WHR-25

MARTEN IN BRITISH COLUMBIA WITH IMPLICATIONS FOR FOREST MANAGEMENT

WILDLIFE HABITAT RESEARCH

Ministry of Forests and Lands

MARTEN IN BRITISH COLUMBIA WITH
IMPLICATIONS FOR FOREST MANAGEMENT

L.A. Stordeur

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SUMMARY

This problem analysis was initiated as a joint project between the Ministry of Environment and Parks, Wildlife Branch, and the Ministry of Forests and Lands, Research Branch, in response to concern over the potential effect of logging and silvicultural practices on marten (Martes americana).

Marten ranked first in revenues over all furbearers in the province for the 1984/85 trapping season. Present management policies to meet harvest demands are directed toward the manipulation of season lengths and gear restrictions, with little or no emphasis on habitat management. Based on results from a trapper questionnaire, marten density was grouped into three categories and was found to correlate roughly to biogeoclimatic units in the province. Ecosystem, stand age, and type of silvicultural practice were found to influence marten activity, prey productivity, and hence marten populations.

It is recommended that baseline studies on denning, resting, and feeding requirements be initiated. Subsequent to these studies intensive investigations on how the impact of silvicultural practices on marten can be lessened should be instituted. Logistic and monetary constraints may limit study areas and for this reason it is suggested emphasis be placed on coastal ecosystems where data are most sparse and the dynamics of the marten-prey-ecosystem are less complex.

1 INTRODUCTION

This problem analysis was initiated in response to concern by resource users and managers over the effects of a dwindling old-growth forested land base on furbearer populations. Marten (Martes americana) was chosen because of its high public interest, economic value and reported sensitivity to habitat alterations. In addition, this problem analysis aims to provide a basis for incorporating marten into the wildlife habitat handbook project (Harcombe 1984).

Specific objectives for this problem analysis were:

1. to provide an overview of the status and importance of marten in British Columbia.
2. to provide an overview of present management objectives for marten in British Columbia.
3. to describe the habitat requirements for marten.
4. to determine the potential impact of logging and silvicultural treatments on marten populations.
5. to discuss current marten management strategies for marten and suggest future possibilities.
6. to recommend research priorities.

Information was collated from published literature, unpublished reports, and personal communication with interested persons and professionals. In addition, a questionnaire was sent to all registered non-native trappers in British Columbia.

1.1 Distribution and Abundance

Marten are circumboreal in their distribution and are usually confined to forested biotopes. They have been reported in Europe north of the Arctic Circle (Pulliainen 1981a) and as far south as Italy. In North America, marten range from the MacKenzie Delta in the Northwest Territories to as far south as the Las Vegas Mountains in New Mexico (Durrant 1952 cited by Hagmeier 1956). Four recognized subspecies of marten occur in British Columbia (Fig. 1): Martes americana abientinoides in the south and central parts of the province; M. a. actuosa in the north; M. a. caurina along the mainland coast and on Vancouver Island; and M. a. nesophila on the Queen Charlotte Islands (Cowan and Guiget 1978).

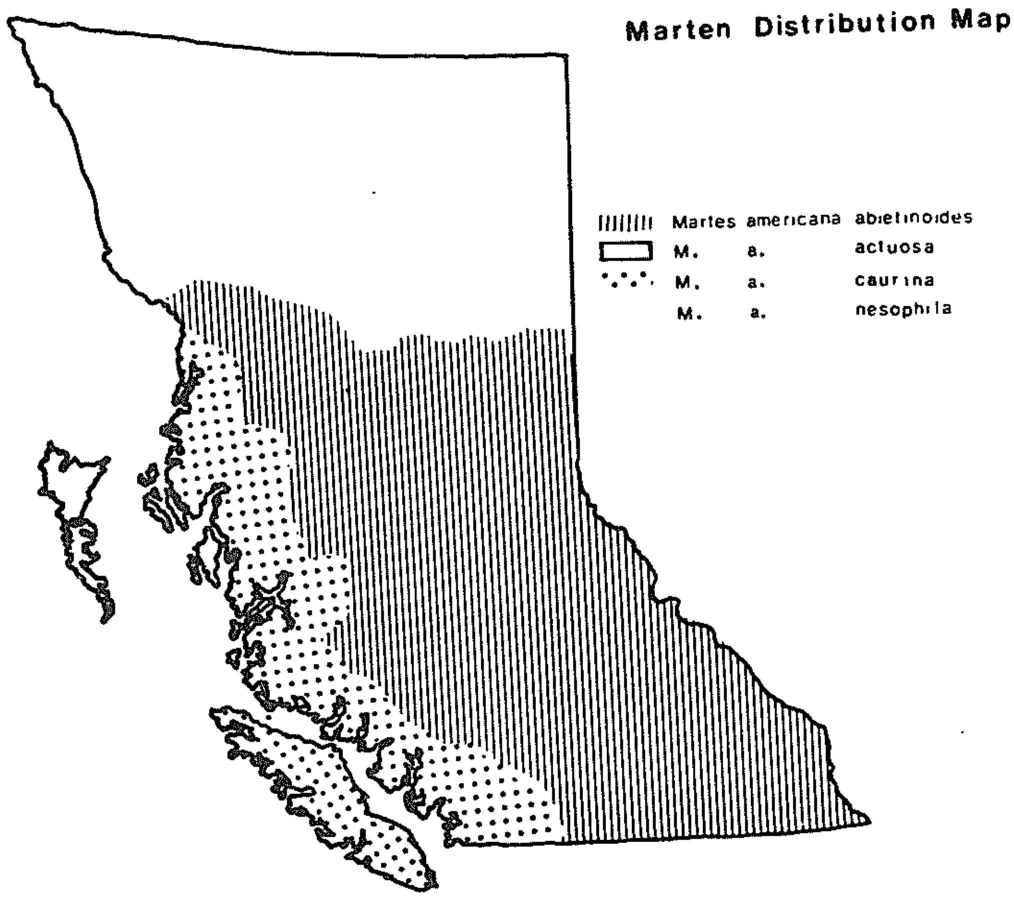

FIGURE 1. Distribution of marten subspecies in British Columbia (from Cowan and Guiget 1955).

Marten density in British Columbia was estimated from the trapper questionnaire and discussions with B. Saunders (Fur Management Specialist, B.C. Wildlife Branch). Chi-square analysis of the data from the questionnaire showed a significant difference in total harvest between south-central areas (M.U. 1,3,8), coast and mid-coast areas (M.U. 1,2,5,6), and the northern Interior (M.U. 7). A small sample precluded M.U. 4 from analysis, but reported harvest levels appear to be consistent with the coast and mid-coast areas. The density distribution areas were overlayed on a biogeoclimatic map (Pojar 1983) and the boundaries found to be roughly correlate. Figure 2 is the result of this process. The associated areas in Figure 2 (Page 5) will be referred to throughout the text as low, moderate, and high density units.

1.2 Economic Values

In Canada, marten ranked first in revenues and fifth in number of pelts harvested of all furbearers (Statistics Canada 1984). In British Columbia marten constituted 36% of the fur harvest in the 1984/85 season for a total value of $2.7 million. This ranked the marten first in revenues and third in number of pelts harvested for all species in the province (B. Saunders, pers. comm.). Since 1975 large increases in the harvest have been reported throughout Canada. In British Columbia the increase exceeded 300% over a 6-year period. Examination of the harvest shows that these levels have been maintained in recent years. An increase in marten populations is believed to be largely responsible for the increasing harvest rates (B. Saunders, pers. comm.). In an attempt to evaluate this a regression was performed on 12 years of marten harvest data in British Columbia using marten price as the independent variable. Results indicated 62% of the variability in the marten harvest could be explained by fur price alone.

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[1] M.U. is an abbreviation for management unit as designated by the B.C. Wildlife Branch.

Additional evidence that pelt price influences harvest:

1. Assuming fur harvest data can be used as a population index, the rate of increase of marten is unable to account for more than a 30% annual increase in harvest statistics;
2. Personal communication with trappers indicated they trap those species that bring the greatest monetary return for effort.
3. The increase in marten harvest is consistent across Canada.

However, caution must be used in the interpretation of the results because fur harvest data alone offer a highly suspect population index. Harvest data are also a function of trapping intensity, trapline length, and trapper expertise. Although the trapper education program initiated in 1975 resulted in a small but steady increase in the number of non-native trappers, the number of trappers was not used in the analysis because there is no record of the number of native trappers. Data on intensity and trapline length were also unavailable for analysis. If price is the major influence on the high marten levels one would expect populations (harvest levels) to undergo a sharp decline.

2 MANAGEMENT OF MARTEN IN BRITISH COLUMBIA

2.1 Provincial Government

2.1.1 Ministry of Environment and Parks, Wildlife Branch (Figure 3)

There is no specific management plan for marten in British Columbia. Instead, marten are included in a mustelid management plan wherein the policy of the Wildlife Branch is to manage mustelids primarily for commercial use (Munro and Jackson 1979).

Two objectives are outlined for marten (mustelids) in British Columbia:

1. "Maintain species diversity, range and population levels."
2. "Manage marten in response to harvest demands."

Province of British Columbia

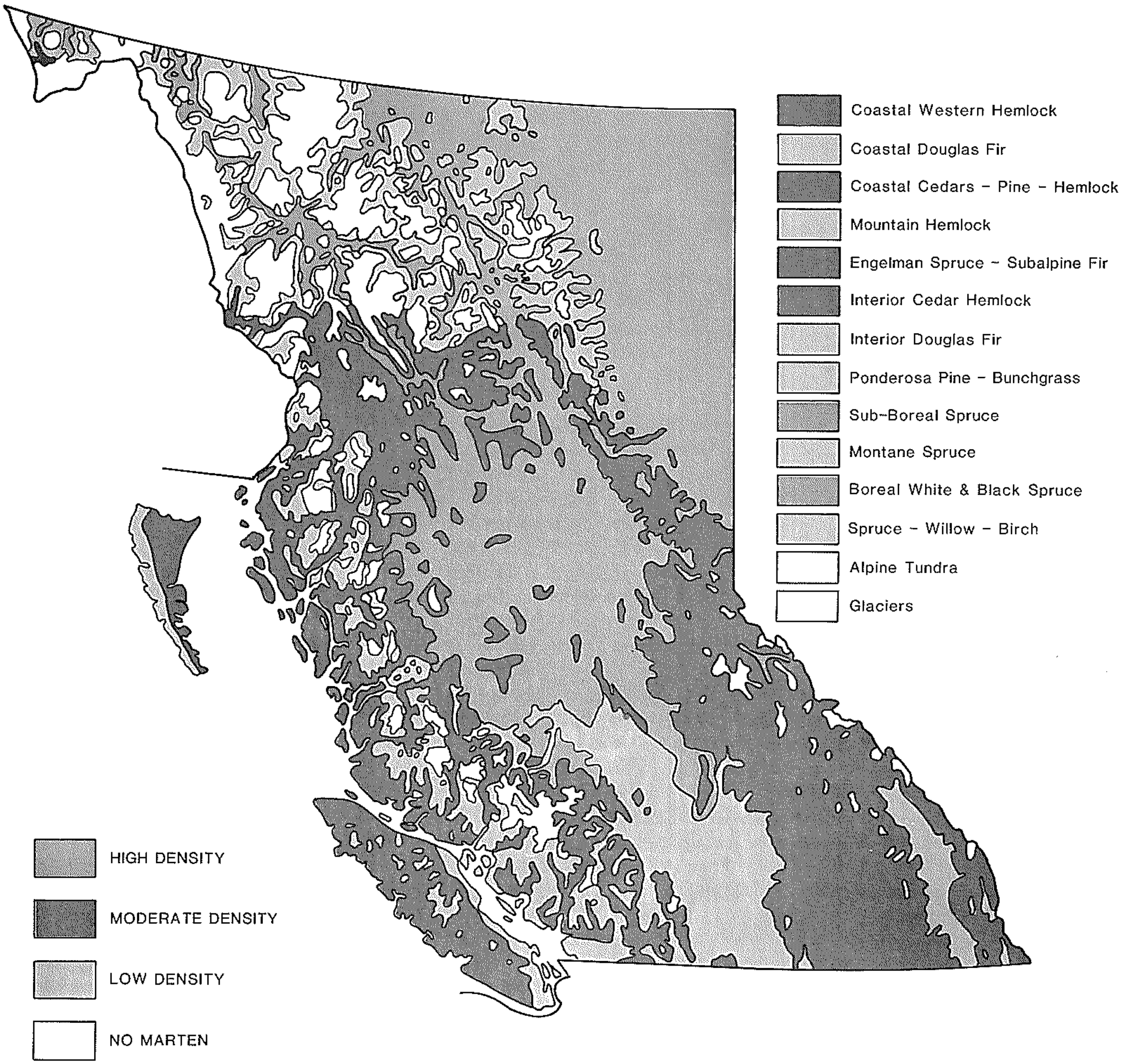

Figure 2: Marten density in British Columbia by biogeoclimatic zone

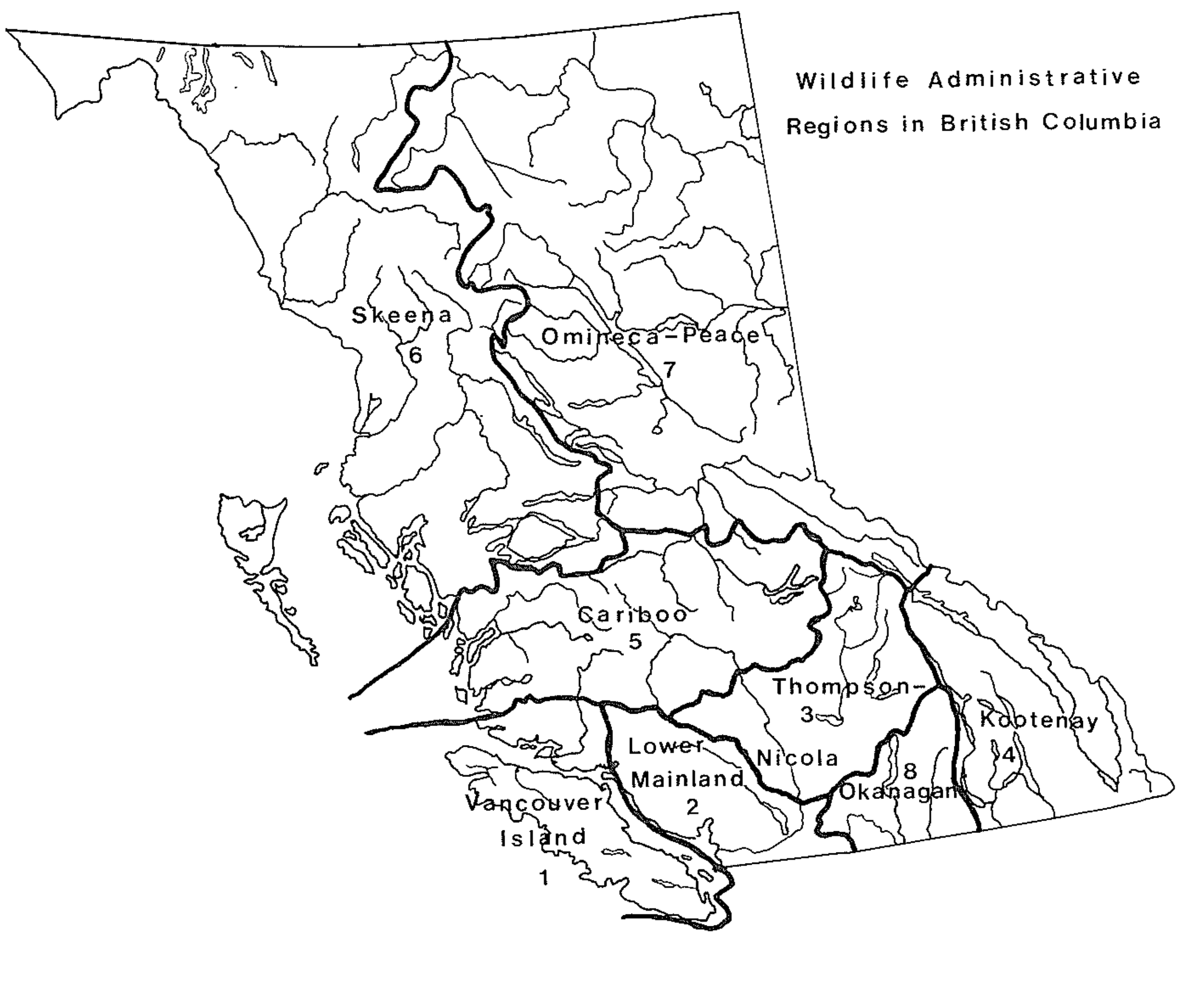

FIGURE 3. Wildlife administrative regions in British Columbia.

To facilitate these objectives five management prescriptions have been proposed (Munro and Jackson 1979):

1. "Protect critical habitat for three species: wolverine, fisher, and marten. This consists of mature conifer stands for wolverine and marten and mixed deciduous - conifer uneven-aged stands for fisher."
2. "Establish inventories to obtain population indices."
3. "Set harvest levels and seasons in accordance with known population characteristics."
4. "Monitor harvests to indicate mustelid population status."
5. "Encourage trappers to engage in education programs in humane trapping techniques and in resource planning to ensure protection of the mustelid family."

2.1.1.1 Headquarters

In 1925 the B.C. Wildlife Branch became the first wildlife agency in Canada to establish registered traplines. The purpose of this system was to encourage the responsible harvest of furbearers while eliminating the over-harvest of any one species. With the exception of minor regulation changes, no other wild fur management plan has been developed until recently. In 1983 a new system of trapping administration was set up, scheduled for operation in the 1985/86 season (B. Saunders, pers. comm.).

In this new system:

1. individual trapline location will be marked on maps no larger than 1:250 000.
2. every trapper will receive an assigned trapper number (ATN) coded by region, wildlife management unit, and registered trapline number.
3. all royalty fur export permits will require the ATN.

The major benefits of the new system will include reduction in time and cost to process trapline registration and, more importantly, the opportunity to obtain better information for local and provincial management (Saunders 1982). Saunders stated that the new system will enable a more accurate interpretation of furbearer harvest trends, thus providing a basis for creating new, or modifying existing, management strategies. A more detailed discussion is presented in Section 5.2.

2.1.1.2 Regional

To assess the consensus and progress of the mustelid management plan, Regional Wildlife and Habitat Biologists within the Wildlife Branch were questioned 1983 about their management objectives and habitat prescriptions for marten. Although most concurred over the overall management plan (Table 1), many felt it would be unrealistic to set any prescriptions specifically for marten and believed that most prescriptions established for ungulate habitat protection would apply to marten habitat as well.

2.1.2 Ministry of Forests and Lands

Official policy requires that any forest harvesting licensee planning a harvesting operation notify the trapper whose traplines are in the proposed development and harvesting areas. Notification is dependent upon identification of the trapper from the Wildlife Branch and only if Ministry of Forests and Lands Regional offices enforce the policy (L. Merkel, pers. comm.).

2.2 Private Corporations

In recent years private industry has begun to recognize the importance of trapping as an industry. As a result several companies have established programs aimed at working with trappers.

2.2.1 B.C. Hydro

In 1979, B.C. Hydro developed a Registered Trapline Program in co-operation with the Ministry of Environment and Parks and the B.C. Trappers Association. (Kelly 1982 b, 1982 c, 1982 d). One objective of the program is to provide a standard compensation policy that is "fair and consistent to all registered trappers." A second is to "allow the trapper to maintain the economic viability of the trapping enterprise." The program outlines measures to compensate trappers on an individual basis for losses related to trapping as a livelihood or business venture.

TABLE 1. Regional biologists' reply to questionnaire

Region	Question 1[a]	Question 2	Question 3	Question 4
1	WILDLIFE: Maintain spp. diversity and pop. levels Manage spp. in response to harvest demands	Unknown	None	Food habits in second growth
	HABITAT: Maintain spp. diversity and pop. levels Manage spp. in response to harvest demands	Unknown	None	Food habits in second growth
2	WILDLIFE: Maintain spp. distribution and pop. levels Permit harvesting through trapping	3000		
	HABITAT: Maintain spp. distribution and pop. levels Permit harvesting through trapping			
3	WILDLIFE: No specific objectives	Generally increasing	None	Better understanding of habitat requirements and productivity of various ages of forest regeneratior
	HABITAT: No specific objectives	Generally increasing	None	Better understanding of habitat requirements and productivity various ages of forest regeneratior
4	WILDLIFE:	No Response		
	HABITAT:	No Response		
5	WILDLIFE: None	Unknown	None	
	HABITAT: Maintain spp. diversity and pop. levels Manage spp. in response to harvest demands	Unknown	None	"Would like to see some"
6	WILDLIFE: None	Unknown	None	1) Pop. status 2) Marten ecology 3) Effects of habitat disturbance
	HABITAT: Maintenance of geographic distribution and "normal" pop. levels	Very common and widespread	None	
7 Omineca-Peace	WILDLIFE Supply trapper demand	Unknown	None	Methods of slash disposal
	HABITAT: Maintain diversity of the species	Unknown	None	
7 Prince George	WILDLIFE:	No Response		
	HABITAT:	Static	None	
8	WILDLIFE Maintain opportunity for regulated trapping Maintain present ranges whenever possible	Unknown	None	
	HABITAT:	No Response		

[a] Question 1. What are the management objectives for marten in your region?
Question 2. What is the population status of marten in your region?
Question 3. What prescriptions for logging or silvicultural practices do you set in areas of marten concentration?
Question 4. What are your priorities for marten research in your region?

The program is divided into 3 development phases:

1. Feasibility and preliminary design stage program compensates the trapper for loss of potential harvest and loss of presently used cabins, cubbies, traps and trails. This includes all activities such as exploration work up to the date of B.C. Hydro receiving project approval from the B.C. Utilities Commission.
2. Rights-of-way program compensates for harvest and trapline cabin losses caused by construction activities and provides incentives to improve the remaining portions of the registered trapline.
3. Power generation project program compensates for harvest and trapline improvement losses caused by construction activities. It will also provide incentives to trap (a payment based on pelt value up to the maximum potential harvest) and improve the remaining portions of the registered trapline.

In all three programs it is the trappers' responsibility to "actively and honestly participate in all phases of the program" (Kelly 1982 b, 1982 c, 1982 d). (Methodology for compensation payments for the three programs can be reviewed in Kelly 1982 b, 1982 c, 1982 d).

2.2.2 Petro-Canada

Petro-Canada Exploration Inc. recognized the importance of trapping both as a "vocation and a lifestyle" in the Monkman Pass and Monkman Trail area of northeast British Columbia, and designed a program especially for the Monkman Coal Project (Petro-Canada 1982).

The program consists of compensation costs in three forms:

1. for damage to property during exploration
2. for impacts on livelihood during exploration
3. for impacts on livelihood during construction and operation of the mine.

2.3 Forest Industry

Logging companies have not yet fully recognized the value of furbearers or the importance of trapping as an industry. There appears to be inconsistency between and within forest companies in the amount of communication with trappers. For example, B.C. Forest Products (BCFP) which operates throughout the province has only one division -- the MacKenzie Division in north central British Columbia -- that has any interactions with the trapping industry. (D. Lindsay, pers. comm.). Its policy is to inform affected trappers and to modify cutting plans where possible, perhaps leaving strips to incorporate trapper cabins. If logging takes place on short notice and traps are subsequently covered and lost, BCFP will purchase new traps. Other large companies like MacMillan Bloedel (R. McLaughlin, pers. comm.) and Northwood Pulp (G. Hazelwood, pers. comm.) will notify trappers of proposed cutting plans only if government policy dictates (see Section 2.1.1.2). Otherwise no other actions are taken.

3 MARTEN ECOLOGY

Characteristic of most mammals, marten experience frequent fluctuations in density. These are a result of changes in the reproductive, mortality, immigration, and emmigration rates that appear typically as a response to environmental influences. This section will present a cursory review of parameters limiting marten populations and provide a more detailed analysis of food habits and habitat requirements.

3.1 Population Parameters

Marten are typical of a K-selected species. The females become sexually mature after their 1st year with ovulation suspected to be induced by coitus. Males become sexually mature at the beginning of their 2nd year with a single period of spermatogenesis each year lasting 3-4 months (Mead and Wright 1983). Mating in summer is followed by a prolonged period of delayed implantation (approx. 7 months), with embroyos implanting in late winter in response to increasing daylength (Pearson and Enders 1944, cited by Mead and Wright 1983). Gestation is short (approx. 27 days), with birth occurring in April, but can range from March through May. An average of three young are born but ranges of one to six have been reported. The average life span of a marten in the wild is unknown, although records document that marten can live as long as 17 years in captivity (Burton 1962, cited by Johnson 1981).

Sex ratios are reported equal at birth (Markley and Bassett 1942). A 1:1 sex ratio is maintained in resident adult populations (Archibald and Jessup 1981), however during the initial phase of population decline a higher number of males to females has been reported (Weckwerth and Hawley 1962). The proportion of juveniles in a population has been reported as 30% in an unexploited population (Hawley and Newby 1957), 45% in a harvested population (Lensink n.d.), and up to 60% in an expanding population (Strickland and Douglas 1978).

3.1.1 Parasites

Mortality caused directly or indirectly by parasites in fur-bearing animals have been reported in fur seals (Dunsmore 1981), coyotes and wolves (Todd *et al*. 1981), beaver (Jellison *et al*. 1960), mink (Fyvie 1971), and otter (Kenyon *et al*. 1965, cited by Sweatman 1971). Known parasites of marten are listed in Table 2. While ectoparasitic infestations have been light, the stomach worm *Soboliphyme batarini* is frequently reported.

Only basic information on parasitic species infecting marten is known. Evidence from other fur-bearing species suggests that more attention should be directed toward the role that parasites play in marten populations.

3.1.2 Disease

The only known record of disease is an occurrence of pseudotuberculosis in European marten (Mair 1969). From this evidence disease does not appear to play a significant role in regulating marten populations.

3.1.3 Predators on marten

The effect of animal predators on marten populations is minor (de Vos 1952). Raptors, particularly great horned owls (Seton 1929, Silver 1957), have been reported as preying on North American marten. Other furbearers, such as lynx (Seaton 1929) and in particular fisher (J. Piper, pers. comm., cited by Silver 1957; Raine 1982) have been reported as occasional predators. A few British Columbia trappers also reported wolves and fisher as occasional predators on marten. Predators on European marten (*Martes martes*) include raptors such as golden eagles (Pulliainen 1981*a* or *b*), greaty grey owls, goshawks (Oksanen *et al*. 1985), and fox (Oksanen *et al*. 1985).

TABLE 2. Parasites reported in marten (<u>Martes americana</u>) populations

Parasite	Geographic Location	Reference
a) Ectoparasites		
Fleas:		
<u>Cnaetopsylla floridensis</u> (I. Fox)	Alaska	Johnson, 1981
	California	Zielinski, 1984
<u>Monopsyllus ciliatur protinus</u> (Jordan)	Alaska	Johnson, 1981
	California	Zielinski, 1984
<u>Monopsyllus vision</u> (Bak.)	Ontario	de Vos, 1957
<u>Hystrichopsylla dippiei spinata</u> (Holland)	Alaska	Johnson, 1981
<u>Megabothris atrox</u> (Jordan)	Ontario	de Vos, 1957
Mites:		
<u>Listtrophorus mustelae</u> (Megnin)	British Columbia	Cowan, 1955
<u>Lynxacarus mustelae</u> (Megnin)	Alaska	Johnson, 1981
Lice:		
<u>Stachiella</u> spp.	Alaska	Johnson, 1981
Ticks:		
<u>Ixodes texanus</u> (Banks)	Alaska	Johnson, 1981
b) Endoparasites		
Cestode:		
<u>Alaria taxideae</u> (Swanson and Erickson)	Manitoba	Poole <u>et al</u>. 1983
	Alaska	Sekerak, 1969
<u>Taenia mustelae</u> (Gmelin)	Alberta	Holmes, 1963
	Manitoba	Poole <u>et al</u>. 1983
<u>Taenia martis</u> (Zedar)	Alberta	Holmes, 1963
	Manitoba	Poole <u>et al</u>. 1983
<u>Baylisascaris devosi</u> (Sprent)	Manitoba	Poole <u>et al</u>. 1983
Nematode:		
<u>Soboliphyme batarini</u> (Petrow)	Alaska	Johnson, 1981
<u>Trichinella spiralis</u>	British Columbia	Schmitt, <u>et al</u>. 1976
	Quebec	Bourque, 1985

Although animal predators appear to play a minor role in regulating marten populations, they may influence marten habitat selection. Martin need for psychological or hiding cover has been cited by researchers as a possible deterent to their using cutover sites (Soutiere 1978; Steventon 1979; Burnett 1981). Research is needed to clarify the importance of psychological cover and its role in interspecific predation on marten.

3.2 Food Habits

Diet has received a great deal of attention. Marten are primarily carnivorous, preying on a wide range of vertebrates, but invertebrates and vegetation are also included in the diet. Table 3 presents food habits data for North American and European marten.
Because timing of data collection, type of collection (scats vs stomach contents), the precision of prey identification, and type of statistical analysis may introduce biases, interpretation of results should be made with caution.

In summer, marten generally select for voles as the major food item, primarily Southern red-backed vole (*Clethrionomys gapperi*) and meadow voles (*Microtus* sp.) as the major food items (Cowan and MacKay 1950; Lensink *et al*. 1955; Weckwerth and Hawley 1962; Koehler *et al*. 1975; Clark and Campbell 1977; More 1978; Soutiere 1978); with squirrels, birds, and berries important when in abundance (Murie 1961; Novikov 1962; Francis and Stephenson 1972; Penner 1981).

Winter food habit studies indicate voles, primarily red-backed voles and meadow voles, are the major food items (Cowan and MacKay 1950; Lensink *et al*. 1955; Quick 1956; Murie 1961; Koehler *et al*. 1975; More 1978; Soutiere 1978; Pulliainen 1981*a*; Kelly 1982*a*); with squirrels and rabbits important when in abundance (Zielinski *et al*. 1983).

Information from the literature (Table 3) suggests a seasonal and year-to-year variation in food habits. This is usually in response to a high abundance of a less preferred food item or more commonly a corresponding decline in arvicolid populations (Marshall 1946; Novikov 1962; Weckwerth and Hawley 1962; Pulliainen 1981*a*). In contrast to Burnett (1981) and Quick (1955) who believe marten to be opportunistic feeders, most researchers

TABLE 3. Food habits of marten throughout its geographic range (percent occurrence)

Location	Season	Voles	Squirrel	Small mammals[a]	Rabbits	Birds	Vege-tation	Insects	Misc. (carrion, etc.)	Reference
Prince George, British Columbia	Winter (2 yrs)	72.9	16.6	25.3	2.7	12.0	29.9	0.6	0.6	Kelly 1982
Fort Nelson, British Columbia	Winter (1947)	39.0		7.5		53.5	0.8		1.8	Quick 1956
	Winter (1948)	40.0	12.7	21.9	10.9	12.8			4.0	
Rocky Mountains	Summer	70.4	22.7	32.8	3.4	10.0	10.9	14.0	7.0	Cowan and McKay 1949
	Winter	77.1	5.9	20.1	5.9	1.2	4.7		5.9	
Idaho	Summer	79.0	15.0				20.0			Koehler *et al.* 1975
	Winter	79.0	8.0							
Alaska	Summer	74.2				7.8	18.1			Lensink *et al.* 1955
	Winter	68.2	1.9		0.9	18.8	9.3		0.9	
Wyoming	Summer	30.2	7.8	23.3	14.7	6.0	54.3	6.6		Murie 1961
California	Winter (1979-80)	26.1	21.0	9.4	11.6	2.2	1.11	0.3	13.0	Zielinski *et al.* 1983
	Summer (1980)	13.0	14.9		14.5	13.3	1.5	10.8	15.5	
Maine	Summer	79.5	6.0	6.0	0.9	25.1	20.3		10.5	Soutiere 1978
	Winter	70.8	18.1	8.3	5.6	6.0			13.6	
Montana	Winter (1942)	25.0	45.0		20.0					Marshall 1946
	Winter (1943)	39.0	35.0		5.0	8.0	6.5	1.5		
Northwest Territories	Summer	102.3		1.2		4.1	58.1	32.0	2.9	Douglass *et al.* 1983
Idaho	Summer (2 yrs)	81.0	6.5	10.5	2.0	37.0	39.0			More 1978
	Winter (2 yrs)	70.0	6.5	10.5	14.5	19.0	31.0			
Ontario	Summer	15.1	5.3	20.3	0.6	15.6	28.3	9.3		Francis and Stephenson 1972
Finland	Winter (1977)	49.4	10.1	0.3		11.8	16.1		26.9	Pulliainen 1981*a*
	Winter (1978)	94.4	0.7	1.2		7.1	5.7		1.0	
	Winter (1979)	97.6	0.2	3.3		8.3	1.0		0.1	
	Winter (1980)	13.5	6.8	15.6		29.4	20.8		29.4	

[a] May include voles.

believe marten actively select for a particulár food group or species (Weckwerth and Hawley 1962; Francis and Stephenson 1972; Clark and Campbell 1977; Douglass et al. 1983; Buskirk and MacDonald 1984).

Two theories have been advanced to explain these marten food habit preferences: energy benefits and the temporal or spatial habitat characteristics of the prey.

More (1978) investigated the role of energy benefits by comparing the mean caloric values per gram of biomass for three major prey species: Southern red-backed voles, meadow voles, and deer mice. Caloric values of 1.69, 1.40, and 1.85 kcal/gram, respectively, indicated voles are the most energy-rewarding prey when their greater mean adult weight is considered (27.5, 37.5, and 21.0 grams, respectively).

The temporal and spatial characteristics of preferred prey species have received much attention. Voles are active year-round, are slow moving and are relatively docile (Kelly 1982a). In winter, many construct runways and nests above ground thus making them relatively easy to capture (Friesen 1972; cited by More 1978; Coulter 1966; cited by Powell 1982). More importantly the Southern red-backed vole's patterns of temporal activity most closely resembles that of the marten (Stebbins 1971 cited by More 1978; Friesen 1972 cited by More 1978; Herman 1975; McPhee 1977), while meadow voles are somewhat intermediate in their overlap of marten activity (Ambrose 1973). In contrast, the activity pattern of deer mice are quite different than those of marten (Stebbins 1971 cited by More 1978; Friesen 1972, cited by More 1978). Deer mice are fast moving, more alert than voles and therefore more difficult to capture (Kelly 1982a), although they are also active on the snow surface during winter. Red squirrels are intermediate in their overlap of marten activity patterns from spring to fall, but usually progress to a subterranean state during freezing weather. In addition, some small mammals, particularly voles, exhibit winter aggregations (West and Dublin 1984). This behaviour may enhance their detection by marten and more readily predispose them to capture. In general marten and voles prefer mesic sites, while deer mice and squirrels select xeric sites.

This discussion indicates that marten select for voles, although they have optimized their foraging strategy by exhibiting a flexibility which allows them to take advantage of unexpected food surpluses. The effects of habitat selection and hunting strategies in prey selection by marten will be discussed in Section 3.3.

3.3 Habitat Selection

Measures of habitat selection or preference should reflect habitat quality as percieved by marten, as it is assumed that increasing individual biological fitness forms the basis of habitat selection. This section will be primarily qualitative with an attempt in Section 4 to describe quantitatively the role that environmental variables play in the temporal and spatial patterns of marten distribution.

Marten preferences for broad ecological units are well documented (Marshall 1951; Hagmeier 1956; Weckwerth and Hawley 1962), but microhabitats have received less attention (Francis and Stephenson 1972; Clark and Campbell 1977; More 1978). Emphasis in this section will focus on microhabitats defined by hunting, resting, and denning sites. Microhabitats are believed to better reflect an animal's strategy of habitat use than are larger units. It is the environment within a cover type that is important, rather than broad measures of cover itself.

3.3.1 Hunting sites

Marten hunt almost exclusively on the ground (Marshall 1951; More 1978; Campbell 1979; Steventon 1979; Pulliainen 1981a); although Spencer and Zielinski 1984 found marten using elevated perches in areas where vision is limited near the ground. Marshall (1951) and Spencer and Zielinski (1984) reported that in summer marten hunt from one snag, windfall, or dense tangled clump of low brush to another, searching every hole and crevice in detail. Campbell (1979) reported that in winter most of the hunting was done beneath the snow's surface and that 93% of the sites investigated were associated with fallen trees having diameters greater than 20 cm. In California, Hargis (1982) recorded marten digging through snow for distances up to 72 cm, and suggested that marten gain access to their prey in winter via leaning trees, fallen logs, and other debris protruding above the snow.

Most researchers observed hunting behaviour only in areas with an overhead canopy. However, many of the open areas studied were meadow systems or clear cuts in which cover was removed. Lensink et al. (1955) and Steventon and Major (1982) reported a greater than expected use of clearcuts in summer during periods of high berry production. Dense pockets of raspberry bushes appeared to provide adequate overhead cover and a desirable food source for marten.

Hunting or feeding sites in summer appear to be dependent upon vegetated mesic sites, a preferred habitat for a preferred prey species, or an abundance of a short-term alternate food source such as berries. In winter, debris or vegetation is necessary for access to prey species under snow.

3.3.1.1 Hunting strategies

To understand how marten use hunting sites, the strategies used to capture prey must be considered. Unfortunately this type of information for marten is limited, typically based on incidental observations. For purposes of this discussion, information from studies on ermine (*Mustela erminea*) will be used. This species occupies similar habitats to marten and its major prey species is also Southern red-backed vole.

Five steps have been defined in the hunting strategy or predatory sequence for weasels: approach, detection, choice, capture, and consumption (Nams 1980). Nams showed that the more preferred prey species was approached at a higher frequency than expected, based on availability. This, he concluded, was due to spatial and temporal overlap between prey and predator when the predator was moving. Ermine therefore hunt habitats used by preferred prey species at a higher frequency than those habitats used by other equally abundant prey. Marten also show a temporal and spatial overlap of its preferred prey species and therefore also probably optimize prey selection by activity patterns and microhabitats selected.

There is much controversy about how mustelids detect their prey. Erlinge (1974, cited by Nams 1980) reported that stoats use sound. However, Nams (1980) concluded that smell was important in prey detection at distances (< 3 m) and cited several studies in support of this (Herman 1973 cited by Nams 1980; Smith 1978). Subjective observations suggest that a combination of sight, smell, and sound are used (Burnett 1981; Spencer and Zielinski 1984). Nams (1980) found no evidence to suggest weasels selectively chose preferred prey once they are encountered. Rather, he hypothesized that prey can be explained by microhabitat selection. This is probably the case for marten.

Nams (1980) showed the probability of capture after detection was independent of microhabitat type for ermine. This may not be true for marten. Ermine are much smaller and can enter tunnels and holes used as escape routes by prey. Marten, because of their size, would be more restricted, so microhabitats may be of more importance in the ability to catch prey.

Wolves, foxes, and ermine all kill prey without immediate consumption (Kruuk 1972; MacDonald 1976; and Nams 1980, resp.). Evidence indicates that this behaviour is uncommon for marten. Pulliainen (1980) reported that European marten cached prey and later returned to eat it, sometimes up to several months later. However no further evidence is available to suggest that caching food is a common practice and Spencer and Zielinski (1984) reported that in all successful hunting observations marten immediately consumed the prey.

Hunting sites and food habit preferences interact in the hunting strategies employed by marten. Mesic sites with blowdowns, rotting stumps and herbaceous cover are much preferred by marten and its principal prey, the vole.

3.3.2 Resting sites

Published literature suggests that resting sites are associated with food resources. Marshall (1951) in Montana and Pulliainen (1981b) in Finland often found resting sites in association with recent kills. Ground level sheltered areas (under logs and in densely vegetated sites) appear to be preferred resting sites. In winter, evidence suggests resting sites may be chosen to reduce thermoregulatory costs. Eiberle and Matter (1985) in Switzerland have shown that rainy winters or large amounts of snow over successive years have a depressive effect on weasel and stoat populations, while summer weather conditions does not appear to have significant influence. Sites selected in winter are usually below the snow in natural cavities between rocks, stumps, or downed trees (Marshall 1951; Clark and Campbell 1977; Mech and Rogers 1977; Steventon 1979; Pulliainen 1981b; Spencer 1982). Spencer (1982, citing Gipson et al. 1981) in Alaska reported that marten in summer used red squirrel middens almost exclusively. Man-made sites such as slash piles are also commonly used (Clark and Campbell 1977; Burnett 1981; Spencer 1982; Steventon and Major 1982).

Use of trees as resting sites is less common and may be seasonal in nature. In Maine, Masters (1980) reported use of large ($\bar{x}$ dbh=42 cm) living trees in the spring. He suggested that melting snow made usual ground sites unattractive. In Wyoming (Clark and Campbell 1977) and California (Spencer 1982) marten reportedly use large ($\bar{x}$ dbh=48 and 102, respectively) dead, rotten spruce and fir trees as resting sites in the summer. Dwarf mistletoe bundles in subalpine fir are less commonly used, again mainly in the spring and summer months (Clark and Campbell 1977; Burnett 1981; Steventon and Major (1982) in Maine reported a switch from ground sites in the winter to resting sites at the crowns of softwood in the summer. In the absence of snow, ground resting sites may not provide adequate cover for concealment. Repeated use of resting sites has been reported by Burnett (1981), Soutiere (1978), and Steventon and Major (1982). Ground-level sheltered sites therefore appear to be preferred in winter, summer, and fall, while wet spring conditions dictate the use of aboveground sites.

Sheltered sites that promote the reduction of thermoregulatory costs in winter and those in close association with a food supply appear to dictate resting site locations. Alterations of resting habitat through silvicultural practices may be tolerated to some degree since the arboreal nature of the marten appears to have been over-emphasized (Zielinski et al. 1983). However, it should also be recognized that some arboreal resting sites are necessary for the persistance of marten populations in wet sites.

The maintenance of resting sites is necessary for the persitence of marten populations. Although alterations of the habitat may have deleterious affects on resting sites availability it is reassuring to note how readily marten utilized man-made resting sites.

3.3.3 Natal den sites

Den site availability may limit marten populations (Bergerud 1969; Wynne and Sherburne 1984). Natal den sites have been reported in natural cavities in escarpments, hollow logs, and snags and among boulders (Marshall 1952, Francis and Stephenson 1972; Mech and Rogers 1977; Thomas 1979; More 1981; Wynne and Sherburne 1984). Ahola and Terhivud (1982) reported European marten displacing owls from their nest boxes for den sites. Swann (1982) in Scotland found marten using buzzard nests. That marten show flexibility in denning site location is further supported by Novikov (1962) who reported a den in a pile of logs along the side of the road. Accordingly evidence advocates sheltered sites are preferred as denning sites for marten.

Hunting, resting, and denning sites all require cover. In hunting, cover is indicative of the preferred habitat type for the prey and provides access to the prey during winter months. Resting and denning sites require cover as insulation in winter, as a protective screen in summer, and as security against predators. Although information on coastal marten is not available it is presumed that their requirements are the same.

3.4 Habitat Use

3.4.1 Home range

The size of an animal's home range is a function of the individual's energy requirements and the resources available in the habitats used (McNab 1963).

Home range sizes for marten have been estimated by track and trail counts, mark re-capture studies, and radio telemetry projects (Table 4). Examination of Table 4 shows a wide scope in home range estimates; for example, winter values for males range from 1.8 to 28.6 km^2 and for females from 0.6 to 9.8 km^2. Home range estimates are most common at the lower end of the scale. The upper range estimates from Finland probably reflect low habitat productivity. The two largest home ranges reported by Mech and Rogers (1977) probably represent juvenile dispersal because the body weights reported suggest juvenile animals. Home range data from British Columbia are limited to one study Sub-Boreal Spruce Zone of the Interior (Kelly 1982a), which gives

TABLE 4. Home range estimates from published studies

Location	HOME RANGE km^2 Winter		Summer		Source	Type of study	Sample Size	
	Male	Female	Male	Female			Male	Female
Maine [a]	9.2	2.1			Steventon 1979	Telemetry & Trapping	2	2
Russia [b]	17.9	8.5			Pulliainen 1981b	Track & Trail	3	2
British Columbia [c]	2.3				Kelly 1982	Track & Trail, Trapping	16	
Montana [e]	2.9	0.7			Burnett 1981	Telemetry & Trapping	3	3
Maine [a]	1.8	0.6			Soutiere 1978	Mark Re-capture	29	17
Montana [d]			2.4	0.7	Hawley & Newby 1957	Mark Re-capture	6	5
Michigan [d]	15.7	4.3			Mech & Rogers 1977	Telemetry	3	1
Ontario [a]			3.6	1.1	Francis & Stephenson 1972	Mark Re-capture	4	4
Wyoming [e]	2.2	0.8			Clark & Campbell 1977	Telemetry & Trapping	3	1
Maine [a]			7.6	1.0	Major 1979	Telemetry	3	1
Maine [a]			5.6	2.9	Wynne & Sherburne 1983	Telemetry	2	3
Finland [b]	28.6	9.8			Pulliainen 1984	Track & Trail	5	4
Manitoba [f]	8.9	6.6			Raine 1982	Telemetry	2	1

[a] Resident adults only
[b] May include juveniles
[c] No seasonal or sexual differentiations
[d] All residents including juveniles
[e] All residents, no seasonal differentiations
[f] Juveniles only

an average home range of 2.3 km^2. Since the track and trail technique was used the home range estimate is probably low by at least an order of magnitude (Steventon and Major 1982).

Partial overlap between home ranges of adult males has been reported but evidence in these studies suggest some kind of spacial - temporal aversion was in effect so that individuals were active at different times in areas of overlap (Francis and Stephenson 1972; Mech and Rogers 1977). There appears to be a greater tolerance in the overlap home ranges of females, while male - female home range overlap is common (Hawley and Newby 1957; Francis and Stepenson 1972; Clark and Campbell 1977; Archibald and Jessup 1981; Burnett 1981). Pulliainen (1984) suggests that a space resource use system rather than territoriality exists for marten. However, I believe that male marten exhibit a territoriality during the breeding season. Fighting, an important territorial mechanism, has been reported to coincide with the breeding season (Hawley and Newby 1957; Herman and Fuller 1974). Scats have been recorded along home range boundaries in the summer (Archibald and Jessup 1981) and in greater concentration during June and July (Warner and O'Sullivan 1982). Pulliainen (1984) did not find any concentrations of marten scats during the winter months which lends further support to the breeding territory hypothesis.

3.4.2 Dispersal

Dispersal is generally associated with the juveniles of a population and commonly occurs from August through November although a late spring dispersal period has been documented (Archibald and Jessup 1981; Burnett 1981). It is not unusual for marten to search large areas for suitable unoccupied sites. Hawley and Newby (1957) recorded a maximum dispersal distance of 40 km over a 2.5 month period and Archibald and Jessup (1981) in the Yukon reported juvenile dispersal in male and female marten of 8.4 and 10.4 km, respectively.

Although dispersal in adults is uncommon, severe habitat changes can precipitate dispersal. Raine (1982) reported an adult male dispersing 61 km after a large fire.

3.5 Movement

Movements by marten are generally made in association with the breeding season or in foraging, and are commonly measured as straight line distances between resting or kill sites or as the distance travelled between locations on successive days.

In Ontario, summer movements by resident adults between successive days averaged 0.97 km for males and 0.61 km for females (Francis and Stephenson (1972). Mech and Rogers (1977) in Minnesota reported a distance of 0.4 km for a male between successive days.

Winter movements are greater than summer movements. Mech and Rogers (1977) found average daily movements of 2 km in males; whereas in Maine, Steventon (1979) reported an average daily movement of 5.9 km for males and 4.7 km for females. In Finland, Pulliainen (1981b) recorded winter movements of European marten between resting sites that averaged 4.7 km for males and 2.9 km for females. Citing Nyholm (1970) and Nasimovic (1948), Pulliainen (1981b) reported the average length of "hunting trips" were 8.6 and 7.8 km, respectively. The longest movement he recorded for a 24-hour period was 28.2 km.

3.5.1 Activity patterns

The activity of a predator, such as the marten, is affected by weather, temperatures, and previous hunting success (More 1978). Lensink (n.d.), using track counts in Alaska, found marten activity was very high in fall and early winter, followed by a sharp decline during the cold winter months with a resumption of activity in late February or March when the weather became milder. More (1978), working in Alberta with radio-collared marten and track counts, generally supported Lensink's observations. More (1978) showed that marten in summer had a bimodal daily activity pattern peaking around the hours of sunrise and sunset. Data collection during winter was biased toward daylight hours but also supported a bimodal activity pattern, with activity concentrated in late morning and late evening. These findings were similar to those of Clark and Campbell (1977). Major (1979), using radio-collared marten in Maine, found a high degree of diurnal activity in the summer. Active logging in the study area may have accounted for the different peak times of activity, indicating marten are affected by human activity regardless of its results, although more information is needed to clarify this point.

The eyes of marten are adapted for dim light conditions rather than bright light or darkness (Kavanau and Ramos 1975, cited by More 1978). More (1978) in Alberta found that marten tended to be active on overcast or rainy days and inactive on clear and snowy days. He concluded that time of day during summer and winter and weather during the fall were the best variables with which to predict activity patterns. Habitat variables were the least valuable predictors. Marten activity was also shown to be synchronized with that of the prey (Zielinski et al. 1983). The marten's quality of vision, daily and seasonal weather patterns, prey activity patterns, and, to a lesser degree, human disturbance all influence daily activity patterns of marten. However, the degree to which these influences may effect marten populations is not adequately understood.

Natural selection dictates that animals should optimally forage in ways that maximize individual fitness (Pyke et al. 1977). Marten are consistent with optimal foraging strategists in that they show a marked preference for a particular food item by their habitat selection, by how they use that habitat, and by their flexibility in activity which allows them to adapt to prey activity regimes.

Information on marten in coastal ecosystems is almost non-existent. Since the prey base and weather patterns may differ from those on the mainland, specific differences in habitat, use, and activity is probable. However, how and why marten select microhabits is likely the same.

4 FORESTRY IMPACTS ON MARTEN POPULATIONS

Timber harvesting affects marten adversely by altering their habitat (Grakov 1972; Clark and Campbell 1977; Mech and Rogers 1979; Soutiere 1979; Kelly 1982). Logging and subsequent silvicultural practices alter marten habitat by removing marten cover, the total effect of which depends on how much cover is removed. Selective logging, for example, does not result in as drastic a change as clearcut logging. In addition, timber harvesting -- particularly clearcut logging and associated clean-up operations -- alters the edatopic nature of the site. Increases in temperature range, windspeed, and snowpack occur. Radiation, convection, and conduction in the site are also altered (Moen 1973).

These changes could seriously affect marten populations in many ways. Habitat alterations resulting from logging will elevate already high thermoregulatory costs for marten, whose long, thin bodies and short pelage have higher energetic costs for thermoregulation compared to compactly shaped mammals (Brown and Lasiewski 1972). If the quality of the habitat is reduced, home range size, daily movements, and dispersal distances typically increase. Therefore these three parameters could act as a barometer of the marten's ability to cope with any deleterious alterations of the habitat resulting from forestry practices.

4.1 Logging

Changes in marten populations as a result of logging operations are well documented. Grakov (1972) in Russia concluded that marten populations were significantly decreased when more than 25% of the mature or overmature timber was removed. Soutiere (1978) in Maine reported that in areas of clearcutting, marten population densities were reduced up to 75%, home ranges were expanded, and there appeared to be fewer immature and non-resident marten using the area. In areas where less than 40% of the basal area was removed only total marten density appeared to be affected. Steventon and Major (1982) working in the same area concluded that clearcuts limited female movements and suggested that this indicated a need for psychological cover. In areas of north central British Columbia, Kelly (1982a) reported that marten selected uncut habitats. This occurred most often in winter where snow accumulations prevented access to food resources. This is supported by Raine (1982) who stated that a snow depth greater than 20 cm would restrict movements by marten. Therefore, any habitat alterations resulting in an increase in snow accumulation would have serious effects on marten populations in heavy snowfall areas of British Columbia.

The effects of logging may not be as important in coastal areas of British Columbia, especially on Vancouver Island where mild winters predominate (many winters do not have any appreciable snowfall). Prey populations would remain available to marten year-round in young-aged stands such as clearcuts because of the lack of snow. Indeed, trappers and field personnel on Vancouver Island say there are abundant marten populations in older clearcut (5-10 yr.) and young second-growth stands. High prey populations have not been confirmed.

Martell and Radavanyi (1977) in Ontario found that clearcutting black spruce forests caused a decrease in the populations of Southern red-backed voles, rock voles, and bog lemmings, but an increase of deer mice, meadow voles, heather voles, and chipmunks, resulting in a change of small mammal composition only, and not overall density for over a minimum of 3 years (Svendsen 1981; Martell 1983). West et al. (1980) in Alaska reported a 50% reduction in Northern red-backed vole density in clearcuts when compared to populations in corresponding partial-cut and uncut stands. His study further showed that Northern red-backed voles discriminate between suitable and unsuitable overwintering sites. For 3 consecutive years the voles abandoned clearcut areas during the winter and repopulated them after snowmelt before remaining as year-round residents. Lack of adequate ground cover was identified as the cause. The lack of a preferred food source may serve to artificially depress marten populations over the short term. In contrast, dense second-growth stands may have artificially high mice and squirrel populations because of the number of cones being produced. This temporarily abundant food source may serve to increase marten populations on the short term.

4.2 Silvicultural Treatments

4.2.1 Site preparation

4.2.1.1 Mechanical

Mechanical treatments are aimed mainly at destroying vegetation that compete with tree growth, and they result in the exposure of the mineral soil (Smith 1962). Reduction in marten habitat suitability is severe. Cover by shrubs and herbs is greatly reduced for a minimum of 3 years, eliminating customary hunting, resting, and denning sites.

Scarification is the most common method of mechanical site preparation presently used in British Columbia. Martell and Radavanyi (1977) reported that scarification appears to enhance deer mice. Food specialists such as Southern red-backed voles would probably decrease in numbers, reflecting the destruction of their food resource and cover.

Competitive exclusion of Southern red-backed vole by deer mice has been reported by Dyke (1971, cited by West 1982) and Martell and Radavanyi (1977). If scarification is followed by seeding, deer mouse populations may remain high for several years, resulting in an extension in the displacement of vole populations. This in turn may depress marten populations below their potential until voles re-establish.

4.2.1.2 Controlled burning

Fire is used to clear logging debris left after harvest operations. Broadcast burning usually results in the destruction of all vegetation and exposure of the mineral soil (Smith 1962). Broadcast burning used as a silvicultural tool reduces the suitability of the area for marten. Overhead cover is eliminated and, without any herbaceous growth, prey populations are excluded from the area for at least 3 years (West 1982). In a clearcut, unburned site, however, use of the area by prey populations was recorded in the first summer (West *et al*. 1980). Spot burning, which is usually restricted to landing sites, reduces the impact on vegetation and soil in an area and can be better tolerated by marten and their prey.

4.2.2 Fertilization

Forest fertilization has become an operational management practice in parts of British Columbia during the past 20 years (P. Barker, pers. comm.). This treatment can affect marten habitats by increasing plant understory growth and by the presence of high levels of urea at the initial phase of fertilization. As discussed in Section 3, increased cover can be beneficial to marten and their prey populations.

Research by Postovit (1976) indicated that the application of urea as a forest fertilization is not likely to damage populations of deer mice or other small mammals. Applications up to 400 lb N/acre applied during wet conditions (a standard procedure) will dissipate in 24-40 hours in the forest. Although there is no research directed towards the effects on marten, conclusions resulting from studies on prey populations and large ruminants suggest that there would be no adverse effects. In fact, fertilization may be beneficial by making previously unsuitable habitats more favourable.

4.2.3 Thinning

Spacing (or precommercial thinning) and commercial thinning was introduced to British Columbia over 10 years age, as an operational tool to reduce competition and decrease rotation time.

4.2.3.1 Pre-commercial thinning

Spacing is commonly applied in seriously overcrowded stands that have developed from natural regeneration or dense plantations (Smith 1962). Felled trees are left in the stand, and with the opening of the canopy, herbaceous growth is promoted. Resulting herbaceous growth in turn may promote the increase of preferred prey species in the spaced area. In addition, debris from spacing may provide hunting, denning, and resting sites for marten. G. Burnett (pers. comm.) in Montana reports use of spaced stands by marten in winter.

4.2.3.2 Commercial thinning

Commercial thinning is applied to older stands to promote tree growth. Felled timber is removed, leaving the stand only minimally disturbed. Effects on existing marten and prey populations would be minimal.

4.2.4 Biocides

Treatment of forest land with herbicides for the purpose of conifer release in immature stands is the predominant type of biocide application (Humphreys 1981). Residues of herbicides are of low concentration and short-lived, suggesting that the effect on marten populations is probably minimal. Ingestion of contaminated vegetation by prey species is probably the major vehicle of transmission to marten populations. Monosodium methane arsenate (MSMA) used in spaced stands to kill conifers is toxic to mammalian populations (Smith 1962) but more research must be done before effects on marten can be determined.

Loss of herbaceous vegetation through biocide application will lead to a reduction of canopy cover and a more open and xeric site, resulting in a temporary loss of suitable resting sites. A change in small mammal composition from voles to mice will probably result, thus reducing the marten's preferred food source. However the overall effect on marten populations would likely be of a short duration.

Rodenticides are used to control small mammals in nurseries and young plantations. They are not presently used in British Columbia, but are in limited use in the United States. Anticoagulates commonly used, such as coumarin and indandione, are reported to have caused secondary poisoning of some mustelid species (Hegdal et al. 1981).

Tables 5a, b and c summarize the information presented in this section. Based on this author's belief that different biogeoclimatic zones respond differently to the same silvicultural treatment, the predictions are subdivided by the three marten density distribution areas discussed in Section 1.1.

4.3 Wildfire

Wildfires have played a significant role in influencing furbearer populations. Lensink (n.d.) cited it as one of the destructive forces contributing to the disappearance of marten from its range and said that effective management of marten requires control of forest fires. Lutz (1956) states that the marten is "... more menanced by forest fires than any other furbearer" and indeed Raine (1982) reported a dispersal of 61 km by an adult male after a fire. In addition, Bailey (1981) reported that marten are extremely scarce in areas of Alaska where wildfires have occurred periodically over the past 100 years. Wildfires eliminate cover and alter the edatopic nature of the site. As discussed in Sections 4.1 and 4.2.1.2, this can eliminate preferred prey populations for at least four winters (West et al. 1980).

TABLE 5a. Effects of forestry practices on marten life activities in high density areas within 5 years after disturbance

Marten Life Activities	Forestry Practices							
	Clear-cut logging	Selective logging	Scarification	Slash burning	Fertilization	Pre-commercial thinning	Commercial thinning	Biocide application
Denning	-	0	-	-	0	+	0	0
Resting	-	-	-	-	+	+	-	-
Hunting	-	-	-	-	+	+	-	-
Prey:								
Southern red-backed vole	-	-	-	-	+	+	0	-
Meadow vole	+	0	+	-	+	0	0	-
Deer mouse	+	+	+	+	-	0	+	-
Squirrels	-	0	-	-	+	0	0	0

Key: + positive
- negative effect
0 no appreciable effect

TABLE 5b. Effects of forestry practices on marten life activities in moderate density areas within 5 years after disturbance

Marten Life Activities	Forestry Practices							
	Clear-cut logging	Selective logging	Scarification	Slash burning	Fertilization	Pre-commercial thinning	Commercial thinning	Biocide application
Denning	-	0	-	-	0	+	0	0
Resting	-	0	-	-	+	+	0	-
Hunting	-	-	-	-	+	+	-	-
Prey:								
Southern red-backed vole	-	-	-	-	+	+	0	-
Deer mouse	+	+	0	0	-	-	0	-
Townsend's vole	+	0	-	-	+	0	0	-
Meadow vole	+	0	+	-	+	0	0	-
Squirrels	-	0	-	-	+	0	0	0

Key: + positive
- negative effect
0 no appreciable effect

TABLE 5c. Effects of forestry practices on marten life activities in low density areas within 5 years after disturbance

Marten Life Activities	Forestry Practices							
	Clear-cut logging	Selective logging	Scarification	Slash burning	Fertilization	Pre-commercial thinning	Commercial thinning	Biocide application
Denning	-	-	-	-	0	+	-	0
Resting	-	-	-	-	+	+	-	-
Hunting	-	-	-	-	+	+	-	-
Prey:								
Southern red-backed vole	-	-	-	-	+	+	-	-
Meadow vole	-	0	0	-	+	0	0	-
Deer mouse	+	+	+	+	-	0	+	-
Squirrels	-	0	-	-	+	0	0	0

Key: + positive
- negative effect
0 no appreciable effect

Conversely, Koehler and Hornocker (1977) concluded that wildfires in southern areas provide a mosaic of habitats, resulting in marten populations being maintained over longer periods of time than if fires were controlled. Bunnell (1980) reports that burned areas should still be used by marten in summer and fall and may be limiting only in winter. This may be related only to prey abundance, as debris resulting from the fire may provide hunting, denning, and resting sites.

Questionniare responses from British Columbia trappers indicating that the effects of wildfires on marten populations may be influenced by ecosystem type. The information suggests that regenerating young burns in the boreal white spruce zone may provide excellent but probably short-term marten habitat. This has not been confirmed, and more information is needed to assess the influence of fire on marten habitat in the different ecosystems.

Wildfires can effect marten populations adversely if they are large, hot and frequent. However evidence suggests periodic small fires can promote favorable aspects of marten habitat by increasing herbaceous growth and dead and down material.

5 MANAGEMENT

A harvest strategy is the only present form of marten management in British Columbia. The objectives, directions, and recommendations for change of the program with respect to marten populations will be discussed. In addition the habitat suitability index, or HSI model, developed in the United States will be examined and its applicability to British Columbia discussed.

5.1 Fur Harvesting Impacts on Marten Populations

Trapping mortality is meant to compensate or substitute for natural mortality without reducing mean levels of breeding populations (Todd et al.1981). However, because marten have low rates of increase and are easily trapped, trapping mortality in some areas has exceeded surplus animals in the population and resulted in serious declines (Marshall 1942; Yeager 1950; de Vos 1952; Silver 1957; Dodds and Martell 1971).

Ecological, economic (Section 1), and social factors (Dixon and Swift 1981) play an important role in determining allowable levels of fur harvests. Models are now being developed in the United States which use optimization techniques (population dynamics) to allow economic and social factors to be combined with biological models and ecosystem models. These models are necessary to determine the optimal harvest from furbearer populations and to assure that these populations have a secure future (Dixon and Swift 1981).

5.2 Management in British Columbia

According to B. Saunders (pers. comm.) the present use of furbearers, including marten, is far below total potential use in British Columbia. The harvest strategy for marten in British Columbia is administered by the alteration of gear restrictions and season lengths. New regulations encourage yearly use of registered traplines such that inactive traplines may be rescinded. Consideration is being given to new regulations for marten, including the basing of trapping seasons on the biology of the marten as well as fur primeness. This would be a positive step towards a better management strategy for marten in British Columbia.

The ATN or Assigned Trapper Number system (see Section 2.1.1.1) was developed to provide accurate records of harvested species by trapline. Fur harvest on private property and on Indian Reserves are be recorded but will be retrievable by Management Unit (M.U.) only. At present, harvest data are the only information available to the wildfur manager in British Columbia. This information is useful as an indicator of population trends only if <u>several</u> years of data are available, and therefore it can be considered a delayed reaction system in that important population changes may not be immediately recognized. In addition, variation in capture probabilities would further confound harvest record indices.

A more accurate estimate of population trends from harvest data should include some measure of effort. This can be estimated by recording the average number of traps used, number of days (because trappers may use different sections of their line each year), and the average length of the trapline used each year.

Estimation of the rate of exploitation of marten populations averaged for the entire province can be severely biased. The same harvest rates from areas of different productivity can have very different exploitation rates. Information presented in Section 1 indicates that the carrying capacity for marten varies throughout British Columbia. The inclusion of the three density distribution areas within the ATN monitoring system would provide the wildfur manager with data in corresponding to habitat capability.

Ultimately, the trapper has the greatest influence on the number of marten harvested on his trapline. The best management strategy therefore would be one in which the trapper undertakes the management of marten. Because marten are easily trapped and consequently have a high potential of being over-harvested, education of the trapper is an important component of this type of harvest strategy. The trapper must be able to recognize an increasing, decreasing, or stable population if he wants to manage on a sustained yield basis.

The trapper is a ready source of useful information. Interested trappers that primarily harvest marten could be requested to save carcasses. This is currently being done with much success in M.U. 1, resulting in large samples. Carcasses are providing data on the sex and age class of the harvest, reproduction, food habits, and parasite loads and disease. On a province-wide basis, short-term benefits of collecting carcasses would include a measure of productivity of specific ecosystem units. Long-term benefits would include an excellent data base on which future management decisions could be made and research based.

5.3 Habitat Suitability Index Model

The HSI or Habitat Suitability Index model was developed as a basis for improved decision making and increased understanding of the impact of habitat alterations on the target species (Schamberger et al. 1982). Initial HSI models were usually developed from "... scant data relying on experimental evidence and intuition ..." to establish the model variables and relationships (Shimamota and Airola 1981). Model variables are typically confined to habitat characteristics, not species population variables. Since regional differences in population responses are expected, separate regional models are usually prepared (Patton and Escano 1983).

The HSI model for marten in the northwestern U.S. only considers one life requisite, winter cover, and assumes if it is present in adequate levels, habitat and food requirements throughout the year will not be limiting (Allen 1982). This model is illustrated in Figure 4.

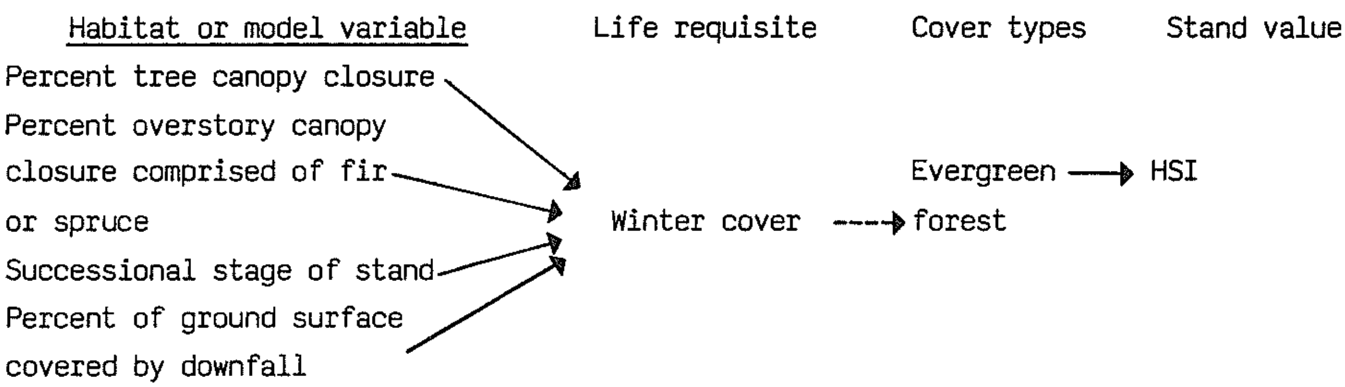

FIGURE 4. Relationships of habitat variables, life requisities and cover types in the marten HSI model (taken from Allen 1982).

The HSI word model is then reduced to a graphic representation of the relationship between the habitat variables and the derived habitat suitability index (see Figure 5). The suitability index values are combined in the following format $(V_1xV_2xV_3xV_4)^{\frac{1}{2}}$. An index value of 0.0 is considered as unsuitable habitat, while 1.0 is considered optimal habitat.

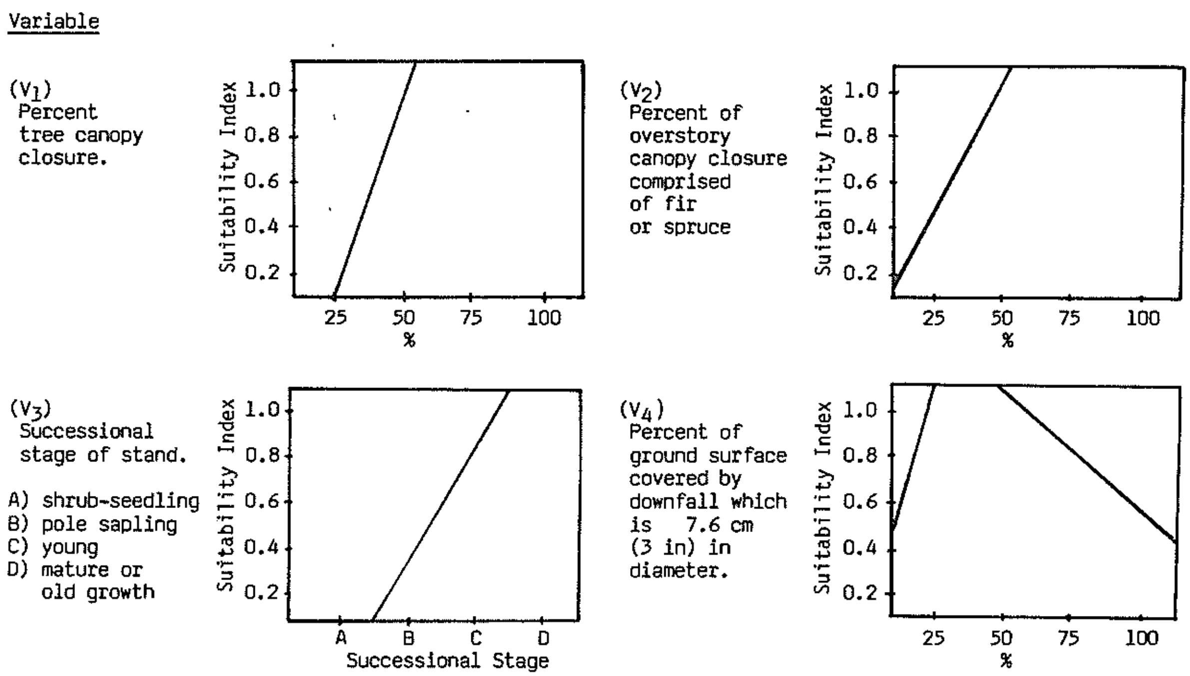

FIGURE 5. Habitat suitability index model for marten (adapted from Allen 1982).

With the present level of information, construction of models for the three density regions of British Columbia would be premature. Instead a GENERAL HYPOTHESIS for the moderate density distribution area on the coast is presented in Figure 6. It is intended that these hypothesized numerical responses will aid in refining research direction.

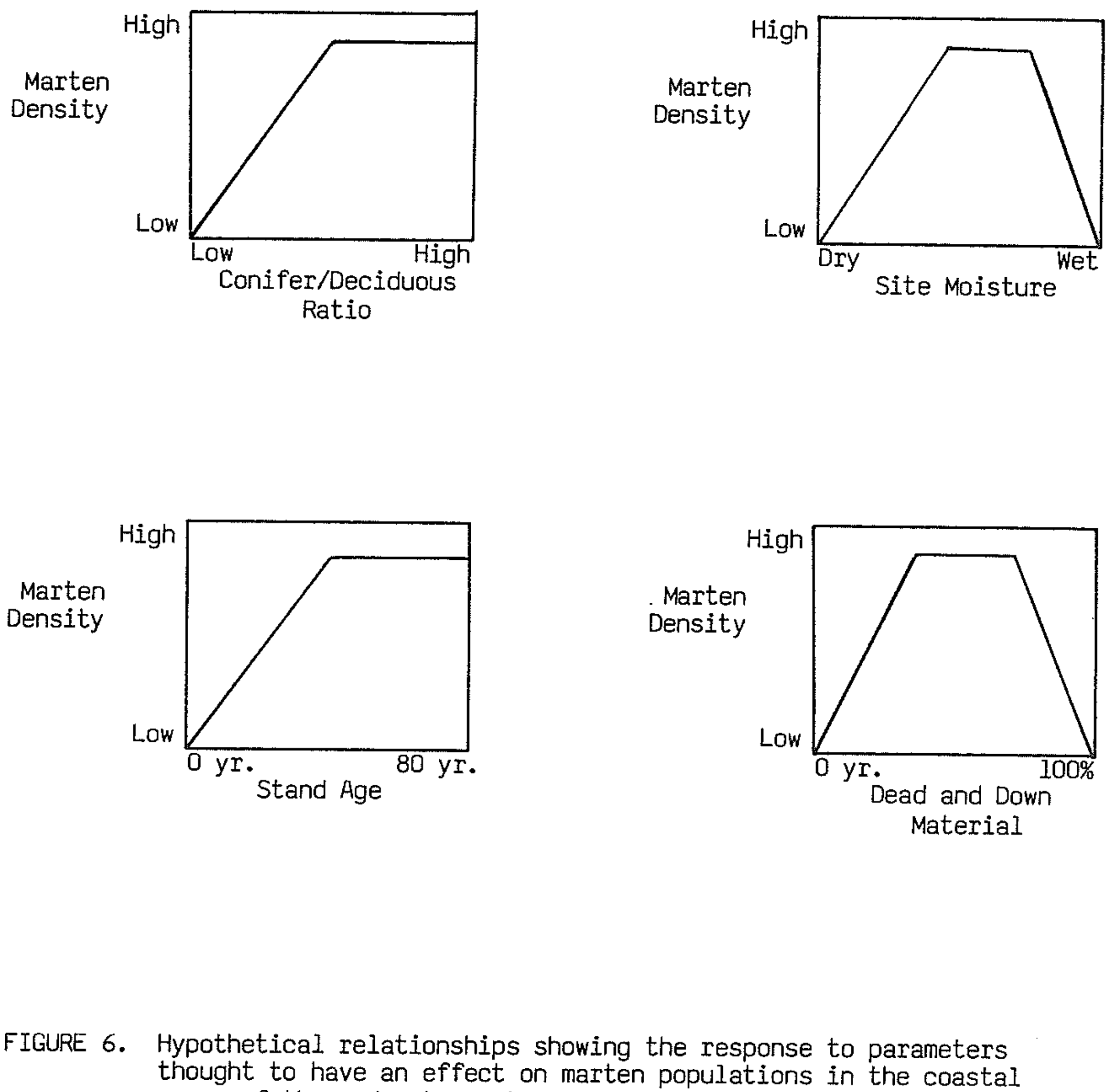

FIGURE 6. Hypothetical relationships showing the response to parameters thought to have an effect on marten populations in the coastal areas of the moderate marten density area in British Columbia.

There is an additional need to outline present information and future needs, and to provide preliminary management tools. With the existing level of information, predictions of marten habitat use in each biogeoclimatic zone are possible. As a result of logging activities, wildfires, and other processes of habitat alteration, British Columbia is a mosaic of successional stages. