MARTEN USE OF CLEAR-CUTS AND RESIDUAL FOREST STANDS IN WESTERN NEWFOUNDLAND

By
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TABLE OF CONTENTS

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The objectives of this study were to determine 1) if stage of regeneration in clear-cuts influenced use by marten (Martes americana); 2) if size of residual balsam -fir (Abies balsamea) and black spruce (Picea mariana) stands was related to their use by marten; and 3) which habitat variables characterized successful trap sites. Habitat use by marten was investigated by livetrapping and snow tracking. Residual stands were classified into five size categories and clear-cuts into three categories baser on height of balsam fir regeneration.

From June to December 1983, marten were trapped in 43 residual stands and 35 clear-cuts. A total of 3,587 trap-nights yielded 57 captures of 10 male and 8 female marten. Six (10.5%) captures were in clear-cuts, all less than 8 years old; 51 (89.5%) marten were captured in residual stands. Capture rates were greater in larger residual stands. Only five captures were in residual stands <15 ha.

From January to March 1984, marten tracks were followed for 29 km..Although clearcuts represented 41% of the study area, only 26% of marten travel was recorded here, all in clear-cuts <10 years old. Residual stands and undisturbed forest composed 46% of the study area; 74% of marten travel was recorded in these forested habitats. These data indicate that marten seldom use clear-cuts, or residual stands <15 ha, but de use larger residual stands. Management recommendations are discussed.

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Bowater (Newfoundland) Limited were very cooperative in allowing us access to the study area, use of maps and aerial photographs, and providing us with accommodations for the fall and winter.

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LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Marten (Martes americana), inhabitants primarily of undisturbed, dense coniferous or mixed forest throughout North America, are now less widely distributed and less abundant (Strickland et al. 1982). Loss of large areas of old-growth coniferous habitat because of harvesting and fire and excessive trapping of marten, have been cited as major reasons for this decline (de Vos 1952; Koehler and Hornocker 1977; Mech and Rogers 1977).

Marten had a wide distribution in most forested regions of Newfoundland, however they are now restricted to isolated areas of mature forest in the western part of the province (Bergurud 1969). Although marten were once trapped commercially in Newfoundland, Skinner (1979) reported that they were never abundant. The marten trapping season was closed in 1934 because of declining populations. Despite complete protection since then, marten numbers and distribution have not increased markedly. Accidental trapping and snaring, and habitat alteration may be responsible. Limited prey base and the low reproductive rate of marten probably result in a slow recovery from low population densities.

Research on marten in Newfoundland is limited. The Newfoundland Wildlife Division conducted a distributional study in 1982 and 1983, which showed that the Little Grand Lake area is one of the few areas that contain a remnant marten population. Bateman (1982) investigated habitat use by marten in winter in western Newfoundland and reported that marten preferred old-growth balsam fir (Abies balsamea) / black spruce (Picea mgriana) and balsam fir / white birch (Betula papyrifera) forests with dense overhead cover.

Studies conducted elsewhere have shown that timber harvesting, especially clear-cutting, is detrimental to marten populations. Marten densities in commercially clear-cut areas in Maine were 2/3 less than those in partially-cut and undisturbed forests (Soutiere 1979). These same clear-cuts were seldom used in winter, probably because of poor hunting conditions (Steventon and Major 1982). In Montana, marten did not use clear-cuts during the first year after timber harvesting (Campbell 1979). In Ontario, marten were 2 to 3 times more abundant in undisturbed forests than in cutover areas (Thompson 1982).

The effects of timber harvesting on the pine marten in Newfoundland have not been investigated. How marten respond to the particular pattern of cutting is not clear. This study was initiated to investigate the effects of timber harvesting on marten habitat use in western Newfoundland. The goal was to determine marten use of clear-cuts,, and the residual stands of forest remaining within these clear-cuts, to provide information on which to base management recommendations. Specific objectives were to:

1) determine if stage of regeneration of clear-cuts influenced use by marten;
2) determine if size of residual stands influenced use by marten;

determine if areas where marten were trapped could be characterized by certain habitat variables.

STUDY AREA

The 140 km 2 study area was located in western Newfoundland, adjacent to Little Grand Lake and approximately 50 km south of Corner Brook (Figure 1). Topography was moderately rugged, with steep slopes extending from naturally barren hilltops to river valleys and low areas. Elevations ranged from 300 m to 2,000 m on some hilltops.

The area was within the Corner Brook section of the Boreal Forest Region of Canada (Rowe 1972). The dominant tree species were balsam fir, black spruce, and paper birch. Regenerating clear-cuts were dominated by paper birch, red maple (Acer rubrum) and raspberry (Rubus idaeus) until balsam fir became established.

Annual temperatures in this region average 50C, with a January mean of -60C and a July mean of 170C. Total annual precipitation averages about 1,150 mm and mean annual snowfall is about 520 cm. (Weather information is based on summaries for Stephenville.)

