Porcupine Feeding Damage in Precommercially Thinned Conifer Stands of Central Southeast Alaska

Andris Eglitis, *USDA Forest Service, Deschutes National Forest, 1645 Highway 20 East, Bend OR 97701, and*
Paul E. Hennon, *USDA Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 2770 Sherwood Lane, Suite 2A, Juneau, AK 99801-8545.*

ABSTRACT. *This study describes feeding damage by porcupines* (Erethizon dorsatum) *in precommercially thinned young growth stands of Sitka spruce* (Picea sitchensis) *and western hemlock* (Tsuga heterophylla) *on Mitkof Island in central southeast Alaska. We examined 641 trees from 54 sampling plots along transect lines in three 12 to 20 yr old stands. Porcupine feeding was monitored each spring and fall from 1985 to 1987. Four categories of feeding damage are described: complete girdling of the bole, partial girdling (bole scars), branch clipping, and "tasting wounds" (small basal bole scars). Sitka spruce, the primary crop tree in these thinned stands, sustained significantly higher damage (52% of trees affected) than western hemlock (26% of trees affected). Porcupine feeding was greater on taller than shorter Sitka spruce. Although only 8 of 59 trees initially girdled in 1985 were killed, many later sustained additional feeding damage. Following the 1987 season 3 yr after thinning, nearly 30% of the spruce and 14% of the western hemlock crop trees had been partially or completely girdled. Issues deserving future attention include the role of thinning in predisposing stands to porcupine damage, methods of population assessment, and mechanisms of host selection by porcupines. West. J. Appl. For. 12(4):115–121.*

The porcupine (*Erethizon dorsatum*) is found throughout the forests of North America and within this range uses many species of hardwoods and conifers as its principal source of winter food. Porcupines feed on the succulent inner bark (phloem) of host trees, often causing top-kill or stem deformation and a subsequent reduction in timber values. Specific host preferences vary with geographical location and with vegetative types (Smith 1982). In the northeastern United States and in Canada, eastern hemlock (*Tsuga canadensis*), larch (*Larix* spp.), spruce (*Picea* spp.), and balsam fir (*Abies balsamea*) are the preferred conifers; preferred hardwoods include sugar maple (*Acer saccharum*), red maple (*A. rubrum*), oak (*Quercus* spp.), beech (*Fagus grandifolia*), and birch (*Betula* spp.) (Dodge 1982, Reeks 1942). Many pine (*Pinus* spp.) species are heavily damaged in the Lake States (Krefting et al. 1962). Further west, ponderosa pine (*P. ponderosa*) and pinyon (*P. edulis*) are favorite winter foods of the porcupine. In western coastal forests, porcupines were previously uncommon but have become a problem in recent years with more intense forest management (Dodge 1966, Dodge and Borrecco 1992). Preferred hosts include Douglas-fir (*Pseudotsuga menziesii*) in Washington (Dodge 1982) and western hemlock (*Tsuga heterophylla*) in young growth stands in British Columbia (Sullivan et al. 1986).

Porcupine feeding damage to trees has been reported in southeast Alaska (Meehan 1974, Ruth and Harris 1979) but has received little attention until recently. In the past few years, localized tree damage has developed on Mitkof Island in central southeast Alaska (Figure 1) where harvesting and precommercial thinning have been extensive since the mid-1960s. In this study we assessed levels of tree damage attributed to porcupine feeding in precommercially thinned stands on Mitkof Island and established a baseline for monitoring additional damage.

Methods

Description and Selection of Study Sites

Located midway between Juneau and Ketchikan, Mitkof Island covers about 135,000 ac (54,700 ha). Since the late

NOTE: We thank J.P. Wisman, Jay Kittams, Jim Tambling, Rick Wesseler, and others from the USDA Forest Service Petersburg Ranger District for assistance in the field and for logistical support.

