. Commercially available tree trunk protectors.

Wire cylinders are generally considered effective if properly installed. The initial investment for these devices is often higher than for most types of wraps and other materials applied directly to the trees. Most individual cylinders, tubes, or cages are designed for long-term use (generally for several years). Wire mesh guards can be reused on other trees once no longer needed to protect the existing trees.

Once in place, cylinders and seedling cages require little maintenance except checking to make sure they aren't injuring the tree or have been damaged while performing cultural practices such as mowing, pruning, or picking and making any necessary repairs. Wire cylinders may restrict tree development so it is important that the diameter of the guards allows for tree growth and that the guards be removed or enlarged as the trees grow into them (Marsh and Salmon 1979). While the basic design of these wire-cylinder guards is similar, the exact dimensions required to exclude the various species differ.

Meadow voles--Although not highly effective for voles, 1/4-in hardware-cloth cylinders are the most commonly suggested protectors against meadow voles. Most are 18 to 24 in high, but some range as high as 36 inches. The height needed varies with the pest species and snow depth (Powell and Powell 1977). Most sources recommend burying the bottom few inches, generally 2 to 6, of the cylinders. Even so, these guards--like wrap-around protectors--are not considered effective tree protection against burrowing pine voles or pocket gophers because they feed on the roots well below the practical depth of most installed cylinders.

What diameter of cylinder should be used varies with the age, type, and branching structure of the tree. Recommendations often suggest cylinders with 6-in diameters for young orchard trees (1 1/2 to 2-in in diameter), while others prefer cylinders somewhat larger in size. Mills (1929) and Wilkinson (1915) recommend crisscrossing two pieces of string or twine across the cylinder tops to keep them centered and to prevent chafing the tree. Silver (1924) reports that wire screening

cylinders of a fine mesh (window screen) protect against insect borers as well, if closed by stuffing cotton or rags around the top of the cylinder.

Rabbits--Hardware cloth and wire screening cylinders like those used for meadow voles can also be used to exclude rabbits although the cylinders may need to be taller. Where meadow voles are not a concern, tree guards can be made using wire netting with larger (1/2 to 1-in) mesh sizes, which generally lower their cost.

Guards made of 20-gauge chicken wire/poultry netting with 1-in mesh are commonly used (Johnson 1964, Marsh and Salmon 1979) (Fig. 2). Cylinders generally extend to 1-1/2 to 3-ft tall with the diameter varying with the size and type of tree being protected. The height and diameter may depend on the distance from the ground where tree branching start. Cylinders should be tall enough and of large enough diameter so that the trunk and lower young branches are screened from rabbits (Thomas and DeGraaf 1974). Cylinders should also be braced with 1 or 2 stakes or spreaders to prevent rabbits from pressing the wire against the trunk and damage the trees through the mesh. Three-foot high poultry netting may also be used to encircle haystacks to protect them from rabbit damage (Marsh and Salmon 1979); if the wire mesh if extended to 6 or 8 ft, it will help prevent damage from deer, antelope (Antilocapra americana) and elk (Cervus elaphus).

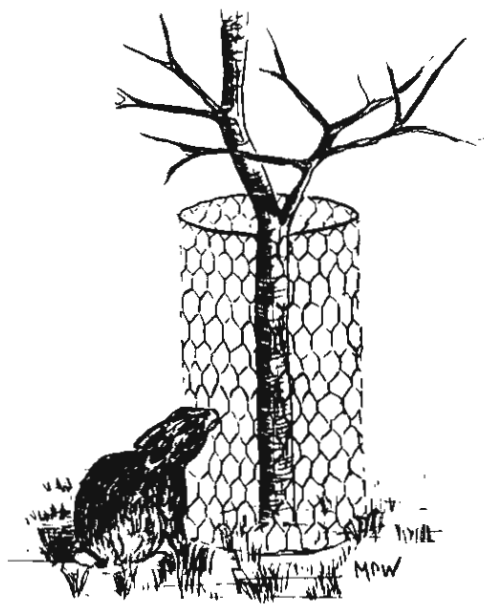

Figure 2. Wire-mesh cylinder for protecting individual trees from rabbits and certain gnawing rodents.

