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TECHNICAL
REPORT R10-86-1

PORCUPINE DAMAGE ON MITKOF ISLAND

PRELIMINARY REPORT

APRIL 1986

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ABSTRACT

In recent years porcupine damage has been noted in precommercially thinned conifer stands on Mitkof Island. In the fall of 1985 a series of monitoring plots were established in some heavily affected stands to assess present damage and to provide a means for evaluating future trends in damage. This report describes survey procedures used on Mitkof Island and presents baseline damage information. Porcupine damage was noted on about 25% of the 640 trees on the sampling plots. Porcupines showed a preference for Sitka spruce (33% of trees damaged) over western hemlock (15% of trees damaged) and damaged spruces were slightly taller than undamaged ones.

INTRODUCTION

The porcupine *Erethizon dorsatum* (Appendix A) is a transcontinental species that occurs throughout the forests of North America. Within this range, the porcupine utilizes many species of hardwoods and conifers as its principal source of winter food. Porcupines feed on the succulent inner bark of host trees, often causing top-kill or stem deformation and a subsequent reduction in timber values. In many areas foresters have had to undertake control measures to reduce porcupine numbers and damage to the forest resource.

Since the late 1950's, over 15,000 acres of commercial forest have been harvested on Mitkof Island in central Southeast Alaska (Figure 1). Much of that harvesting has taken place since the mid-1960's, and Mitkof Island now has extensive second-growth conifer stands in the 10- to 20-year old age class. Precommercial thinning has been carried out in many of the young stands, with nearly 4,000 acres thinned since 1978.

In recent years USDA Forest Service personnel have noted porcupine damage on crop trees in thinned stands throughout Mitkof Island. At the request of the Petersburg Ranger District, the Forest Pest Management staff carried out preliminary field work to assess present damage levels and to establish the means for following trends of porcupine damage in the future. The purpose of this report is to present baseline damage data on monitoring plots which were established in some heavily affected young-growth stands.

LEGEND

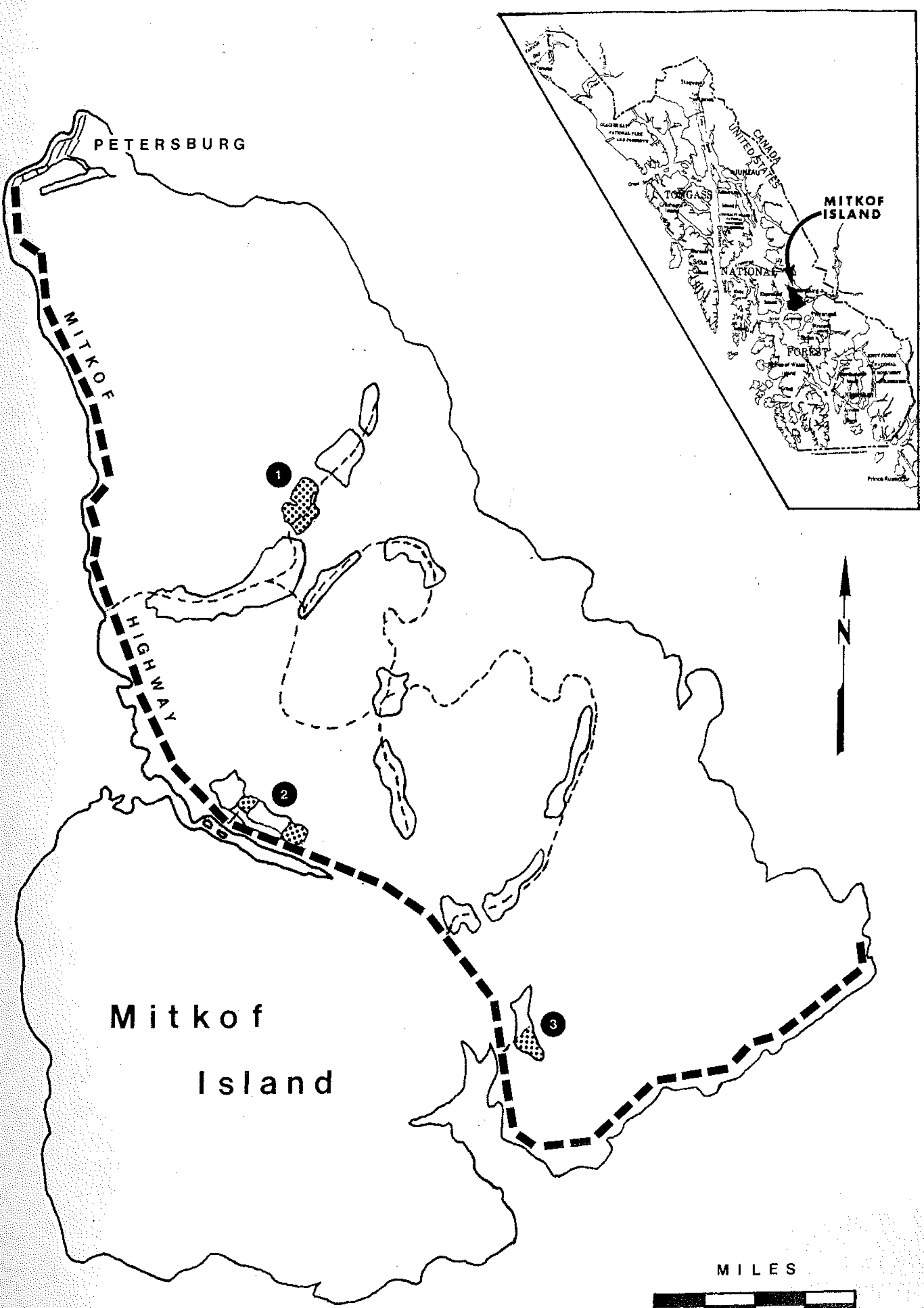
Thinned stands

Stands sampled for porcupine damage and enlarged in Figures 2, 3, and 4

Mitkof Highway

Secondary and logging roads

Figure 1. Young-growth conifer stands precommercially thinned on Mitkof Island including those sampled for porcupine damage. October 1985