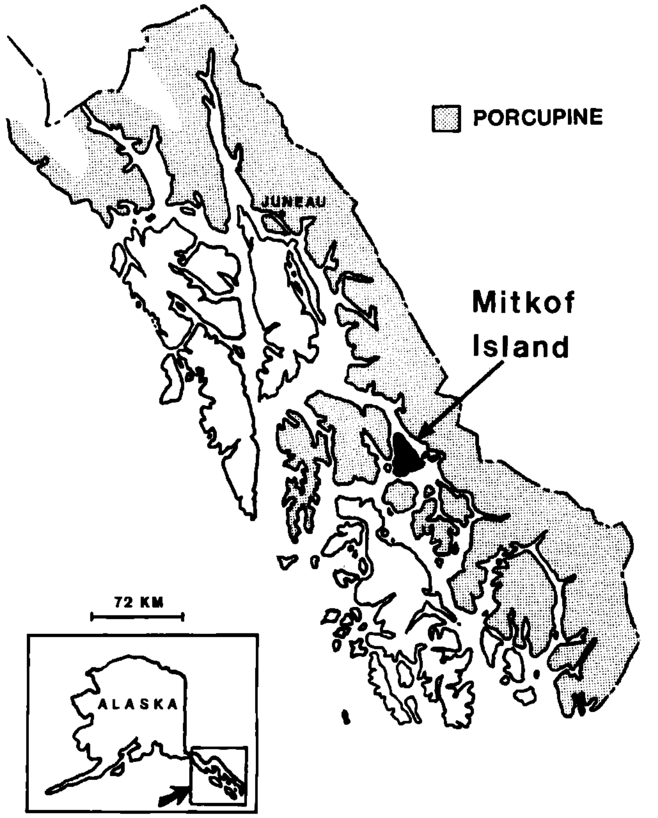

Figure 1. Location of study area (Mitkof Island) and distribution of porcupines within the southeast Alaska panhandle. (From Alaska Department of Fish and Game. 1977. A fish and wildlife inventory of southeastern Alaska. Vol. 1. 239 p., Juneau AK.)

1950s, over 15,000 ac (6070 ha) of commercial old-growth forest have been harvested on Mitkof Island. Much of this harvesting has taken place since the mid-1960s, and the island now has extensive young growth conifer stands in the 20 to 30 yr old age class. Precommercial thinning occurred in many of these young stands. Nearly 6100 ac (2520 ha) were thinned since 1978. These young naturally regenerated stands are composed primarily of Sitka spruce (*Picea sitchensis*) and western hemlock with some western redcedar (*Thuja plicata*) and yellow-cedar (*Chamaecyparis nootkatensis*). Sitka spruce often was favored over western hemlock during thinning, so that the thinned stands in the study area generally consist of about 60% spruce and nearly 40% western hemlock. The cedars are a minor component. After thinning, the stocking is approximately 300 trees/ac (740 trees/ha) at 12 × 12 ft spacing (3.7 × 3.7 m). Other woody vegetation in the young stands consists of blueberry (*Vaccinium* spp.), salmonberry (*Rubus spectabilis*), devilsclub (*Oplopanax horridus*), rusty menziesia (*Menziesia ferruginea*), Pacific red elder (*Sambucus callicarpa*), and red alder (*Alnus rubra*). Several forbs also are present, but they are mostly unavailable during winter.

Recently thinned stands in three areas were examined in late October 1985 for porcupine feeding damage. All three sites had southeast or southwest exposure and ranged in elevation from 250 to 1000 ft (80 to 300 m) above sea level. Two of the three sites were considered by local USDA Forest Service personnel to be among the most heavily affected on Mitkof Island (Wisman 1985, pers. comm.). The third site had a stand with concentrated tree damage from feeding and another stand relatively free of damage, but adjoining an unthinned stand. Stands in the three sites were logged between 1965 and 1973. All stands were precommercially thinned in 1985, except one which was lightly thinned in 1980. Residual crop trees were between 12 and 20 yr old at the time of our initial examination.

Sampling Design and Feeding Damage Assessment

Line transects were established in each of the three sampling sites in October 1985. In two stands these transects were located parallel to and 100 ft (30 m) from a logging road (Most of these old roads have minimal traffic or are completely closed to motorized vehicles). In the third stand the transects were established along a predetermined compass bearing. Sampling plots were located at 200 ft (61 m) intervals along these transect lines. The sampling plots were generally 1/20 ac (1/50 ha) but were occasionally adjusted to 1/40 ac or 1/10 ac to compensate for irregular stocking. Plots contained an average of 12 sample trees. Fifty-four plots were established along seven transects in the three areas.

A permanent numbered tag was attached to each crop tree within the plots. For each tree, we recorded species, estimated total height to the nearest foot (0.3 m), and examined the entire stem for evidence of porcupine feeding. Damage on each tree was described in sufficient detail to ensure that any additional porcupine feeding could be detected in future examinations. When girdled tops were encountered, the length of dead leader was estimated to the nearest foot (0.3 m). The length and circumference of bole scars, their position on the tree with respect to cardinal direction, and their distance above the ground were recorded. Branch clipping (small branches in the upper crown that were apparently removed by porcupines) was noted and described by position in the crown.

Plots were re-examined four times at 6 month intervals (late April and late October 1986 and 1987) to assess seasonal differences in porcupine feeding between winter and summer.

Statistical Analysis

Differences in height between all spruce and hemlock trees were tested by Student's unpaired "t" test ($P \leq 0.05$) The same test was used for both spruce and hemlock to determine height differences between undamaged trees and trees that sustained serious feeding damage (complete or partial bole girdling). A Chi-square test ($P \leq 0.05$) was used to evaluate differences in porcupine feeding by tree species Both cedar species were excluded from most analyses because they were relatively uncommon in these stands.

Results

Stand Structure

The average stocking level on the precommercially thinned plots was 259 trees/ac (640/ha). Sitka spruce was the predominant crop tree (62% of 641 trees). Western hemlock represented 37% of the sample trees. The remaining 1% was comprised of western redcedar (3 trees) and yellow-cedar (5 trees). Western hemlock [x = 16.0 ± 6.5 ft (4.9 ± 2.0 m)] plot trees were significantly taller than Sitka spruce [x = 13.9 ± 6.5 ft (4.2 ± 2.0 m)], western redcedar [9.7 ± 5.1 ft (3.0 ± 1.6 m)], and Alaska-yellow cedar [8.4 ± 2.6 ft (2.6 ± 0.8 m)] (Figure 2).

General Observations on Porcupine Feeding

Several types of porcupine feeding were found on Mitkof Island (Figure 3). The most common (and most severe) feeding activity was the complete girdling of the main stem. This usually occurred somewhere near the top of the tree and caused the death of the top quarter or third of the stem. In many of these cases, the bark was completely stripped from the bole for a length of 2 to 3 ft (0.6 to 1.0 m). Where porcupines removed bark from tree boles, teeth marks were consistently observed on the exposed wood (Figure 4). Some trees showed evidence of repeated girdling by porcupines. A common symptom of this revisitation was a brown top caused by the original girdling, with slightly off-color foliage in the crown directly above the second girdling lower on the main stem. Another common type of damage was "bole scarring," which refers to any bark removal that is less than a complete girdle. In some cases porcupines had removed nearly all the bark for three-quarters of the circumference of the bole for a vertical distance of about 6 ft (2 m) without killing the main stem. More commonly, bole scars covered about one-half of the circumference of the bole and ranged from 6 in (15 cm) to 2 ft (0.7 m) in vertical distance along the bole. While girdling occurred high on most trees, bole scars were found at all positions along the main stem.

On some trees (< 3%), the distal ends of branches had been removed by clipping. Where such porcupine feeding had occurred repeatedly, the branches appeared bushy and resembled heavy infections by dwarf mistletoe (*Arceuthobium* spp.). The final category of porcupine feeding was a small wound on the bole, generally about 2 × 3 in (5 × 8 cm) and usually 3 to 4 ft (1–1.3 m) above the ground, which we termed a "tasting wound." Since these wounds were usually not accompanied by additional bole scars, branch clipping, or top girdling, we believed that they were sampling bites taken on trees which were subsequently rejected as unsuitable for food. Nearly half of the trees (42%) sustained more than one type of porcupine feeding damage.