From 1960 to 1983, forests in this area were extensively clear-cut by Bowater (Newfoundland) Limited to supply their pulp and paper mill in Corner Brook. All softwood timber was removed, leaving only scattered birch trees and unmerchantable softwood stands. These stands, called residuals, were often isolated from other patches of uncut forest. They were between 1 and 270 ha and composed 16% of the area. Clear-cuts, ranging up to 1,600 ha.. composed 41% of total area. Cutover areas were extensive because the harvesting pattern involved clear-cutting contiguous to the previous year's cut. Thirty percent of the area was undisturbed forest where harvesting had not yet occurred. Seven percent was naturally barren and 6% was water.

The study area was part of a larger region established in 1973 by the Newfoundland Wildlife Division to protect marten. Trapping and snaring of all species are prohibited in this region.

An extensive network of logging roads provided excellent access to the area during the study and a locked gate limited traffic to authorized vehicles. However, many sportsmen and recreationists entered the area on all-terrain cycles, trail bikes, and snowmobiles. During the moose and caribou hunting season, from mid-September to the end of October, the area was open to all traffic and was heavily used.

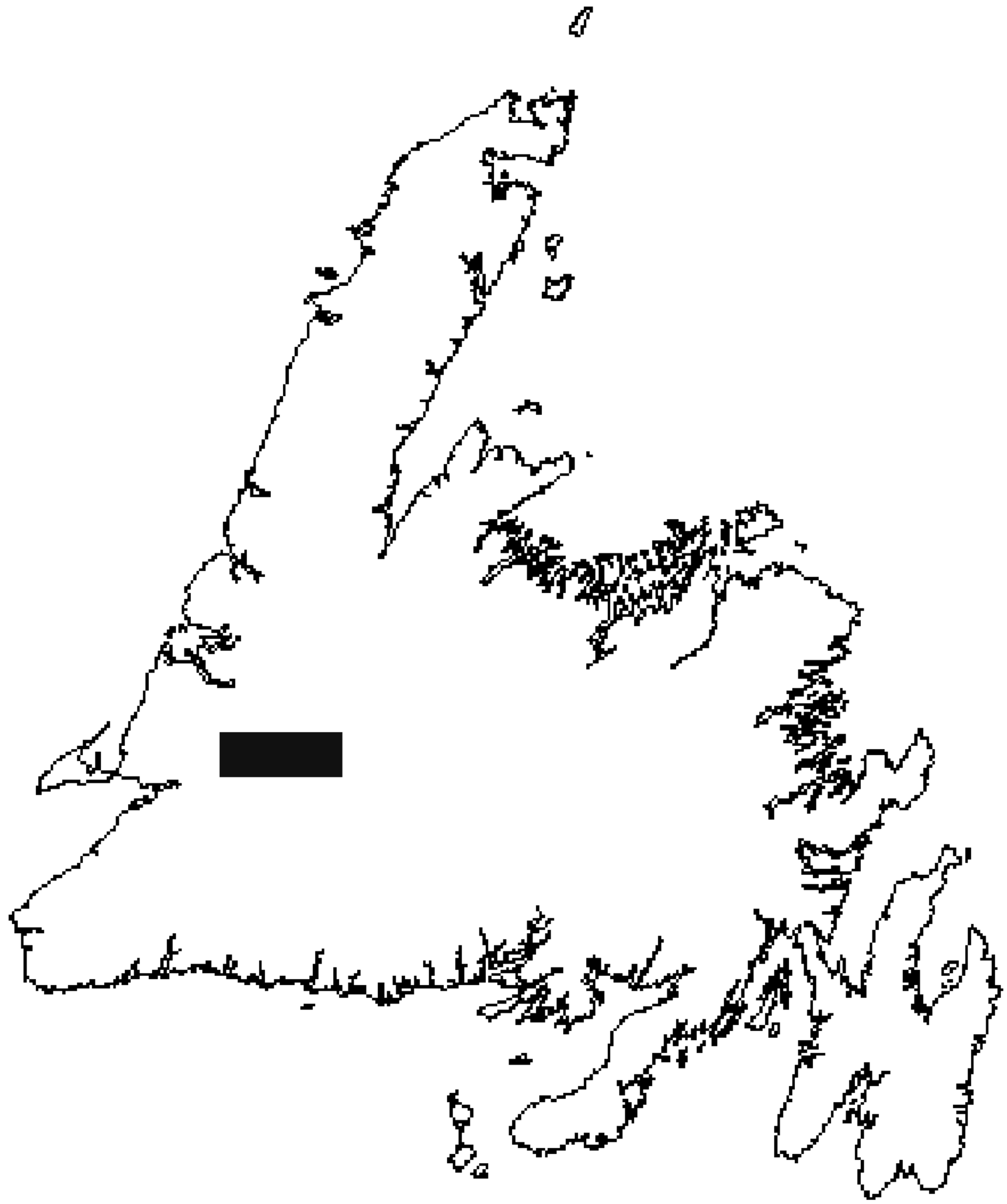

Figure 1. Location of the study area in western Newfoundland

METHODS

Fieldwork was conducted from June 1983 to March 1984 and was divided into two study periods: 1) summer and fall, and 2) winter. In the summer and fall, marten use of residual stands and clear-cuts was investigated by trapping. Snow tracking was used for more detailed investigations of habitat use by marten during the winter.

Habitat Categories

Residual stands were classified into five size categories: <5.0, 5.0-14.9, 15.0-24.9, 25.0-34.9, and >35.0 ha. Clear-cuts were classified into three categories based the height of balsam fir regeneration: (1) balsam fir <1 m high, generally <8 years after harvesting; (2) balsam fir 1-2 m high. Generally 8-15 years after harvesting; (3) balsam fir >2 m high, generally 16-23 years after harvest. The height of balsam fir regeneration was used as an index of vegetation regeneration because it is 1) the major species present on the regenerating clear-cuts, and 2) the species of primary importance in providing the overhead cover considered to be important to marten (Hawley and Newby 1957; Herman and Fuller 1974).

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Summer and Fall

Trapping. Trapping was conducted from June to December 1983 in 43 residual stands and 35 clear-cuts using the methods of Soutiere (1978). The traps were set at 100 m intervals along parallel Transects spaced 300 m apart in the residual stands, and extending at least half way into the adjacent clear-cut. An attempt was made to sample each category in proportion to its availability on the study area. Each site was trapped for six consecutive days. On initial capture, marten were immobilized with 0.1 cc of ketamine hydrochloride (100 mg/cc) to facilitate handling. Each animal was ear-tagged, weighed, and age and sex were determined (Marshall 1951, Newby and Hawley 1954). A first premolar tooth was extracted from each marten for accurate aging by cementum analysis. On subsequent recaptures, tag numbers and weights were recorded.

Trap site characteristics. At each trap site, the following information was recorded: forest type, dominant over-story species, percent overhead cover, average tree height, average tree dbh, major understory and ground cover species, distance to nearest different habitat, distance to nearest water, slopes, aspect, occurrence of slash, fallen trees and snags, and category of clear-cut or size of residual stand.

Analysis. Chi-square analysis was used to test for differences in captures between residual stands and clear-cuts, and among residual stand categories. Stepwise logistic regression was used to analyse habitat data recorded at each trap site to determine which variables accounted for the differences between successful and unsuccessful trap sites. Stepwise logistic regression was also used to determine habitat differences between residual stands and clear-cuts, among clear-cut categories and among residual stand categories. Tree, understory and ground vegetation species at successful and unsuccessful trap sites were examined for differences (FUNCAT procedure, SAS, 1982).

Winter

Snow stations. Snow depths and profiles were measured at six stations; one in each of the three clear-cut categories, and three in residual stands. Each station consisted of four substations, with stakes calibrated in cm for depth measurements. All were read at least once a week and a snow profile was dug weekly.

Tracking. All residual stands and clear-cuts in which marten had been trapped were searched for marten tracks. Additional clearcuts, residual stands and forested areas were also searched. Searching was accomplished by travel on snowmobile and snowshoes, depending on snow and habitat conditions. Distances searched and tracked were estimated and routes recorded on aerial photographs. Direction of travel, activity, habitat, topography, tracks of other species encountered, snow condition and sinking depth were also recorded. Tracks were followed until snow conditions deteriorated or tracks were lost.

Analysis. Habitat selection by marten in winter was determined by comparing distance of marten trails observed in each habitat with the expected distance. Expected values were calculated based on the availability of each habitat in the study area. A chi-square goodness of fit test was used. For each habitat types use was
compared to availability using an electivity index developed by Ivlev (1961). This index was calculated as follows:
$E = (X - Y) / (X + Y)$.
X = proportion of total travel in habitat A
Y = proportion of availability of habitat A
Strongly avoided habitats have a -1 value and strongly selected
habitats have a +1 value.

RESULTS AND DISCUSSION

Summer and Fall

Ten male and 8 female marten were caught in 3,587 trap nights, with 39 recaptures, for a total of 57 captures (Table 1).

Residual vs. clear-cut captures. Capture rates of marten were greater in residual stands than in clear-cuts. ($X2 = 15.10$, $df = 1$, $P < 0.001$) (Table 2). Fifty-one (89.5%) of the marten captures were in residual stands and six (10.5%) were in -.Iear-cuts. Using captures per 100 trap nights (C/100TN) as a relative index of density, this is equivalent to 2.19 C/100TN in residual stands and 0.48 C/100TN in clear-cuts. In a study in Ontario, capture rates were greater, averaging 2.26 C/100TN in uncut forest and 1.09 C/100TN in clear-cuts, based on 57 captures of 28 marten in IY892 trap nights. (Thompson 1982). Other studies have shown significant reductions in marten densities in clear-cut areas when compared with partially-cut or undisturbed forests (Capmbell 1987, Soutiere 1979). However, trapping was not conducted specifically in residual stands for a comparison of marten use of these areas.

Clearcut captures. Only 6 marten were captured in clear-cuts. Five of the captures were in category 1 clear-cuts, harvested in 1978 and 1981, with balsam fir regeneration less than 1 m in height. One marten was captured in a category 2 clear-cut, harvested in 1976s with regeneration between I and 2 m high. Because of the small sample size, it was not possible to analyse this data for variation

Table 1. Marten trapping and capture data in clear-cuts and residual stands.