PETERSBURG
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METHODS

Plot establishment

Recently thinned stands in three areas were selected in late October, 1985 for examination of porcupine damage[1]. The three sampling areas are shown in Figure 1 and are referred to as Engineer's Camp (Area 1), Blind Slough (Area 2) and Olson's Dump (Area 3). Engineer's Camp and Olson's Dump were considered by Petersburg RD personnel as being among the most heavily affected stands on Mitkof Island (J. P. Wisman, 1985, personal communication). Based on aerial photography, Unit #6 at Blind Slough was also considered to be seriously damaged. These sampling areas were selected to represent the most extreme present for assessing porcupine damage on Mitkof Island. The final area, Unit #3 at Blind Slough represented the other extreme, being almost devoid of porcupine damage following a recent thinning. We felt that this area might be susceptible to future damage by porcupines migrating in from lightly thinned neighboring stands. We chose Unit #3 to provide a contrast in damage trends between heavily affected and relatively unaffected stands. In each area, line transects were located either along a logging road or at a specific compass bearing, and sampling plots were established at intervals along these transects. The specific locations of the transects are shown in Figures 2-4 and more detailed characteristics of each sampling area are given below:

Table 1

Stand characteristics of sites on Mitkof Island surveyed for porcupine damage

Site No.	Site Location	Comp/ stand (#)	Clearcut size (ac)	Stand age (yrs)	Year thinnned	Thinning spacing (ft)	Slope (%)	Aspect
1.	Eng. Camp (north)	70/3	95	12	1985	12x12	35	SE
1.	Eng. Camp (west)	70/3	95	12	1985	12x12	25	SE
2.	Blind Slough #3	74/3	30	16	1985	12x12	30	SW
2.	Blind Slough #6	74/6	59	20	1980	10x10	60	SW
3.	Olson's Dump	76/9	85	18	1985	12x12	40	SW

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[1]We gratefully acknowledge the participation of Petersburg RD personnel Phil Wisman, Jim Tambling, and Rick Wessler in the plot establishment procedure.

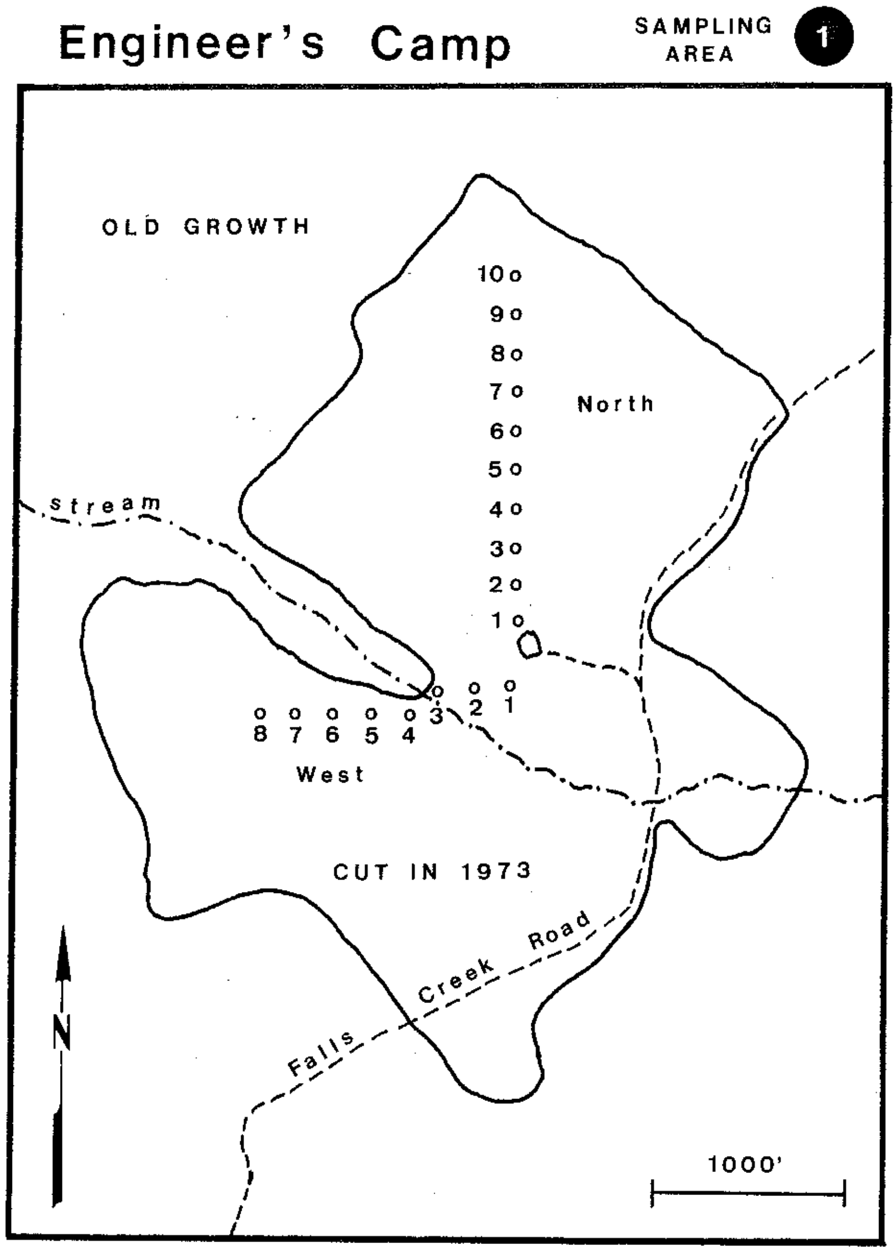

Figure 2. Location of transects and sampling plots for monitoring porcupine damage at Engineer's Camp (Area 1), Mitkof Island, October 1985