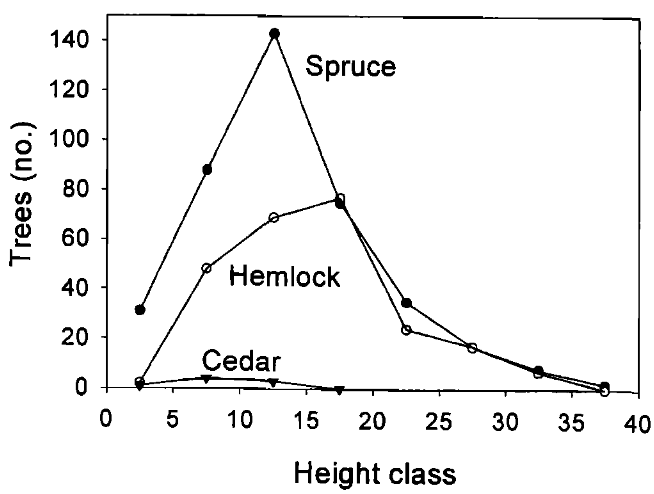

Figure 2. Height classes (in ft) of plot trees in three sampling sites for porcupine feeding damage assessment on Mitkof Island, southeast Alaska (October 1985).

Porcupine feeding appeared to be concentrated in distinct patches throughout most of the affected stands. A patch often consisted of 15 to 20 neighboring trees, each with some degree of bole scarring. These clusters of damaged trees are believed to be associated with denning sites, and each patch may be caused by a single porcupine (Spencer 1964).

Incidence of Feeding Damage

The incidence of porcupine feeding at our initial observations in October 1985 is shown in Table 1. The data in Table 1 are combined for the three areas and are presented in a hierarchical manner, with the most severe type of feeding damage taking precedence and lesser damage on the same trees not being considered. For example, the number of trees with bole scars (partially girdled) would be higher if we added in girdled trees which also had bole scars as a lesser level of damage. Bole scars were considered more serious than branch clipping, and trees with both forms of feeding would be included under the bole scar category. Tasting scars were the lowest damage type in the hierarchy, and trees in this category had no other type of porcupine feeding.

Sitka spruce sustained significantly more porcupine feeding than western hemlock, and the two species of cedars were undamaged (Table 1). One-third of the Sitka spruce (34%) showed some type of porcupine feeding; complete girdling was the most common form. Porcupines damaged 13% of the western hemlock trees but girdled only 8 of 239 trees. Bole scars (partial girdles) and branch clipping also were substantially more common on Sitka spruce than on western hemlock (Table 1). Damaged Sitka spruce trees [x = 15.5 ft (4.73 m)] were significantly taller than undamaged trees [x = 12.4 ft (3.78 m)]. Clipped branches and tasting wounds on spruce also were more frequent on taller trees, but differences were not significant. The relationship between height and porcupine damage was not as strong for western hemlock.

The average length of dead leaders on girdled trees was fairly consistent in the three sampling areas. Dead leaders on both spruce and hemlock averaged around 8 ft (2.4 m) or about 60% of the total height for those trees girdled by porcupines. Eight of the 59 trees that had been girdled were killed. All of these were Sitka spruce.

Cumulative Porcupine Damage

In the fall of 1985, 20.1% of spruce and 5.4% of hemlock had been partially or completely girdled (Figure 5). By the spring of 1986 following winter feeding by porcupines, the percentages increased to 26.4% for spruce and 9.2% for hemlock. One year later, the level of partial or complete girdling increased to 29.2% on spruce and 13.8% on hemlock. Very little new feeding was observed in the fall visits.

The accumulation of all forms of porcupine damage, including branch clipping and tasting wounds, is shown in Table 2. Over half of the Sitka spruce crop trees sustained some form of porcupine feeding damage, while 26% of the hemlocks were damaged.