Deer--Encircling trees with wire mesh can prevent browsing and antler-rubbing damage by deer. Such cylinders have been constructed of 1- or 2-in wire mesh, poultry netting/chicken wire, small-mesh sheep wire, and other types of wire fencing (Scheer and Juergenson 1976). Cylinders should be high enough and of large enough diameter that deer are unable to reach over the wire or browse tree foliage that may protrude through the wire (Lape 1979). They should be supported by 1, 2, or 3 posts such as 2-in x 2-in redwood stakes or 1-in steel angle fence posts.

Pocket gophers--Wire cylinders have been less useful in preventing pocket gopher damage. Teipner et al. (1983) considered them impractical for protecting seedlings in reforestation efforts because of the expense and limited efficacy. Hooven (1971) questioned the value of using wire cylinders for seedling protection because of gophers' burrowing ability and depth of root damage.

Beaver--Henderson and Craig (1932) indicate that 3-ft high sturdy woven-wire cylinders can be used to protect fruit, shade, or other valuable trees from attacks by beaver (Castor canadensis). They recommend that cylinders extend a few inches out away from the trees and be supported by sturdy stakes. This type of cylinder would also prevent rabbit damage.

Other species--In this and other countries, wire-mesh cylinders/collars have been suggested for preventing damage by other species as well. These include rats (Hartley 1977, Williams and Hsu 1979, Turner and Gillbanks 1982), woodchucks (Marmota spp.) (Fraser 1927), Old World porcupines (Hystrix spp.) (Hartley 1977, Williams and Hsu 1979), and South American agoutis (subfamily Agoutinae) (Hartley 1977, Turner and Gillbanks 1982). In Malaysia chicken-wire guards on oil palms have been used for rats (Rattus spp.) and red-bellied squirrels (Callosciurus notatus) (Wood 1976). However, such devices were not highly effective for preventing damage by rats (Wood 1976, Williams and Hsu 1979) or Old World porcupines (Hartley 1977).

Plastic-mesh Tubing (Vexar) for Individual Trees

Tubes of photodegradable plastic tube netting (Vexar and similar tubing) have been extensively studied in the past two decades and show great promise as a more practical and cost-effective means of protection, especially for protecting forest tree seedlings. Plastic netting tubes may be used to provide total tree protection to newly planted seedlings or as sleeves to protect the terminal shoot of small established trees (Larson et al. 1979, DeYoe and Schaap 1984).

While primarily used to prevent browsing or clipping damage by deer, elk (Larson et al. 1979; Anthony 1982; DeYoe and Schaap 1984), rabbits and hares (Campbell and Evans 1975), plastic netting tubes also provide some protection against damage by mountain beavers (Aplodontia rufa) (Campbell and Evans 1975), pocket gophers (Anthony et al. 1978), and other small rodents. However, in Louisiana Vexar tubes have not been very effective in protecting bald cypress seedlings from damage by rodents as large as nutria (Myocastor coypus) (Connor and Toliver 1987).

Plastic-net tubing is available in several mesh sizes and patterns. Three-eighths-inch mesh openings are recommended because of the low incidence of terminal shoots growing out through the openings of this size mesh, and because it least affects lateral branch development (Campbell and Evans 1975, Larson et al. 1979). Tube diameters and heights depend on the species of trees being protected. Tubes must be installed absolutely vertical to prevent terminal shoots of conifer seedlings from growing out through the sides where they are unprotected from the pest and cause tree deformity. Wire pins or stakes should be used to anchor and support the longer tubes.

Some minor problems have been experienced in reforestation practices using such tubing. At least some plastic netting may become brittle during freezing weather, and there are occasional reports of tubes shifting or being compressed by snow, frost heaving, trampling etc. (Campbell and Evans 1975; Anthony et al. 1978; Larson et al. 1979).

For reforestation purposes, the use of plastic-net tubing is often cost-effective. However, the cost in a particular

situation will depend on the materials used, installation and support methods employed, type of terrain, and seedling stocking rate.

Vexar and similar mesh tubing have received much attention for protecting seedlings in reforestation but little attention for protecting fruit and nut trees of agriculture. They also have the potential for protecting individual plants of other crops including grapevines. Plastic mesh tubing could prove valuable in other agricultural situations and should be considered or researched for potential uses.

TREE CROWN AND ROOT PROTECTORS

Soil Mounding/Banking and Other or Substrates to Reduce Access

Another form of tree trunk protection used in the past, primarily against meadow voles, involves the banking or mounding of soil against the trunk (Thomas 1903, Kains 1940, Wilkinson 1945). Other types of materials or substrates have also been used around trees. Crushed stone or gravel (Greene 1977, Ritter 1978) or heavy manure (Waugh 1901) are examples of such substrates, although the latter material may be of questionable value. Soil is generally mounded in the fall to a height of 6 to 10 inches and thoroughly packed down (Knapp and Auchter 1929). Clean, smooth soil should be used rather than turf or sod because cavities tend to form in the latter, which may compromise the effectiveness of this technique.

Mounding is an old method that was considered effective to a degree. However, Knapp and Auchter (1929) suggest that it may not provide enough vole protection in orchards using permanent cover crops or sod culture or those surrounded by meadows or other situations where meadow voles may be abundant. This technique is rarely used today; but where chemical control of voles is not an option, it may be worth re-exploring. Crushed stone (1 1/4 to 2 1/2 cu ft) or coarse gravel has also been explored to protect trees from meadow vole damage. It should be piled 3 to 6 inches deep around the trunk (Greene 1977, Ritter 1978) extending 15 to 18 inches out from the base. Growers provide mixed reports on the effectiveness of this technique.

Tree Root Guards/Protectors

In addition to tree trunks, tree and vine roots are also subject to gnawing damage. In the West, root damage is primarily caused by pocket gophers. To prevent this damage, some recommend lining the planting hole with wire-mesh cylinders to completely surround the roots (Wickson 1889, Storer 1953). This technique will exclude meadow voles and moles as well, although voles may go over the top edge if it does not extend well above the ground. For gophers, cylinders should be made of 1-in or smaller mesh with a diameter of at least 12 inches (Stewart and Baumgartner 1978) and a height of 1 to 1-1/2 feet. One-half inch mesh or smaller is needed to exclude meadow voles; however, the finer the mesh, the greater the potential for restricting root growth. The size of the cylinder or basket, which it is sometimes called, is determined by the type and kind of plants to be protected. Both baskets and cylinders should be sunk into the ground with the top edge positioned at or just below the soil surface to avoid problems when mowing or cultivating around the trees. Cummings and Marsh (1978) report that wire netting protectors are not particularly cost-effective for protecting young orchard trees on a commercial scale. Because of their cost, they are used primarily for the planting of ornamentals such as bulbs and occasionally the trees of a backyard orchard. Home gardeners with a severe pocket gopher problem often find this method very helpful (Clark 1983).

CROP AND PLANT PROTECTORS

Tree Bands/Shields

Metal flashing and other types of shields are used on mature trees to prevent animals from climbing the trunks to defoliate trees or damaging or consuming fruits, nuts, or pine cones. Bands of galvanized metal or aluminum flashing have been used to prevent ground squirrels, tree squirrels (Shubert and Adams 1971, Powell and Powell 1977), rats (Popenoe 1913, Williams and Hsu 1979), and raccoons (Procyon lotor) and woodchucks (Logsdon 1981) from climbing crop trees. For squirrel exclusion Storer (1953) recommended using a 2- to 3-ft-wide band beginning 2 ft above ground, while Powell and Powell (1977) and Shubert and Adams (1971) reported that 18-in-wide bands were sufficient. Flat, 2-ft diameter, sheet-metal disks encircling tree trunks below the first branches have also been used to keep ground squirrels out of trees (Storer 1953). Popenoe (1913) recommended 12-in wide bands beginning 3 ft above ground to protect against rats, while Williams and Hsu (1979) suggested that bands should be 16 in wide for that purpose.

These types of protectors can be effective as long as there are no drooping branches providing access from the ground and no nearby unbanded trees permitting tree-to-tree travel. These bands and shields also need to be adjustable to accommodate expansion as the trees grow.

Domes, Caps, and Cones as Protectors for Seeds and Seedlings.

A few other exclusionary devices have been used to protect trees at various stages of growth. Warder (1867) suggested encircling tree stems with inverted funnels made of brown wrapping paper to protect them against rabbits. At that time wire mesh was very expensive and not readily available.

Domes made of 1/3-in mesh, 21-gauge galvanized hardware cloth have been used to protect forestry seed spot plantings from depredation by small rodents, particularly white-footed mice (Peromyscus leucopus) (Garlough and Spencer 1944). Others have suggested similar domes for protecting seed spots from ground and tree squirrels as well as chipmunks (Eutamias spp.) (Stoeckeler and Scholz 1956). Their effectiveness against bird depredation is well established. The top of the dome extends 3 inches above the soil with the rim extending 1 inch into the soil. Wire mesh domes are reusable and should last several years. However, the cost of the domes and their placement was generally considered impractical for large reforestation efforts (Shubert and Adams 1971). Inverted plastic strawberry-type baskets make excellent inexpensive protectors for garden seed spots and young seedlings. They have also been evaluated for direct seeding reforestation (Utterback and Berry 1977).

Cone-shaped seed spot protectors of hardware cloth have also been used in reforestation (Fig. 3). While effective, they are more expensive, bulkier, and more time consuming to make and install than dome-shaped protectors (Shubert and Adams 1971). The effectiveness of cone-shaped protectors, as with domes, is lost if they are knocked over by livestock or big game species. Both types may be lifted by snow movement or frost heaving, and small rodents occasionally

burrow underneath them. Other forest tree seed spot protectors that have been tried with mixed results include flyscreen or hardware cloth cylinders, solid metal cylinders (including some made from beer cans), and paper covers (Shubert and Adams 1971). In the West, seed spots are rarely used as a silviculture practice today and thus there is little need for domes or cone protectors.

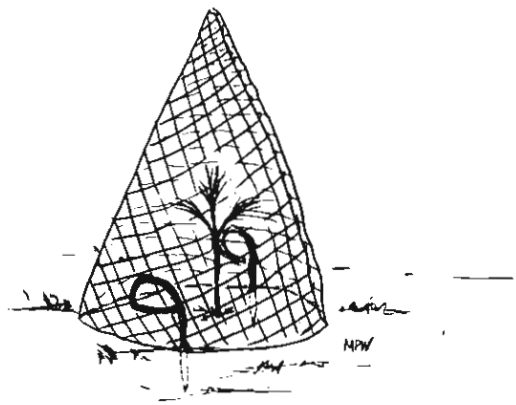

Figure 3. Cone-shaped seed spot protector used in reforestation.

The use of cone-shaped wire protectors by home gardeners to protect young plants from vertebrate pests is relatively common, especially against pest birds. They are sometimes made of plastic, thereby serving as miniature greenhouses to provide warmth and protection from cold temperatures. Some commercial protectors even have water-filled tubules to capture and retain additional heat. These, while not intended for pest management, they do serve that extra purpose in some situations.

In nearly all cases, wire domes and cones must be removed as the plants mature and need more space. By that time they are often less prone to certain kinds of vertebrate damage.

Natural Plant Materials for Seed or Seedling Protection

Prickly or physically restrictive plant materials are also used to protect seeds and seedlings from depredating mammals. Larkcom (1976) noted that some people cover pea seeds with holly leaves to deter pests and suggested that hawthorn twigs or prunings could be used to protect seeds and seedlings from damage by cats. Barry (1860) suggested securing thorns, briers, or some prickly brush around the base of trees to protect the trunk bark from damage by cats (scratching) or hogs.

Brushy leafless cuttings or twigs (of a nonprickly nature) are sometimes laid over the top or stuck in the soil along both sides of rows of young seedlings to physically make it difficult for rabbits and certain other vertebrates to get to and feed on the young plants (Fig. 4). Later this brushy material is generally removed as the plants mature and are less susceptible to damage.