Habitat type Category	No. of sites	Trap nights	Marten captures	Captures/ 100 TN
Clear-cut				
1	20	74	5	0.67
2	10	432	1	0.23
3	5	82	0	0
Subtotal	35	1,260	6	0.48
Residual stand (ha)				
<5.0	15	286	2	0.70
5.0-14.9	10	308	3	0.97
15.0-24.9	5	239	6	2.51
25.0-34.9	6	303	14	4.62
>35.0	7	1,119	26	2.18
Subtotal	43	2,327	51	2.19
Total	78	3,587	57	1.60

Table 2. Comparison of marten captures in clear-cuts and residual stands.

Habitat	Trapnights	% Effort	% of Area	Captures Observed	Captures Expected	Chi Square Value
Clear-Cut	1260	35.1	41	6	20	9.8
Residual	2327	64.9	16	51	37	5.3
Total	3587	100.0	57	57	57	15.1*

* $p < 0.001$

among clear-cut categories. The small sample size was a result of limited use of clear-cuts by a sparse population.

These marten may have been taking advantage of a temporary increase in prey abundance in the young clear-cuts. One- to fifteen-year-old clear-cuts in Maine had more small mammals, particularly meadow voles (Microtus pennsylvanicus) and masked shrews (Sorex cinereus)p than did undisturbed softwood stands (Monthey 1978). Meadow voles and masked shrews are important marten prey in Newfoundland (Bateman 1982). However, it is not known how clear cutting in Newfoundland forests affects the limited prey base available to marten. Although prey abundance may not be affected by forest harvesting, availability of small mammals, primarily meadow voles and masked shrews may decrease, especially in winter (Koehler and Hornocker 1977). In the summer, dense plant growth may decrease marten hunting success by increasing escape cover for prey (Steventon and Major 1982). Difficulty in hunting may be a major reason why marten avoid clear-cuts.

There were no captures in category 3 clear-cuts. These clear-cuts tended to be more extensive than the younger ones with few residual stands remaining. Although category 3 clear-cuts may approach a stage of regeneration that seems to provide good marten habitat, marten use Of these areas was not observed.

Category 3 clear-cuts were located at the western end of the study areas which sustained the greatest amount of human activity throughout the year. Pre-commercial thinning in some of these clearcuts was conducted from July to September 1983. Thinning operations were sometimes within 1 km of trapping transacts. These disturbances may have influenced marten use of the immediate area.

Weckwerth and Hawley (1962) suggested that juvenile marten may be forced to move to less favorable, unoccupied areas because they are unable to compete with resident adults. More captures of juvenile marten than adults were expected in clear-cuts, especially in the late summer and fall when juveniles were dispersing. No juveniles were captured in Little Grand Lake clear-cuts. We captured only l-, 2-, 3-, and 11-year-old animals in clear-cuts. All were recaptured at other times in residual stands in the same general area. Therefore, they were probably resident marten and not transients just travelling through the area. Soutiere (1979) reported that male marten travelled more extensively in commercial clear-cut forest than did females. He captured 12 marten in clear-cuts, but only one was a female. In this study, two male and three female marten were captured in clear-cuts.

Residual captures. Trapping in 43 residual stands resulted in 51 captures in 2,333 trap-nights. Marten captures differed among residual stand size categories, with more captures in the larger residual stands (X2 = 13.36, df = 4, P = 0.010) (Table 3). Only five (10%) of the 51 captures were in residual stands <15 ha. Thirteen captures would be expected if marten use was not influenced by size of residual stands. Therefore, actual use is less than half of expected use. Residual stands <15 ha may not be large enough to provide all of a marten?s habitat requirements. The smaller residual stands were usually more isolated from undisturbed forest and often

Table 3. Distribution of marten captures by residual stand size category.

Residual stand size (ha)	Trap-nights	% of effort	Captures observed	Captures expected	Chi-square value
<5.0	286	12.3	2	6.3	2.93
5.0-14.9	308	13.2	3	6.7	2.04
15.0-24.9	239	10.3	6	5.3	0.09
25.0-34.9	303	13.0	14	6.6	8.30
>35.0	1,119	151.2	26	26.1	0.00
Total	2,327	100.0	51	51.0	13.36*

* p = 0.010

consisted of small patches of scrubby black spruce or balsam fir on wet sites. Large residual stands were frequently on the edges of large clear-cuts in areas such as steep slopes that were inaccessible to harvesting equipment.

Residual vs. clear-cut habitat.--Stepwise logistic regression showed tree height, percent overhead cover, presence of slash and distance to the nearest habitat edge to be the variables contributing most to the difference between residual and clear-cut trap sites. Species of trees and dominant ground vegetation did not differ between clear-cut and residual trap sites, although raspberries were more common in clear-cuts of categories 1 and 2.

Marten have been recorded foraging in clear-cuts for raspberries in late summer, indicating that they may exploit this seasonal food source in marginal habitat (Steventon and Major 1982). Soutiere (1979) found raspberry seeds in 22% of marten scats from the late summer, suggesting a seasonal shift in habitat use at this time. Newfoundland pine marten were captured in clear-cuts on 28 June; 4 August; 10, 11, 18 October; and 24 November 1983. Only one of these captures was during raspberry season (mid-July to late August). However, several marten scats found in July and August consisted almost entirely of raspberry seeds. Raspberries may be an important food source for a short period of time, but the results of this study did not show a shift in habitat use by marten during this season.

Clear-cut habitat.--There were 6 successful and 211 unsuccessful trap sites in the clear-cuts. Habitat did not vary among clear-cut categories except in height of regeneration. Stepwise logistic regression -showed that none of the trap site variables were significant predictors of success in clear-cuts.

Residual habitat. Stepwise logistic regression analysis of habitat variables of the 46 successful and 359 unsuccessful residual trap sites indicated that dbh was the only variable that contributed significantly to differences in trapping success, however dbh did not differ with size of residual stands. Average tree dbh >15 cm was preferred by marten in the residual stands. Trap sites in residual stands <15 ha were closer to water but farther from habitat edges than those in residual stands >15 ha. Overhead cover was usually denser and trees were usually taller in small residual stands. White birch was more common in large residual stands. Despite these differences, it seems that the major factor influencing marten use of residual stands is the size of the residual.

Total habitat. When all successful (52) and unsuccessful (570) trap sites were analysed with stepwise logistic regression.. percent overhead cover and dbh were the only predictors of trapping success. Overhead cover averaged 50-10C% and dbh >15 cm at successful trap sites. Tree and ground vegetation species did not differ between successful and unsuccessful trap sites.

Winter

Snow stations. Winter field work was conducted from January to March 1984. Average snow depths were 89.9 cm in residual stands and 108.4 cm in clear-cuts (Table 4). The category 1 clear-cut had the lowest mean depth. Strong winds were common and probably accounted for the lower snow depths since much of the snow was blown away. However, by late February, category 1 clear-cuts were completely snow-covered with no vegetation or slash visible above the snow. Balsam fir regeneration up to 3 m above snow level in the category 3 clear-cut provided about 75-100,% overhead cover, accounting for a lower average snow depth. Overhead cover in category 2 clear-cuts was insufficient to influence snow depth.

Until mid-February, there was little or no powder over a firm crust of 1 to 5 cm. From late February to late March, average powder accumulation increased at all snow stations except for one in a residual stand with 75-100% overhead cover, which probably accounted for less powder accumulation.

Weather. Temperatures averaged -6.80C, ranging from -20.2 to 10.1C. Thaws and periods of rain occurred on four occasions in February and once in mid-March. Snow fell almost daily in March.. making tracking difficult.

Tracking. Marten tracks were followed for 29.0 km (Table 5). Marten preferred residual stands and undisturbed forest. Seventy four percent of marten trails were located in forested habitats, which composed 46% of the total area. Clear-cuts represented 41% of the study area but only 25% of marten travel was recorded in clear-

Table 4. Mean snow depths (cm) recorded at snow stations

Habitat Category	February mean	March mean	Overall mean
Clear-cuts			
1	83.3	101.7	92.5
2	109.5	137.7	123.6
3	100.3	118.0	109.2
Mean	97.7	119.1	108.4
Residual stands			
1	77.6	93.1	85.4
2	79.7	91.8	85.8
3	89.7	107.0	98.4
Mean	82.3	97.3	89.9

Table 5. Distribution of marten trails among habitats.

Habitat Category	% of Study Area	Travel Distance(km) Expected	Travel Distance(km) Observed	% of Total Travel	Electivity Index
Clear cut 1	13.9	4.036	4.302	14.86	0.03
2	15.3	4.418	3.168	10.94	-0.16
3	12.0	3.471	0	0	-1.00
Residual Stands(ha)					
<5.0	1.0	0.301	1.039	3.59	0.55
5.0 to 14.9	2.0	0.570	2.695	9.31	0.65
15 to 14.9	1.2	0.345	5.694	19.51	0.89
25 to 34.9	1.4	0.417	0.828	2.86	0.33
>35 to uncut	39.9	11.549	11.271	38.93	-0.01
Water	6.5	1.888	0	0	-1.00
Barrens	6.8	1.957	0	0	-1.0
Total	100.0	28.952	28.952	100.00	

cuts. Frozen ponds, barrens and category 3 clear-cuts were not used. Category 1 clear-cuts were used slightly more than expected, but the electivity index value was very low, indicating selection was negligible. Category 2 clear-cuts were avoided. Residual stands up to 35 ha were selected. Residual stands >35 ha and uncut forest were used slightly less than expected but the electivity index value of -0.03 is negligible. This inconsistency with the pattern in the rest of the residual stands is probably because deteriorating conditions often hindered tracking in these habitats. Although the tracks continued, we could no longer follow them. This resulted in less distance than expected based on the proportion of available habitat* and produced a slightly negative electivity index value.

Travel patterns differed between clear-cuts and residual stands. Trails in clear-cuts were usually in a relatively straight line, from one residual stand to another. Conversely, trails in forested habitats were often in a zig-zag and looped pattern. In Maine, marten have been tracked across clear-cuts as wide as 200 m (Soutiere 1978) and 300-400 m (Steventon 1979). During this study, marten crossed openings 20-600 m wide, with an average of 150m. Eighty-seven percent of crossings were less than 250 m. We recorded "stops" and "investigations" while tracking.Stops consisted of urination, defecation and scent marking locations, and instances when marten paused briefly while travelling. Locations where marten tracks disappeared into the snow in a hole at the base of a tree or stick, or the marten dug at the snow surface were classified as investigations. Sixty-eight stops and 130 investigations by marten were recorded while tracking. Seventy-nine percent of the stops and 79% of the investigations were in forested habitats. Investigations were often associated with trees, sticks or slash protruding above the snow, and with tracks of other species, especially snowshoe hare (Lepus americanus) and red squirrel (Tamiasciums hudsonicus), which were more common in forested habitats than in clear-cuts.

Although no kills by marten were observed, two possible cache sites were found. One was in the middle of a small clearing and consisted of a hole about 47 cm deep in which a few ruffed grouse (Bonasa umbellus) feathers were found. A marten was tracked to this spot, where it stopped to dig, and then continued into a residual stand. No other grouse remains were found at the cache. The other cache site was in a small residual stand beside a pond. The marten stopped and dug up the remains of a snowshoe hare. it was not a fresh carcass and was almost completely eaten.

No marten tracks were found in category 3 clear-cuts. Overhead cover was between 50 and 10C% in unthinned areas. Approximately half of these clear-cuts had been thinned and trees were spaced 3 m apart, reducing overhead cover to <25%. Tracks of snowshoe hares and red squirrels were abundant in these clear-cuts, but small mammal sign was not evident. Bateman (1982) reported that the most important marten prey species in winter were snowshoe hare and meadow voles, based on the analysis of scats collected in western Newfoundland. Availability and abundance of small mammal prey in clear-cuts may be an important reason for limited use of these areas by marten.. but this has not yet been investigated.

CONCLUSIONS

Low densities of marten continue to inhabit the Little Grand Lake area despite extensive clear-cutting of mature forest. Sparse populations survive in this area because some remnant uncut forest remains. However, their numbers are considerably reduced.

Because of the sparse marten population in the area and their limited use of clear-cuts, it was difficult to detect if variation in use of clear-cuts was correlated with the stage of vegetation regeneration. Ten percent of marten captures in the summer and fall were in clear-cuts, all of which were <8 years old and characterized by balsam fir regeneration <2 m high. Marten were not captured in older clear-cuts 8 to 23 years after harvesting. These data show that marten use young clear-cuts (<10 years after harvesting) minimally in the summer, fall and winter but do not use older clear-cuts.

During the winter, 26% of marten trails were in clear-cuts up to 10 years old. No tracks were observed in older clear-cuts. Winter

Winter tracking corroborated trapping data.

Residual stands composed 16% and undisturbed forest 30% of the study area, yet 90% of all captures were in forested areas; ten percent of these were in residual stands <15 ha; 90% in larger stands. In the winter, 74% of all travel was in forested habitats; 13% in residual stands <15 ha and 61% in undisturbed forest and residuals >15 ha. These data demonstrate clearly that larger residual and undisturbed stands (>15 ha) are important habitat components in extensively clear-cut areas. Areas with less forested habitat can be expected to support lower marten densities. Successful trap sites usually had trees with dbh of 15 cm and overhead cover of 50 to 100%. No other trap site variables were important when analysed by stepwise logistic regression.

A more intensive study of marten use of clear-cuts is necessary to determine how use varies with stage of regeneration; no data exist to document at what stage marten will begin to use regenerating clear-cuts. More than 23 years after timber harvesting is necessary. Overhead cover, small mammal availability and abundance, and resting and denning sites are critical factors for marten (Steventon and Major 1982), and these were lacking in the regenerating clear-cuts studied. Large residual stands and areas of undisturbed forest can provide these important habitat components and may enable at least a remnant marten population to survive despite clear-cutting. If the pattern of forest harvesting continues, with clear-cutting of contiguous areas year after year, available habitat and the

populations that depend on them will continue to decline and recovery to previous levels cannot be expected.

MANAGEMENT RECOMMENDATIONS

Although the results from this study indicate that marten will use clear-cuts to a limited extent, continued timber harvesting may prevent marten populations in the Little Grand Lake area from returning to more secure population levels. There may be a critical population level beyond which continued survival is unlikely. Thirty years of complete protection has not resulted in a noticeable increase in marten numbers. Because of the lack of information regarding the effects of timber harvesting in western Newfoundland, the optimal management strategy at this point is complete protection of marten and their habitat in one or more areas until further research has been conducted.

The Little Grand Lake area is one of the last regions in Newfoundland containing at least a remnant marten population. Despite extensive clear-cutting, some undisturbed forest remains, especially north and south of Little Grand Lake. This area should be designated as a marten reserve until additional information is available on how marten are affected by timber harvesting. If timber harvesting is allowed, it should be conducted under limitations based on the habitat requirements of marten and other wildlife species. In some situations, timber harvesting can be compatible with marten if allowances are made in harvesting patterns to minimize the detrimental effects caused by existing practices. The following recommendations will benefit many other wildlife species, such as moose (Alces alces), red fox (Vulpes fulva), lynx canadensis), mink (Mustela vison), and snowshoe hare, in addition to marten.

1.Small clear-cut blocks or strips interspersed with undisturbed forest are recommended. If uncut stands of forest remain to provide marten with the necessary habitat components that clear-cuts lack, marten populations may continue to inhabit the area. Marten in Maine crossed openings as wide as 300 to 400 m (Steventon 1979). In this study, marten crossed openings from 20 to 600 m wide, with an average of 150 m. Eighty-seven percent of crossings were less than 250 m. Suitable areas of residual and undisturbed forest should not be separated by more than 250 m.

2.If clear-cuts are large, residual stands of at least 15 ha, with minimum average tree dbh of 15 cm and overhead cover between 50 and 100% should be left uncut. If possible, these should be connected to each other by strips of uncut forest of sufficient width for travel and concealment. Residual stands should not be separated by more than 250 m of open area. If large residual stands are left, marten may continue to inhabit the area, although densities will probably decrease after clear-cutting. As the forest regenerates adequately, marten should return to the area. No data is available on how long this process takes, although 23 years is not sufficient. Diversity and patchiness in forest cover with good interspersion of uncut and cut areas should be the guiding principle.

Corridors along waterways should not be cut. These areas are important for many wildlife species, in addition to marten. Furbearers in Maine showed strong selection for habitats within a 0.1 km zone along waterways (DiBello 1982). These corridors were important because of increased prey abundance and availability, especially in winter. Greater densities of snowshoe hares and red squirrels were found in large (>14 ha) strips of uncut softwoods along waterways and bogs than in other habitat types in Maine (Monthey 1978). Based on studies in Maine, corridors should be at least 0.1 km wide and at least 14 ha in area. On steep slopes, erosion and siltation of streams and lakes can be prevented by leaving undisturbed buffer strips along the edges.

4. Fallen trees, snags and stumps are important as resting and denning sites for marten. Female marten in Maine used large (40-70 cm dbh) logs or mature trees of declining vigour as maternal dens (Wynne and Sherburne 1984). Because of their importance as denning sites for females, these trees should be preserved. They are also important for providing habitat for small mammals and access to small, mammal prey under the snow by marten.

5. Until populations recover, complete protection for marten in Newfoundland is necessary. Trappers and snarers should be encouraged to report any accidental marten captures and to give carcasses to the Newfoundland Wildlife Division for examination. Although all trapping and snaring was prohibited within the Little Grand Lake study area, we found many snowshoe hare snares. Accidental trapping and snaring may be an important mortality factor of marten. Newfoundland Wildlife Division records show at least 46 marten have been caught in traps or snares set for other furbearers in Newfoundland since 1970. This probably represents only a small proportion of actual captures. Education of trappers in species-specific trapping methods to minimize accidental captures of marten is recommended. Male marten, especially juveniles, are more vulnerable to trapping than females (Soukkala 1983). However, natural mortality is greater for females (Weckwerth and Hawley 1962, Soutiere 1979). A decreasing proportion of males and increasing proportion of females in the adult harvest indicates the population is being heavily trapped (Soukkala 1983). The age and sex ratios of marten trapped during this study were: one female and two male juveniles; and 7 female and 8 male adults. Although this is a small sample size, the high proportion of adults trapped may indicate that this population is subject to relatively high mortality. The causes of mortality should be investigated.

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BIOGRAPHY

Joyce Elizabeth Snyder was born in Blind River, Ontario on May 5, 1957. She grew up in suburbs of Toronto and Montreal and, graduated from John Rennie High School in Pointe Claire, Quebec in 1974.

Joyce attended St. Lawrence College of Applied Arts and Technology in Kingston, Ontario and graduated in 1977 with a diploma in Animal Care Technology. She then entered the wildlife resources program at Macdonald College of McGill University in Ste. Anne de Bellevue, Quebec. She received a bachelor of science degree with honours in 1980.

After two years working as a wildlife technician, naturalist and marten researcher for the Newfoundland Wildlife Division, and as crew on a sailboat, Joyce entered the University of Maine at Orono in September, 1982. She is a candidate for the degree of Master of Science in Wildlife Management in December, 1984.

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SUPPLEMENT TO

Snyder, J. E. 1984. Marten use of clear-cuts and residual forest stands in western Newfoundland. M. S. Thesis, Univ. of Maine, Orono.

The supplement functions as a depository for appendix-type material of value to research sponsors and subsequent investigators. It may include: detailed methods (including mathematical or statistical presentation), field or laboratory observations, species lists, comprehensive tables and figures, photographs, condensed computer print-outs and maps of relevance to the thesis.

TABLE OF CONTENTS

LIST OF TABLES

FURTHER RESEARCH

Considering the uncertain future of marten and the extensive clear-cutting practices in western Newfoundland, further research on marten is necessary to fully understand the reasons for its continued low density and develop appropriate management plans to prevent further declines. The following research is recommended:

1.Long-term monitoring of the effects of timber harvesting on marten habitat use, home range and activity is necessary. Knowing how marten respond to this disturbance within the first several years, and their reaction to active timber harvest within their home range would facilitate mitigation and management measures. Radio-telemetry and winter tracking methods are the recommended techniques.

2.Information on the food habits of marten, prey abundance and availability, and how these are affected by clear-cutting is needed. Small mammals are the major foods of marten throughout most of their range. There are only two small mammal species in Newfoundland; Meadow voles and masked shrews. Food may be more critical in Newfoundland than in many other areas where small mammal prey is abundant. Knowledge of the abundance and availability of marten prey in clear-cuts is important because this may be one of the major limiting factors of marten numbers. Snap-trapping of small mammals in cut and uncut areas should be conducted. Densities of other potential prey such as snowshoe hares and red squirrels could be investigated with track and pellet counts. Foods consumed by marten in Newfoundland should be investigated by scat analysis.

3. More information on the home range and denning requirements of female marten is needed. Basic reproductive information is also lacking. Timing of reproduction should be investigated to determine when females with litters are most vulnerable to disturbance from forest harvesting. Radio-telemetry of females and observations at dens are recommended.

4. Juvenile dispersal and survival should be investigated. We do not know where juveniles go when they disperse. Only 3 juveniles were captured during this study, suggesting that juvenile mortality may be high. Radio-telemetry is the appropriate technique. Aerial relocations will probably be necessary to monitor long-range movements of juveniles.

5. Limited information is available on mortality of marten in Newfoundland. The age and sex ratios of marten trapped in this study indicate that mortality may be high. The causes and extent of mortality should be investigated. The significance of accidental trapping and snaring should be determined. Special attention should be focused on mortality of females and juveniles as these are the segments of the population that determine whether or not marten are available to re-occupy regenerated habitat.

6.Further winter tracking studies should be conducted for additional information on marten food habits, resting and denning locations, hunting activities, mortality, home range, and habitat use in clear-cut areas. Ideally, tracking should be combined with telemetry to permit identification of individual animals. Tracking is an excellent method of studying an animal in the winter with minimal disturbance.

Table 1. Capture data of marten trapped from June to December, 1983 in western Newfoundland.

Marten No.	Sex	Age in 1983	Captures in Residuals	Captures in Clearcuts	Average Weight (g)	Total Length	Tail Length
1	M	A	1	0	1100	630	165
2	M	5	5	0	1140	600	170
3	M	2	4	1	1300	670	200
8	F	3	2	0	775	540	155
11	F	11+	6	2	669	555	160
12	M	2	1	0	1400	590	179
13	F	2	5	1	514	505	130
14	M	2	1	0	1350	620	169
15	F	1	1	0	750	540	166
16	F	3	2	1	675	565	165
17	M	0.5	2	0	838	595	160
18	M	2	1	0	1250	650	180
19	F	2	5	0	800	575	180
20	M	0.5	10	0	955	610	180
21	F	0.5	1	0	700	550	160
22	M	1	2	0	1125	640	180
23	F	1	1	0	800	527	162
25	M	1	1	1	1125	-----	170

Table 2. Habitat variables contributing to overall success of trap sites.

Summary of Stepwise Results

Step No.	Term Entered	DF	Log Likelihood	Improvement Chi Square	Improvement P-Value	Goodness of Fit Chi-Square	Goodness of Fit P-Value
0	------	---	-178.806	------	------	354.841	1.000
1	Overhead Cover	3	-169.235	19.141	0.000	335.699	1.000
2	DBH	3	-164.647	9.177	0.027	326.519	1.000

Table 3. Habitat variables contributing to success of Clear Cut Tap Sites.

Summary of Stepwise Results

Step No.	Term Entered	DF	Log Likelihood	Improvement Chi-Square	Improvement P-Value	Goodness of Fit Chi-Square	Goodness of Fit P-Value
0	----	----	-148.333	–	—	296.665	0.000
1	Constant	1	-23.724	249.219	0.000	47.447	1.000

Table 4. Habitat Variables Contributing To Success of Residual Stand Trap Sites.

Summary of Stepwise Results

Step No.	Term Entered	DF	Log Likelihood	Improvement Chi-Square	Improvement P-Value	Goodness of Fit Chi-Square	Goodness of Fit P-Value
0	—	—	-282.802	–	–	562.821	0.000
1	Constant	1	-145.752	274.101	0.000	288.731	1.000
2	DBH	3	-139.977	11.550	0.009	277.182	1.000

Table 5. Habitat Variables Accounting For Differences Between Clear-Cuts and Residual Stand Trap Sites.

Summary of Stepwise Results

Step No.	Term Entered	DF	Log Likelihood	Improvement Chi-Square	Improvement P-Value	Goodness of Fit Chi-Square	Goodness of Fit P-Value
0	—	—	-400.358	—	—	800.702	0.000
1	Tree Height	3	-342.544	115.628	0.000	685.098	0.012
2	Overhead Cover	3	-94.248	496.592	0.000	188.498	1.000
3	Slash	1	-52.365	83.766	0.000	104.733	1.000
4	Distance to Edge	1	-47.921	8.889	0.003	95.843	1.000

Table 6. Habitat Differences Between Residuals <15 and >15 ha.

Summary of Stepwise Results

Step No.	Term Entered	DF	Log Likelihood	Improvement Chi-Square	P-Value	Goodness of Fit Chi-Square	P-Value
0	---	---	-280.723	-----	-----	555.890	0.000
1	Constant	1	-211.994	137.458	0.000	418.408	0.191
2	Edge	1	-192.858	38.271	0.000	380.157	0.670
3	Forest Type	5	-174.947	35.823	0.000	344.336	0.946
4	Water	1	-172.421	5.052	0.025	339.282	0.961
5	Overhead Cover	3	-168.683	7.475	0.058	331.806	0.975
6	Tree Height	3	-163.990	9.386	0.025	322.424	0.988