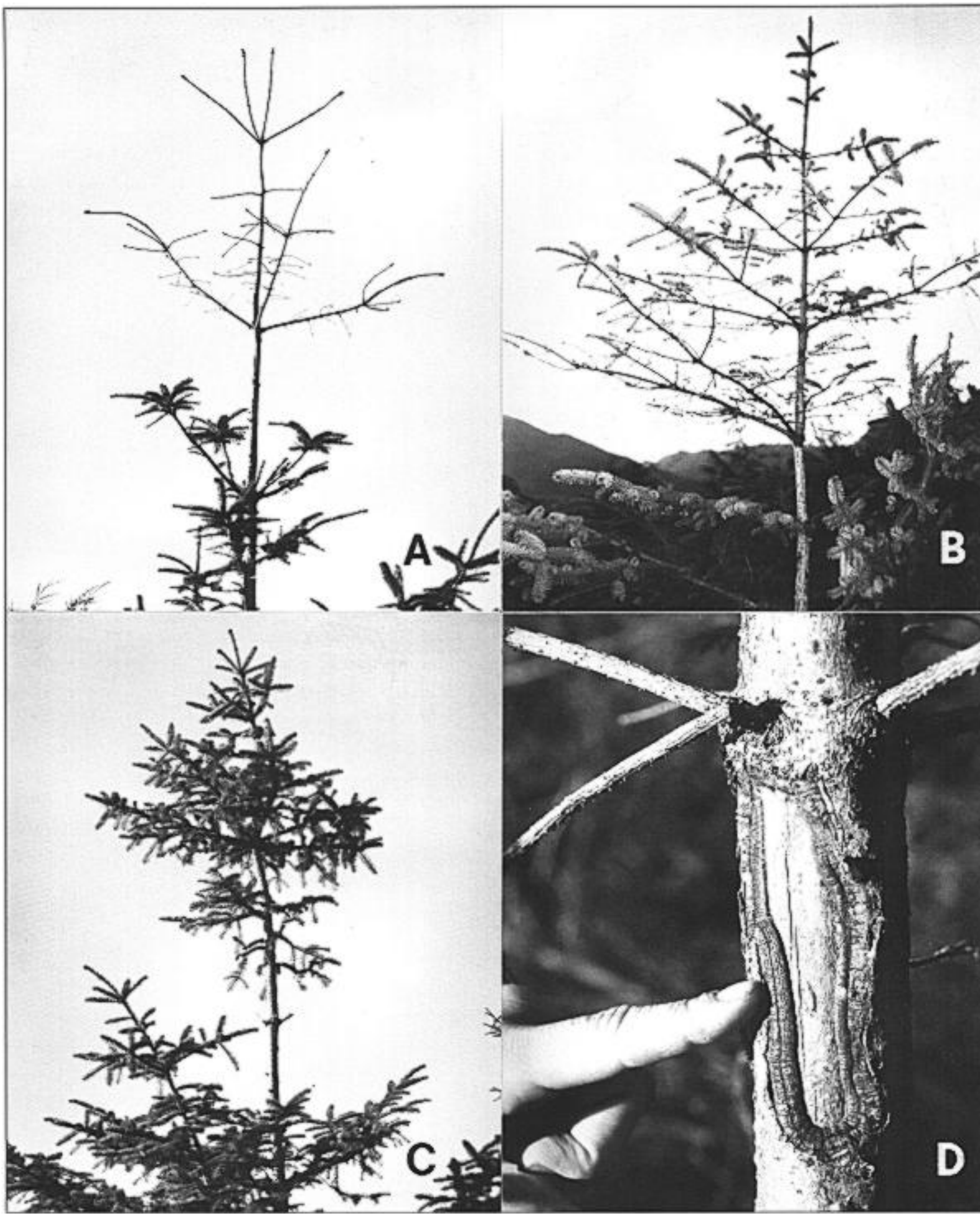

Figure 3. Four categories of porcupine feeding damage to young conifers on Mitkof Island, southeast Alaska. A. Complete girdling of the bole. B. Partial girdle or bole scar. C. Branch clipping. D. Tasting wound on lower bole.