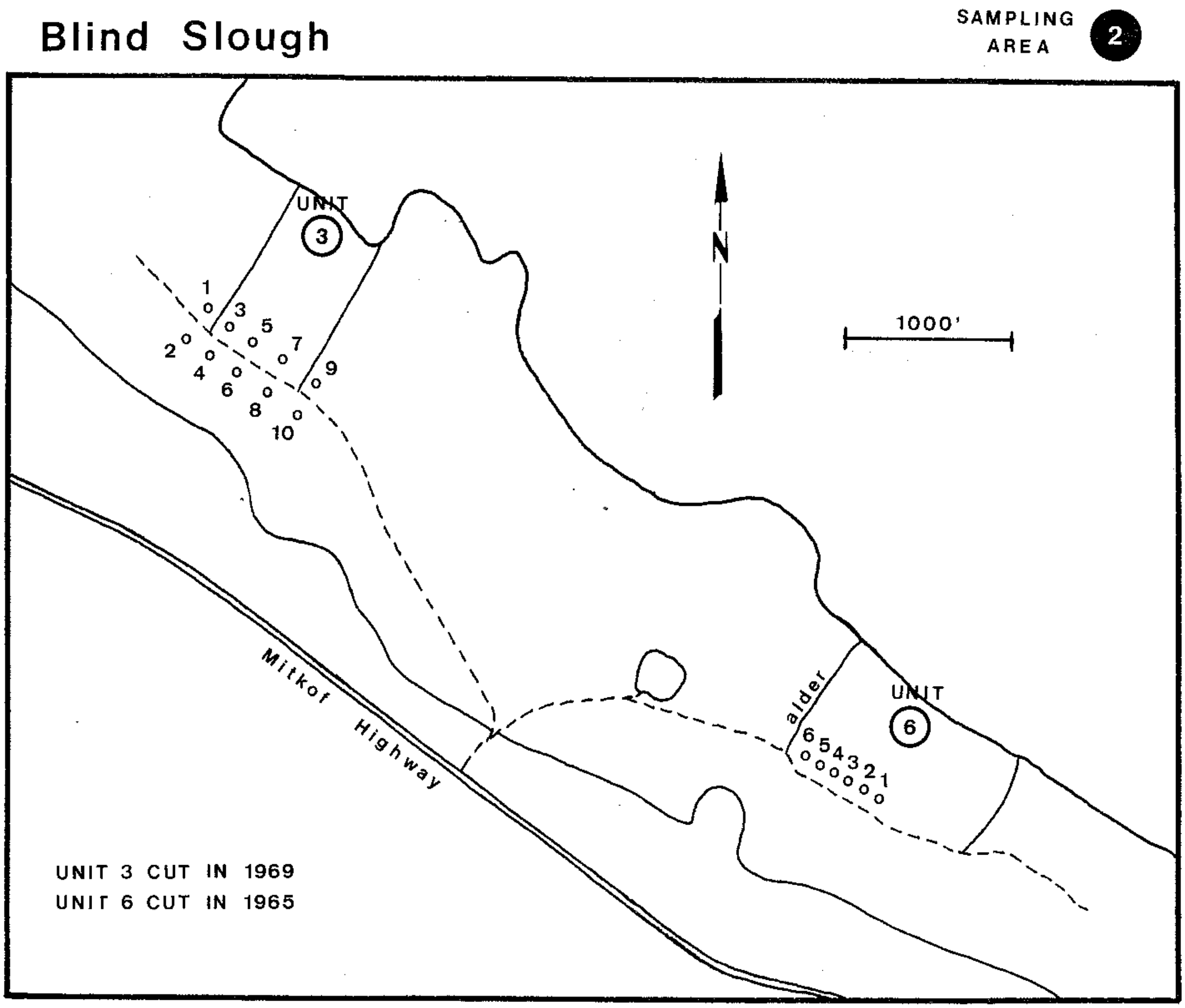

Figure 3. Location of transects and sampling plots for monitoring porcupine damage at Blind Slough (Area 2), Mitkof Island, October 1985