The use of plant materials around or over cultivated plants to be protected from vertebrate pests has long been practiced and continues extensively today in many developing countries where other resources are limited. The practice generally involves family gardens or small plots rather than those of a commercial scale.

Figure 4. Prunings stuck into the ground around plants to be protected offer some protection from damage by cats, dogs, and rabbits.

Cages/Shields

Crop covers/shields made of plastic netting, fly screen, nylon net, or cheesecloth or wire cages can be used to protect individual rows of vegetable plantings from ground squirrels (Splittstoesser 1984), rabbits (Moment 1977), and domestic cats (Larkcom 1976). These techniques are more practical for home gardens than for commercial fields.

Bagging/Wrapping Ripening Fruits or Vegetables

Wraps or bags are sometimes used to protect individual or clusters of ripening fruits or vegetables. This is generally only practical on a small scale and mostly used for backyard gardens. Although this technique is most often used to protect fruits such as dates and figs from damage by birds (Popenoe 1913; Chandler 1958; Roach 1985), it is sometimes used against mammals as well. While bagging of individual fruits or crop clusters may be a useful solution to a home gardener, the netting of the entire tree or crop, when warranted and economically advantageous, is usually a more practical approach for crop protection on a larger scale. The netting of entire crops is in itself a full subject and is not included in this review.

Splittstoesser (1984) suggested covering ripening ears of sweet corn with paper bags to prevent raccoon damage, while sacking or cloth wraps are recommended in other countries for protecting dates and guava from damage by fruit bats or flying foxes (Ochse 1931, Dowson 1982). Other materials used for wraps/bags include matting of woven palm leaflets, cheesecloth, plastic and fiber netting, and muslin (Popenoe 1913; Chandler 1958; Dowson 1982).

There are limitations on how effective this technique is against different mammalian species. For instance, Dowson (1982) notes that in Israel hyenas (Hyena hyena) are capable of tearing open wire-mesh bags to get at ripening dates.

In reforestation plastic netting is sometimes used as for a cap to protect the terminal leader or buds from deer browsing of conifer seedlings (Hines, 1971, DeYoe and Schaap 1984). In these situations the terminal leader is the only protected portion of the plant because it is the part of the young tree most susceptible to browse damage (Fig. 5).

SUMMARY

There are a number of materials, devices, methods, and techniques that can be used to protect individual trees or small groups of garden plants from certain types of mammal

damage. They are generally less expensive than fencing the pest out of the area or netting over an entire crop. The exclusionary methods covered in this brief review, except for commercial trunk guards for a young orchard, are best suited for backyard gardens or commercial plantings relatively small in size.

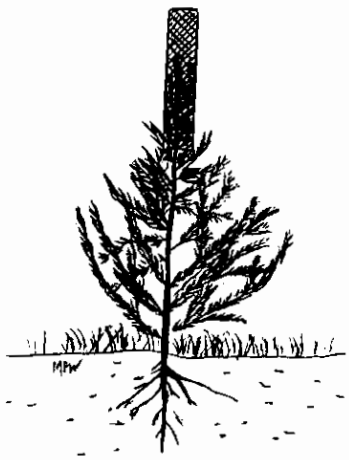

Figure 5. Vexar-type netting used to protect the terminal leader of conifer tree from deer-browse damage.

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LITERATURE CITED

ANTHONY, R.M. 1982. Protecting ponderosa pine from mule deer with plastic tubes. Tree Planters' Notes 33(3):22-26.

ANTHONY, R.M., V.G. BARNES, Jr., and J. EVANS. 1978. "Vexar" plastic netting to reduce pocket gopher depredation of conifer seedlings. Proc. Vertebr. Pest Conf. 8:138-144.

BAER, N.W. 1980. Tree guard tubes to reduce rabbit damage to shelterbelt trees in South Dakota. Tree Planters' Notes 31(3):6-8.

BAILEY, L.H. 1911. Farm and Garden Rule Book. MacMillan Co., NY. 587 pp.

BARRY, P. 1860. The Fruit Garden. C.M. Saxton, Barker & Co., NY. 398 pp.