In addition to attacking new trees, porcupines often revisited previously damaged trees; many spruce and hemlock trees sustained repeated damage over the 3 yr monitoring period (Table 2). Of damaged trees, 41% of the spruce and 20% of the hemlock were fed upon more than once (Table 3). Ten percent of the damaged trees were fed upon at least three different times over the course of our 3 yr monitoring period (Table 3).

Levels of porcupine damage were not uniform among sampling sites. In the most heavily affected site, 34% of the sample trees sustained complete or partial girdling. In the sampling site with unthinned stands adjoining a precommercially thinned stand, porcupines fed on only 9% of the trees.

Discussion

Sitka spruce has been the preferred species in many precommercial thinning operations in southeast Alaska. This preference over western hemlock was apparent in our survey transects, where 60% of the plot trees were Sitka spruce. Both species are prolific at re-establishing a cutover site; hemlocks were favored during thinning only when they were taller than

Figure 4. Characteristic teeth marks left in exposed wood after bark removal by porcupines.

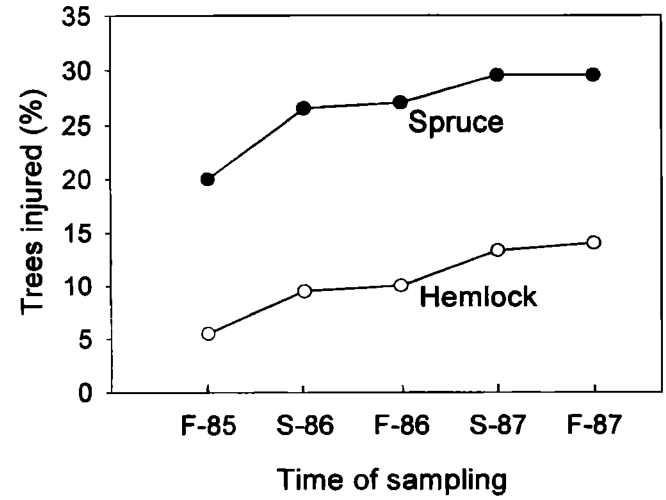

Figure 5. Accumulation of porcupine feeding damage over 5 monitoring periods covering 3 yr. Graph lines represent number of trees with complete or partial girdling of the bole. (F = fall sampling; S = spring sampling).

neighboring spruce. Thus, the average height of hemlock crop trees on our plots was greater than the average height of spruce crop trees.

The preference shown by porcupines for Sitka spruce in our area differs from the observations of Sullivan et al. (1986) in the coastal forests of British Columbia where western hemlock was the preferred host. Regional differences in feeding habits of the porcupine are well documented (Curtis 1944, Roze 1984, Dodge and Borrecco 1992), and local preferences may be based in part on the relative abundance of host plants (Roze 1984). In the young mixed stands studied by Sullivan et al. (1986), western hemlock was far more common than Sitka spruce. Elsewhere in Alaska, a report from Prince William Sound described heavier porcupine damage on western hemlock than on Sitka spruce where hemlock was the predominant stand component (Lutz 1925). We have also observed far more feeding on western hemlock than on Sitka spruce in old forests in southeast Alaska.

Our observation that the tallest (and presumably most vigorous) trees are attacked is consistent with the findings of others (Curtis and Wilson 1953, Van Deusen and Myers 1962, Harder 1979, Sullivan et al. 1986). We found, as did Sullivan et al. (1986), that porcupine feeding generally occurred in the upper boles of trees, where the most nutritious food may be available (Kramer and Kozlowski 1960). As the stands age, we see more feeding on the basal portions of host trees.