Olson's Dump

SAMPLING AREA 3

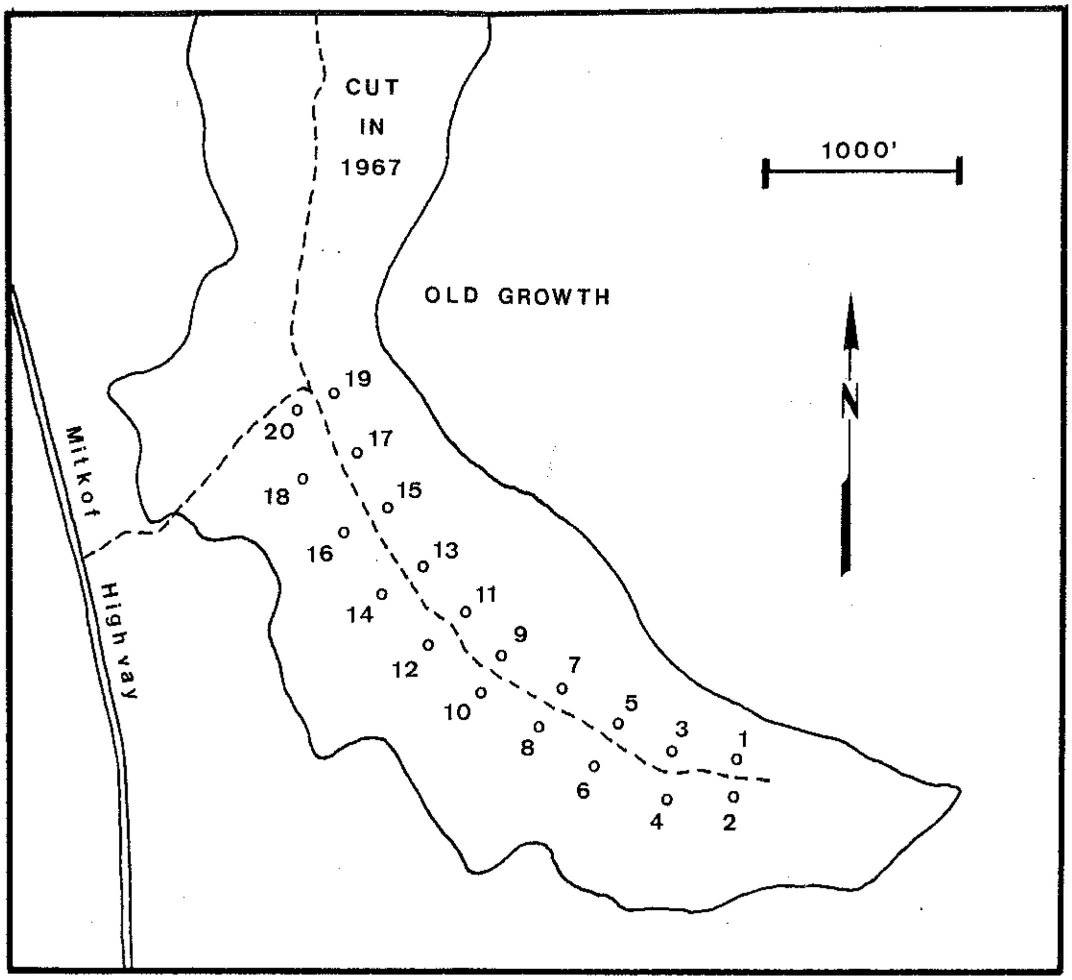

Figure 4. Location of transects and sampling plots for monitoring porcupine damage at Olson's Dump (Area 3), Mitkof Island, October, 1985

Sampling plots were generally 1/20-acre in size, but were occasionally adjusted to 1/40-acre or 1/10-acre to compensate for irregular stocking. In Area 1 (Engineer's Camp) (Figure 2), all plots along the north and west transects were 1/20-acre in size and were spaced at 200-ft intervals. The 18 plots in Area 1 contained 217 trees and represented a 0.45% sample. At Blind Slough (Area 2) (Figure 3), the logging road served as the transect and all plots were located 100 feet into the stand from the road. The stands bordering Blind Slough Unit #3 (Figure 3) had been thinned more lightly than Unit #3; thus the four plots outside Unit #3 were reduced to 1/40-acre while plots # 3-8 were 1/20-acre in size. These 10 plots contained 121 trees representing a 1.3% sample. In Unit #6 of the Blind Slough sampling area, all plots were 1/40-acre in size due to heavy stocking. The sampling intensity was 0.25% with 58 trees on six plots. In Area 3 (Olson's Dump), the old logging road served as the sampling transect. The road was divided into 350-ft intervals; a plot was established 100 feet above and 100 feet below the road at each point (20 plots total). 245 trees were examined in this area, representing a sample of 1.2%.

At each plot we flagged the center with striped ribbon and measured the plot perimeter after selecting the appropriate radius (1/20-acre = 26.3'; 1/40-acre = 18.6'; 1/10-acre = 37.2'). We flagged a low branch nearest the plot center for each tree within the circular plot and wired a small numbered aluminum tag onto the branch near the flagging. We also recorded species, estimated total height to the nearest foot, and examined the entire stem for evidence of porcupine feeding. Damage was described in sufficient detail to insure that any additional porcupine feeding in the future could be detected. Where tops had been girdled, the length of dead leader was estimated to the nearest foot. The length and circumference of bole scars were also noted, along with their position on the tree with respect to cardinal direction and distance above the ground. Branch clipping (small branches in the upper crown that were apparently removed by porcupines) was noted and described by position in the crown.

<u>Monitoring schedule</u>: The plots are to be re-examined at six-month intervals beginning in late April 1986. Literature on porcupine biology (see Appendix) suggests that porcupines have seasonal variation in food resources. A spring and fall monitoring schedule will allow us to identify and compare seasonal differences in porcupine feeding damage between winter and summer.

RESULTS AND DISCUSSION

The total number of plot trees on the transects and incidence of porcupine feeding are shown in Table 2 for each sampling area.