CAMPBELL, D.L., and J. EVANS. 1975. "Vexar" seedling protectors to reduce wildlife damage to Douglas-fir. Wildlife Leaflet No. 508, U.S. Fish & Wildlife Service, Washington, DC. 11 pp.

CHANDLER, W.H. 1958. Evergreen Orchards. Lea & Febiger, Philadelphia, PA. 535 pp.

CLARK, D.E., Ed. 1983. Sunset Gardener's Answer Book. Lane Publishing Co. Menlo, Park, CA. 160 pp.

CONNOR, W.H., and J.R. TOLIVER. 1987. The problem of planting Louisiana swamplands when nutria (Myocastor coypu) are present. pp. 42-49 In: Proc. Third Eastern Wildl. Damage Control Conf. (N.R. Holler, ed.), Gulfshores, AL. 362 pp.

CUMMINGS, M.W., and R.E. MARSH. 1978. "Vertebrate Pests of Citrus," pp. 237-273 In: The Citrus Industry, Vol. IV, Crop Protection (W. Reuther, E.C. Calavan, and G.E. Carman, eds.), Univ. Calif., Div. of Agric. Sciences. 362 pp.

DEYOE, D.R., and W. SCHAAP. 1984. Comparison of 8 physical barriers used for protecting Douglas-fir seedlings from deer browse. pp. 77-93 In: Proc. First Eastern Wildl. Damage Control Conf. (D.J. Decker, ed.), Ithaca, NY. 379 pp.

DOWSON, V.H.W. 1982. Date production and protection. FAO Plant Production and Protection Paper 35:224-227.

FRASER, S. 1927. American Fruits. Orange Judd Publishing Co., NY. 892 pp.

GARLOUGH, F.E., and D.A. SPENCER. 1944. Control of destructive mice. USDI Fish and Wildlife Service Bull. No. 36. 37 pp.

GREENE, G.M. 1977. The vole problem in Pennsylvania apple orchards. pp. 11-13 In: Proc. First Eastern Pine and Meadow Vole Symp. (R.E. Byers, ed.), Winchester, VA. 113 pp.

HARTLEY, C.W.S. 1977. The Oil Palm. Longman, NY. 806 pp.

HENDERSON, J., and E.L. CRAIG. 1932. Economic Mammalogy. Charles C. Thomas, Springfield, IL. 397 pp.

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.

HOOVEN, E.F. 1971. Pocket gopher damage on ponderosa pine plantations in Southwestern Oregon. J. Wildl. Manage. 35(2):346-353.

JOHNSON, W.V. 1964. Rabbit control. Proc. Vertebr. Pest Conf. 2:90-96.

KAINS, M.G. 1940. Grow Your Own Fruit. Charles Scribner's Sons, NY. 434 pp.

KHAN, A.A., and W.R. SMYTHE. 1980. The problem of pika control in Baluchistan, Pakistan. Proc. Vertebr. Pest Conf. 9:130-134.

KNAPP, H.B., and E.C. AUCHTER. 1929. Growing Tree and Small Fruits. John Wiley & Sons, Inc., London. 510 pp.

LAPE, F. 1979. Apples & Man. Van Ostrand Reinhold Co., NY. 160 pp.

LARKCOM, J. 1976. Vegetables from Small Gardens. Faber and Faber, London. 234 pp.

LARSON, J.E., D.L. CAMPBELL, J. EVANS, and G.D. LINDSEY. 1979. Plastic tubes for protecting seedlings from browsing wildlife. ED&T 2217 Project Record, USDA Forest Service Equipment Development Ctr., Missoula, MT. 19 pp.

LOGSDON, G. 1981. Organic Orcharding. Rodale Press, Emmaus, PA. 415 pp.

MARSH, R.E., and T.P. SALMON. 1979. The control of jack rabbits in California Agriculture. pp. 842-857 In: Proc. World Lagomorph Conf., Guelph, Ontario, Canada.

MILLS, E.M. 1929. Do you know that the annual loss from field mice exceeds $6,000,000? Fruits and Gardens 12:4,10.

MOMENT, B.C. 1977. The Salad-Green Gardener. Houghton Mifflin Co., Boston, MA. 147 pp.

OCHSE, J.J. 1931. Fruits and Fruitculture in the Dutch East Indies. G. Kolff & Co., Batavia-C. 180 pp.
POPENOE, P.B. 1913. Date Growing in the Old World and the New. West India Gardens, Altadena, CA. 316 pp.
POWELL, T., and B. POWELL. 1977. Your Garden Homestead. Houghton Mifflin Co., Boston, MA. 272 pp.
RITTER, C.M. 1978. Matters of concern in rodent control in Pennsylvania orchards. p. 10 In: Proc. Second Eastern Pine and Meadow Vole Symp. (R.E. Byers, ed.), Beltsville, MD. 110 pp.
ROACH, F.A. 1985. Cultivated Fruits of Britain. Basil Blackwell (city) 349 pp.
SCHEER, A.H., and E.M. JUERGENSON. 1976. Approved Practices in Fruit and Vine Production. The Interstate Printers and Publishers, Inc., Danville, IL. 584 pp.
SHUBERT, G.H., and R.S. ADAMS. 1971. Reforestation practices for conifers in California. Calif. Div. Forestry, Sacramento. 359 pp.
SILVER, J. 1924. Mouse control in field and orchard. USDA Farmers' Bull. No. 1397. 14 pp.
SPLITTSTOESSER, W.E. 1984. Vegetable Growing Handbook. AVI Publishing Co., Inc., Westport, CT. 325 pp.
STEBBINS, R.L., and L. WALHEIM. 1981. Western Fruit Berries & Nuts. HP Books, Inc., Tucson, AZ. 192 pp.
STOECKELER, J.H., and H.F. SCHOLZ. 1956. A cylindrical screen for protecting direct seedings of forest tree species. J. Forestry 54:183-184.
STORER, T.I. 1953. Controlling field rodents in California. Calif. Agric. Exten. Service Circular 434, Univ. Calif., Berkeley. 47 pp.
TEIPNER, C.L., E.O. GARTON, and L. NELSON, Jr. 1983. Pocket gophers in forest ecosystems. USDA Forest Service Gen. Tech. Rept. INT-154, Ogden, UT. 53 pp.
THOMAS, J.J. 1903. The American Fruit Culturist. William Wood and Co., NY. 823 pp.
THOMAS, J.W., and R.M. DEGRAAF. 1974. "Raccoons on the Roof," pp. 153-168 In: Gardening with Wildlife, National Wildlife Federation, Washington, DC. 190 pp.
TURNER, P.D., and R.A. GILLBANKS. 1982. Oil Palm Cultivation and Management, Incorporated Society of Planters, Kuala Lumpur, Malaysia. 672 pp.
UTTERBACK, R.C., and J.M. BERRY. 1977. Refinements in seedspotting Douglas-fir. State Forest Notes, No. 68, pp. 1-7.
WARDER, J.A. 1867. American Pomology: Apples. Orange Judd and Co., NY. 744 pp.
WAUGH, F.A. 1901. Plums and Plum Culture. Orange Judd and Co., NY. 371 pp.
WAUGH, F.A. 1917. The American Apple Orchard. Orange Judd and Co., NY. 215 pp.
WICKSON, E.J. 1889. The California Fruits and How to Grow Them. Dewey & Co., San Francisco, CA. 575 pp.
WILKINSON, A.E. 1915. The Apple. Ginn and Co., Boston, MA. 492 pp.
WILKINSON, A.E. 1945. Fruits, Berries & Nuts and How to Grow Them. The Blakiston Co., Philadelphia, PA. 271 pp.
WILLIAMS, C.N., and Y.C. HSU. 1979. Oil Palm Cultivation in Malaya. University of Malaya Press, Kuala Lumpur. 205 pp.
WOOD, B.J. 1976. "Vertebrate Pests," pp. 395-418 in: Oil Palm Research (R.H.V. Corley, J.J. Hardon, and B.J. Wood, eds.), Elsevier Scientific Publishing Co., Amsterdam, The Netherlands. 532 pp.