Seasonal feeding habits, as determined from spring and fall examinations of the plots, revealed that porcupine damage in north-coastal Alaskan forests follows the same patterns as elsewhere in the country. Virtually all of the feeding damage to conifers on Mitkof Island occurred during the late fall and winter months. Conifers are usually the only food source available to porcupines in the winter, and feeding preferences change in the spring when the animals begin feeding on herbaceous ground vegetation (Dodge 1982).

The long-term effects of porcupine feeding are somewhat difficult to determine. Lightly damaged trees, particularly Sitka spruce, may compensate for a girdled top by having lateral branches assume apical dominance and replace a damaged leader. In cases where trees are re-attacked or where dead leaders extend through most of the crown, feeding damage may produce a permanently deformed tree which continues to occupy the site. Lighter damage in the form of bole scars or partial girdles is associated with reduced radial growth, possibly for as long as 10 yr after the feeding has occurred (Storm and Halvorson 1967). Furthermore, these wounds may become infected by wood decay fungi, possibly leading to substantial loss of wood volume by rotation age. Prediction of future damage is further complicated because a tree's attractiveness to porcupine feeding may change with

Table 1. Porcupine feeding by type of damage in precommercially thinned stands on Mitkof Island, southeast Alaska (October 1985).

Species	Total trees	No. damaged (%)	Complete girdle	Bole scar	Branch clipping	Tasting wound
Spruce	394	135 (34)	52	27	19	37
Hemlock	239	32 (13)	8	5	4	15
Cedar	8	0 (0)	0	0	0	0
Total	641	167 (26)	60	32	23	52

Table 2 Accumulated porcupine feeding in precommercially thinned stands on Mitkof Island, southeast Alaska after 3 yr of observation (October 1987).

Percent species	Total trees	No. damaged (%)	Complete girdle	Bole scar	Branch clipping	Tasting wound
Spruce	394	203 (52)	74	41	26	62
Hemlock	239	63 (26)	13	20	5	25
Cedar	8	0 (0)	0	0	0	0
Total	641	266 (42)	87	61	31	87

time. For example, 23 trees with older "tasting wounds" eventually sustained severe bole scars or were completely girdled 2 or 3 yr later.

The effects of porcupine feeding on a stand are more difficult to determine than the effects on individual trees. Curtis (1941) warned that damage to a stand cannot be estimated from short-term observations, and that projections from individual trees to a stand often will exaggerate the severity of the problem. Our concern for the thinned stands on Mitkof Island is that 3 yr after precommercial thinning nearly 25% of the crop trees in the study area have been partially or complete girdled. Also, these trees have not yet reached pole-size, considered the most susceptible stage to porcupine damage (Shapiro 1949, Curtis and Wilson 1953, Harder 1979). Furthermore, the onset of crown closure, when porcupine feeding declines, is still several years away for many stands on Mitkof Island.

Porcupines are one of the few organisms responsible for tree mortality in young stands in coastal forests. Thus, the effects of porcupine feeding can be viewed from two perspectives. On one hand, timber production is reduced substantially when concentrated porcupine feeding creates openings in the stand. On the other hand, these openings introduce diversity into otherwise relatively homogeneous stands.

In southeast Alaska, porcupine damage is not limited to Mitkof Island. Damaged trees have been observed elsewhere within the porcupine's range including Wrangell Island and Etolin Island (directly southeast of Mitkof Island), and on the mainland around Juneau. Tree damage may be expected to become even more apparent where older stands are harvested and young-growth stands are intensively managed.

Conclusions

Issues that need to be further addressed include whether thinning creates a more suitable habitat for porcupines; how porcupines select hosts, and the population levels associated with porcupine damage. Some reports indicate that human activity has led to increased porcupine feeding by altering the forest environment (Lawrence 1957). We speculate that timber harvesting and subsequent development of young-growth forests favor porcupine populations because of the abundance of young, fast-growing trees that provide a source of winter food. We also speculate that thinning may enhance stand vigor and alter ground cover to favor porcupines. Within an area, the factors controlling tree selection should be examined more closely. For instance, Harder (1979) believes that physical characteristics of trees may be more important than chemical characteristics in determining whether they are selected by porcupines. The feeding we describe as "tasting wounds" may relate to host selection behavior or possibly territorial marking and should be investigated further. In addition, population levels need to be determined to correlate animal numbers with damage and to assess the efficacy of control measures.

Literature Cited

CURTIS, J.D. 1941. The silvicultural significance of the porcupine. J. For. 39:583–594.

CURTIS, J.D. 1944. Appraisal of porcupine damage. J. Wildlife Manage. 8(1):88–91.

CURTIS, J.D., AND A.K. WILSON. 1953. Porcupine feeding on ponderosa pine in central Idaho. J. For. 51:339–341.

DODGE, W.E. 1966. Status of porcupine in western Washington. Publ. Washington For. Protect. Assoc., Seattle. 6 p.

DODGE, W.E. 1982. Porcupine. P. 355–366 *in* Wild mammals of North America, Chapman, J.A., and G.A. Feldhamer (eds.). John Hopkins Univ. Press, Baltimore. 1147 p.

DODGE, W.E., AND J.E. BORRECCO. 1992. Porcupines. P. 253–270 *in* Silvicultural approaches to animal damage management in Pacific Northwest forests. Black, H.C. (ed.). USDA For. Serv. Gen. Tech. Rep. PNW-GTR-287.

HARDER. L.D. 1979. Winter feeding by porcupines in montane forests of southwestern Alberta. Can. Field-Natur. 93(4):405–410.

KREFTING, L.W., J.H. STOECKELER, B.J. BRADLE, AND W.D. FITZWATER. 1962. Porcupine-timber relationships in the Lake States. J. For. 60:325–330.

KRAMER, P.J., AND T.T. KOZLOWSKI. 1960. Physiology of trees. McGraw-Hill Book Co., New York. 642 p.

LAWRENCE, W.H. 1957. Porcupine control: A problem analysis. For. Res. Notes, Weyerhaeuser Co., Centralia, WA. 43 p.

LUTZ, H.J. 1925. The voracious porky. USDA For. Serv., Serv. Bull. 9(49):11–12.

MEEHAN, W.R. 1974. The forest ecosystem of southeast Alaska. Wildlife habitats. USDA For. Serv. Gen. Tech. Rep. PNW-16.

Table 3. Incidence of all forms of porcupine feeding during 3 yr of observation on Mitkof Island, southeast Alaska.

Host	Total no. trees	Trees not damaged	Total	Damage frequency: Once	Twice	Three times
Sitka spruce	394	191	203	120	63	20
Western hemlock	239	176	63	50	11	2
Total	633	367	266	170	74	22

Reeks, W.A. 1942. Notes on the Canada porcupine in the Maritime Provinces. For. Chron. 18:182–187.
Ruth, R.H., and A.S. Harris. 1979. Management of western hemlock-Sitka spruce forests for timber production. USDA For. Serv. Gen. Tech. Rep. PNW-88.
Roze, U. 1984. Winter foraging by individual porcupines. Can. J. Zool. 62:2425–2428.
Shapiro, J. 1949. Ecological and life history notes on the porcupine in the Adirondacks. J. Mammal. 30:247–257.
Smith, G.W. 1982. Habitat use by porcupines in a ponderosa pine/Douglas-fir forest in northeastern Oregon. Northwest Sci. 56:236–240.
Spencer, D.A. 1964. Porcupine population fluctuations in past centuries revealed by dendrochronology. J. Appl. Ecol. 1:127–149.
Storm, G.L., and C.H. Halvorson. 1967. Effect of injury by porcupines on radial growth of ponderosa pine. J. For. 65:740–743.
Sullivan, T.P., W.T. Jackson, J. Pojar, and A. Banner. 1986. Impact of feeding damage by the porcupine on western hemlock-Sitka spruce forests of north-coastal British Columbia. Can. J. For. Res. 16:642–647.
Van Deusen, J.L., and C.A. Myers. 1962. Porcupine damage in immature stands of ponderosa pine in the Black Hills. J. For. 60:811–813.