Table 2

Total number of plot trees[1/] and incidence of porcupine feeding on transects in three sampling areas, Mitkof Island, October 1985

Area	Total Tagged trees ---(No.)---				Trees with porcupine feeding ---(No.)---			Percent Damaged
	SS	WH	R/YC	Tot	SS	WH	Tot	
1 Engineer's Camp W	74	22	-	96	25	1	26	27.1
1 Engineer's Camp N	104	17	-	121	15	-	15	14.4
2 Blind Slough #3	56	65	-	121	9	2	11	9.1
2 Blind Slough #6	27	31	-	58	14	4	18	31.0
3 Olson's Dump	134	103	3/5	245	65	15	80	32.7
Total	395	238	8*	641	128	22	150	23.4

*None of these cedars had been damaged by porcupines

1/ SS=Sitka spruce, WH=western hemlock, R/YC=western redcedar or Alaska-cedar

Over 600 trees have been tagged on the monitoring plots in the three sampling areas. Although Sitka spruce represents 62% of the total trees, there is considerable variation in stand composition between sampling areas. In Blind Slough western hemlock is slightly more common than Sitka spruce, while at Engineer's Camp, spruce represents 83% of the total plot trees (Table 2). Tree heights of the plot trees, independent of porcupine damage, are as follows: spruce averaged 13.9 $\pm$ 6.5'; western hemlock 16.0 $\pm$ 6.5'; western redcedar 9.7 $\pm$ 5.1"; Alaska-cedar 8.4 $\pm$ 2.6'. The plots contain only eight cedars, all at the Olson's Dump site. Porcupine feeding was noted on nearly one-quarter of all plot trees, with Sitka spruce being preferred over western hemlock and the cedars (Table 2). Damage levels are presently highest at the Olson's Dump site and Blind Slough Unit #6, where nearly one-third of the crop trees have some form of feeding by porcupines.

General observations on porcupine feeding

Porcupine feeding appears to be concentrated in distinct clumps throughout most of the affected stands. A clump might consist of 15-20 neighboring trees, each with some level of bole scarring. These patches or clumps are believed to be associated with denning sites and each clump may be the work of a single porcupine.

Several types of porcupine damage were recognized during the plot establishment. The most common (and most severe) 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 these cases, the bark was often completely stripped from the bole for a length of two to three feet. Many trees showed evidence of repeated attacks by porcupines. A common symptom of this revisitation was a brown top caused by previous girdling, with slightly off-color foliage in the crown directly below the girdle. This more recent discoloration was attributed to a second girdling lower on the main stem. Another common type of damage was termed "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 and for a vertical distance of 5 to 6 feet without killing the main stem. More commonly, bole scars covered about one-half of the circumference of the main stem and ranged from 6" to 2' of vertical distance up the bole. Unlike girdling which seemed to occur high in most trees, bole scars were found at all positions along the main stem.

On some trees (<3%) branches had been clipped near the distal end. Where such porcupine feeding had occurred repeatedly, the branches appeared bushy and resembled heavy infections by dwarf mistletoe. Some authors believe that branch clipping is most common near denning sites and that the foliage from the clipped branches is used to feed the young porcupines. The final category of porcupine feeding was a small wound on the bole, generally about 2" x 3" and usually three to four feet 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 believe that they were sampling bites taken on trees which were subsequently rejected by porcupines as unsuitable food. Many of the trees on our transects had more than one type of damage.

Some trees (predominantly hemlocks) showed evidence of old damage, either as old callused tasting wounds or as bayonet tops resulting from death of the original terminal bud. In most cases, recovery from these old wounds appeared to be very good, especially if the trees were not subjected to additional porcupine attack.

The specific types of porcupine damage are shown for each area in Table 3. Of the 150 damaged trees, nearly 40 have more than one type of porcupine feeding. The data in Table 3 are presented in a hierarchical manner, so that the most severe type of damage takes precedence, and lesser damage is not considered. For example, the number of trees with bole scars would be higher if we added in girdled trees which also have partial girdles as a lesser level of damage. Along the same lines, bole scars are considered more serious than branch clipping, and trees with both forms of feeding would be included under the "partial girdle" category. The tasting scars are the lowest damage type in the hierarchy, and trees in this category had no other type of porcupine feeding.

Table 3

Porcupine damage in young growth stands at different sites on Mitkof Island

Site (No.)	Total Trees[1/] Damaged		Type of Damage: Complete Girdle	Partial Girdle	Branch Clip'g	Taste Scars
			---No.---			
1. Eng. Camp (W)	SS	25	6	5	4	10
	WH	1	0	0	0	1
1. Eng. Camp (N)	SS	15	1	4	3	7
	WH	0	0	0	0	0
2. Blind Slough #3	SS	9	4	4	1	0
	WH	2	1	1	0	0
2. Blind Slough #6	SS	14	8	3	0	3
	WH	4	0	1	0	3
3. Olson's Dump	SS	65	32	8	9	16
	WH	15	7	2	0	6
Total	SS	128	51	24	17	36
	WH	22	8	4	0	10

[1/] SS=Sitka spruce, WH=western hemlock

Over one-third of the damaged trees had sustained complete girdling of the main stem, generally in the upper portion of the bole. Girdling was more common on spruce than on western hemlock and was most prevalent in the Olson's Dump area (Table 3). The average length of dead leaders on girdled trees was fairly consistent in four of the five sampling areas. Both spruce and hemlock averaged around 8' of dead leader, or about the top 60% of the total height for those trees girdled by porcupines. The most heavily affected area was Blind Slough Unit #6 where eight girdled spruces averaged 22 feet of dead leader, representing 77% of their total height. Partial girdles (bole scars) were the most serious form of porcupine damage on another 18% of the trees and, once again, were more common on spruce than on hemlock. Many of these trees may eventually be girdled completely with additional feeding by porcupines.

Branch clipping was often associated with partial or complete girdling (13 trees), and on 17 other trees it was the major form of porcupine damage. This feeding activity was noted exclusively on Sitka spruce.

Nearly one-third of all damaged trees contained nothing more than tasting wounds. It is possible that these trees have already been rejected as unsuitable food, and may not be further damaged. The occurrence of similar older callused wounds on other trees leads us to speculate that damage on these "tasted" trees may not intensify although we can't be sure that as these trees grow older, they won't eventually become attractive to porcupines. It is interesting to note that in proportion to their occurrence, hemlocks were "tasted" more often than spruce (Table 3).

The incidence of all types of damage is shown in Table 4, which combines data from all stands. As the table shows, spruce was damaged at a significantly higher level than hemlock regardless of the type of damage. Interestingly, however, the presence of older scars was more common on hemlock than on spruce.

Table 4

Percent 1/ of spruce and hemlock with various types of porcupine damage

Damage 2/	Spruce	Hemlock
	%	
No damage	67	85
Any porcupine damage	33	15
Types of damage: 3/		
Complete girdle	13	3
Partial girdle	11	3
Taste scar	11	4
Branch Clipping	7	<1
Old scar	1	13

1/ Total may add to more than 100% for each species since some trees had several types of damage

2/ Significant difference in percent trees damaged (combining all types of porcupine damage) between spruce and hemlock, tested with chi square (p=0.05)

3/ Significant difference in percent trees damaged for different types of damage between spruce and hemlock, tested with chi square (p=0.05)

The relationship between porcupine damage and tree height is shown in Table 5, which summarizes the data from all stands. For Sitka spruce, damaged trees were generally significantly taller than undamaged ones. For western hemlock, porcupines selected significantly smaller trees.

Table 5

Tree heights of porcupine damaged and undamaged spruce and hemlock on Mitkof Island

	Tree Heights[1/]	
Damage type	Spruce	Hemlock
	----------feet----------	
No damage	12.9 ± 6.0	16.0 ± 6.4
Complete girdle	16.4 ± 8.3[2/]	11.9 ± 5.6[3/]
Partial girdle	18.9 ± 8.3[2/]	12.9 ± 5.0[3/]
Taste scar	16.5 ± 6.2[2/]	19.6 ± 4.5
Branch Clipping	14.6 ± 7.0	16.0 ± 0.0
Old scar	11.5 ± 2.5	16.4 ± 6.6

[1/] Mean ± standard deviation

[2/] Damaged trees were significantly taller than undamaged trees of the same species

[3/] Damaged trees were significantly shorter than undamaged trees of the same species

Impact on the stand

The effect of porcupine damage on a stand basis is difficult to assess at this time. On the positive side, many trees appear to recover from porcupine damage or to compensate for it by having lateral branches assume dominance when the leaders are girdled. However, porcupines often revisit the same trees and repeated attacks sometimes cause death of the tree. Natural reseeding may lead to replacement of a dead tree but the subsequent stand would be composed of mixed ages with prolonged rotation age. The worst case would be where a badly deformed tree continues to occupy the site for part or all of the rotation and the site is essentially lost for timber production. The clumping pattern of porcupine activity is also a very undesireable feature from a timber production standpoint. The opening created by removal of 10-15 neighboring trees may be temporarily lost to competing understory vegetation.

The long-term effects of wood decay in trees scarred, but not killed, may be an important factor when evaluating damage caused by porcupines. Wounds allow wood-decay fungi to infect exposed wood and begin the long process of wood decay. Trees wounded and infected at a young age may have a considerable amount of decayed wood by rotation age.

The most important question to be addressed is the one relating to future damage in the affected stands. In other areas where porcupines are a problem, workers have found that pole-sized trees (4-10 inches dbh) appear to be the most heavily damaged (Shapiro 1949, Curtis and Wilson 1953, Harder 1979) and that porcupine feeding decreases after crown closure. Most of the stands on Mitkof Island would probably remain susceptible for several years to come, and cumulative damage over the years may become intolerable if porcupines remain active in the area. Curtis (1941) states that damage to a stand cannot be estimated by short-term observations, and that projections from individual trees to a stand will often exaggerate the severity of the problem. We hope that, with a long-term examination of the porcupine problem through our transects on Mitkof Island, we will be able to address the question of stand impact in a meaningful way.

Future work

The plots will be monitored on a semi-annual basis with visits to the field in late April and late October. These spring and fall observations will allow us to compare winter and summer feeding patterns in the thinned stands.

Other questions to be addressed include the levels of porcupine population, host selection mechanisms, and the relationship between thinning and the level of porcupine damage. The fact that porcupines migrate between seasons and while foraging makes population assessment somewhat difficult. Spencer (1964) believes that the compact damage pockets may serve as indicators of the number of porcupines in an area (with one porcupine per clump). The selection criteria used by porcupines should be investigated. The preference by porcupines for large, fast-growing trees has been widely reported (Harder 1979, Rudolf 1949) and was noted on our Mitkof Island transects as well. Where many species grow closely together, the porcupines do exercise some choice (Curtis 1941) and these preferences will vary regionally. For instance, western and mountain hemlock were reported as preferred species in Prince William Sound, while Sitka spruce seems to be preferred in Southeast Alaska. Harder (1979) states that physical characteristics of these trees may be more important than chemical characteristics in determining whether or not they are selected by porcupines.

The relationship between thinning and the intensity of porcupine damage is an important question to be addressed. In other areas it has been shown that damage is most severe in young thinned stands (Van Deusen and Myers 1962, Dodge and Canutt 1969). Damage in a precommercially thinned stand certainly is more conspicuous and costly than in a natural stand, and if stand vigor is increased by thinning, then proportionately more trees may become attractive to porcupines. It should be determined if porcupines migrate into freshly thinned stands from neighboring natural stands. As thinning activities increase in areas within the range of the porcupine (see Figure 5 in Appendix), the problem could intensify to include other islands in the Stikine Area and young stands on the mainland.

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APPENDIX

Porcupine
Erethizon dorsatum

GEOGRAPHICAL DISTRIBUTION: The porcupine occurs throughout most of North America including Alaska, all the Canadian provinces, the western half of the United States, the Lake States, and northeastern U.S. In southeast Alaska, the porcupine is found throughout the mainland and adjoining islands except for Prince of Wales, Admiralty, Baranof, and Chichagof Islands (see Figure 5).

HABITAT AND PREFERRED HOSTS: Habitats occupied by the porcupine include the open tundra of Alaska and Canada, the desert chapparal of northern Mexico (Dodge 1982), and most of the forested areas in western and northeastern United States. Across their broad geographic range, porcupines feed on a wide variety of plants including agricultural crops, herbaceous plants, shrubs, and many species of trees. Specific host preferences vary with geographical location and with vegetative types (Smith 1982). In the northeastern United States and Canada, eastern hemlock (*Tsuga canadensis*), the larches (*Larix* spp.), spruces (*Picea* spp.), and balsam fir (*Abies balsamea*) are the preferred conifers along with many hardwoods including sugar maple (*Acer saccharum*), red maple (*A. rubrum*), oak (*Quercus* spp.), beech (*Fagus grandifolia*), and birch (*Betula* spp.) (Dodge 1982). Many pine species are heavily damaged in the Lake States and further west where ponderosa and pinyon pines (*Pinus* spp.) are favorite winter foods of the porcupine. Although a population may have a wide range of favorite trees, individuals within the population may confine their feeding activities to one or two species (Roze 1984).

BIOLOGY: *Description*: The porcupine is the second largest rodent in North America. Adult porcupines range in size from 13 to 25 pounds, with females usually being smaller than males. They are protected by a dense coat of quills covering the tail and the entire body with the exception of the underside. Porcupines depend heavily on their sense of smell, which seems to be more well-developed than their sight and hearing. Although they appear slow and awkward, porcupines can move fairly rapidly along the ground and are very adept at climbing trees. They use their tails to aid in climbing, and possess a good sense of balance which enables them to climb far into the tops of trees and onto lateral branches.

Life cycle: Porcupines normally live for 5-7 years in the wild, and are able to reproduce in their second year. Breeding takes place in the fall (September to December) and females give birth to a single young in spring (April to June) following a gestation period of seven months. Females outnumber males in a population, but virtually all females give birth each year since porcupines are polygamous.

Feeding habits: Porcupines change their feeding habits dramatically from one season to another. In the spring, the animals slowly migrate to meadows to seek out succulent ground vegetation. Riparian and wetlands plants are a

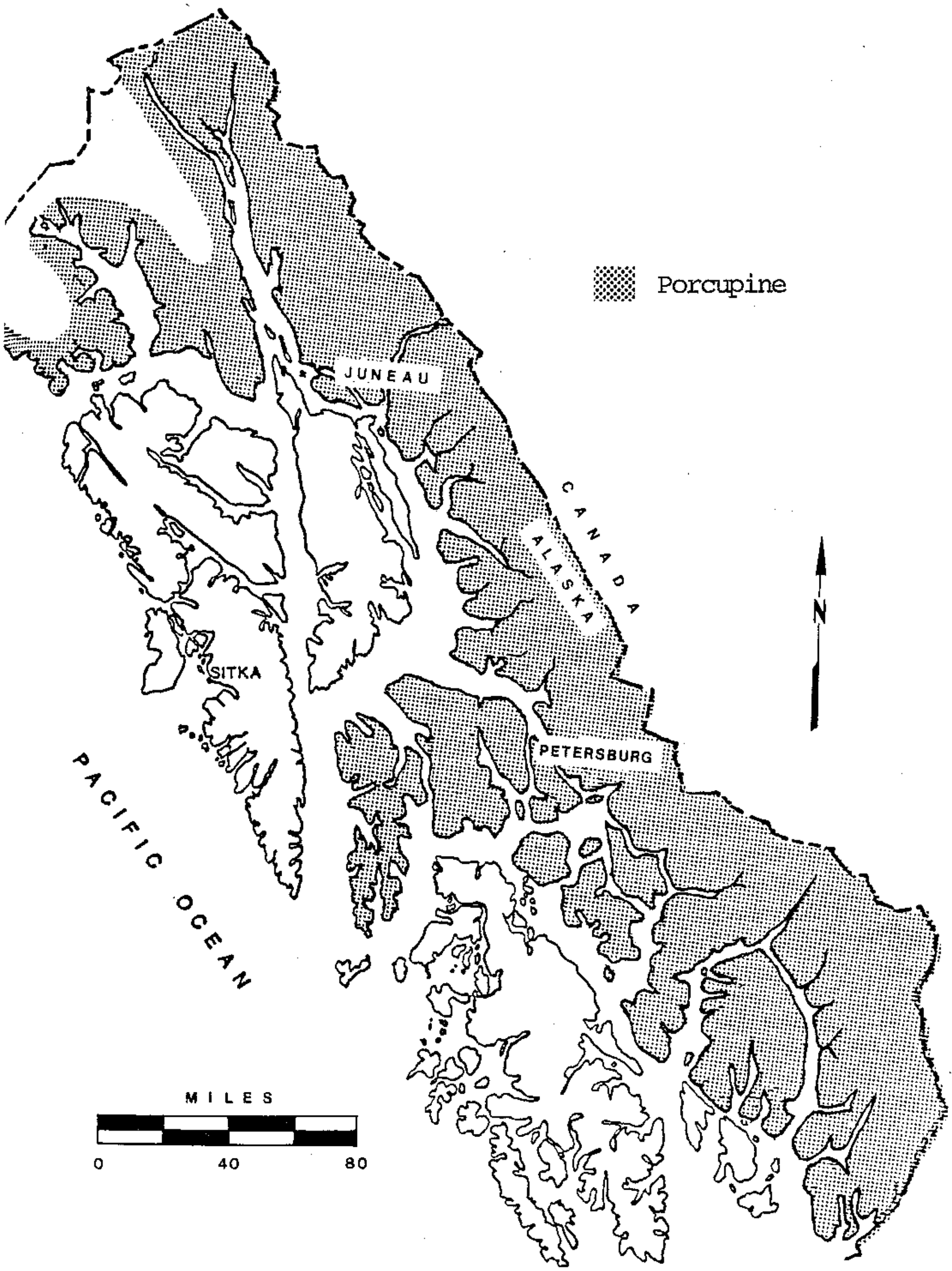

Figure 5. Distribution of the porcupine Erethizon dorsatum in southeast Alaska (From Alaska Department of Fish and Game, 1977. A fish and wildlife inventory of southeastern Alaska. Vol. 1, 239 pp.)

primary spring and summer food, along with freshly emerging leaves of shrubs. The summer feeding range of porcupines seems to be fairly broad, with average daily movements of nearly 300 meters (635 feet) being recorded in some coastal forests (Smith 1979). Movements during the summer sometimes appear fairly random although porcupines do travel along well-established routes. As ground vegetation dies out in the fall and as vegetables and fruits ripen, porcupines change their feeding habits to incorporate these plants. Late in the fall, a fairly rapid movement takes place back to the forest, where the foliage and bark of trees become the predominant food sources. In the winter, porcupines greatly restrict their movements and feed principally on the bark of trees near denning sites. Dens usually are found in rock outcrops although any protected area such as a windthrow or hollow log may be utilized. According to some authors, porcupine dens are rarely found on northern exposures. Dens are rarely occupied by more than one porcupine at a time, although many porcupines may utilize the same den during their migrations. Some porcupines use "station trees" instead of dens, and may spend an entire winter in these trees with coarse branches which afford protection and shelter to the animal.

Population densities: The number of porcupines in a given area tends to fluctuate greatly, depending on the season and on food availability. It is generally recognized that porcupines are solitary animals and occur in low numbers except for temporary concentrations due to a local food supply. Spencer (1950) estimates that under favorable conditions the density reaches one animal per five acres. Others have reported numbers ranging from 3 to 15 porcupines per square mile (Taylor 1935). The winter home range in North Dakota and the Adirondacks in New York was determined to be about 13 acres per animal. Through dendrochronological studies there are some indications of population cycles with 10 years between the end of one decline and the beginning of another increase (Spencer 1964).

Natural control factors: Although porcupines are known to be afflicted with a number of parasites and diseases, mortality from these agents appears to be of little consequence as a population control (Lawrence 1957). Among several predators, the fisher (*Martes pennanti*) appears to be the most effective, and has been successfully reintroduced in many states to control the porcupine (Dodge 1982, Earle and Kramm 1982).

IMPACTS ON FORESTRY: Most studies on the impact of porcupine feeding on forestry have dealt with individual trees and the short-term assessment of damage. Some damage appraisals have identified percentages of trees in a stand with permanent damage and have ascribed a dollar value to these "losses". There are few reports of permanent damage to more than 25% of the stand, and those losses were incurred early in the development of the stand with future stocking levels not being taken into account. Partially girdled trees do experience radial growth loss for a number of years after being attacked by porcupines, so that the effects are not entirely limited to total girdling or tree mortality. An accurate assessment requires the knowledge of how affected stands respond to porcupine feeding, whether or not damage occurs predominantly in young stands, and whether or not additional commercial thinning is to be done before the final harvest.

POPULATION CONTROLS: Various measures have been undertaken to control porcupine numbers. Among the more prominent are trapping, poison baiting, and hunting. Porcupines do not lend themselves readily to trapping, and are usually caught inadvertently in traps meant for other animals. Poison baiting, although somewhat effective in the past, has fallen out of favor as a control method. The U. S. Fish & Wildlife Service no longer recommends this method due to the lack of specificity of strychnine poisons, and due to the potential for misapplication. Hunting is recognized as the most acceptable method of porcupine control, especially if it can be done in conjunction with other activities such as timber cruising. In the fall, porcupines may concentrate after sunset near crops, in natural openings, and along road embankments where they are easy prey for the hunter. Winter hunting is far more successful than summer hunting due to ease in tracking animals through the snow and to their tendency to be more concentrated. Since their feeding at that time is in trees, they are more readily located than in the summer when they migrate and are on the ground. Hunting should be done in the early evening when porcupines are most active and most readily apprehended.

The introduction of fishers has proven effective in some areas in reducing porcupine numbers, but requires a thorough understanding of the ecological requirements of these animals.

The indirect control of porcupines through habitat manipulation has been suggested (Lawrence 1957). Such an approach to control would require considerable additional knowledge of local porcupine behavior, preferred habitats, and would be predicated on losses being at unacceptable levels requiring control.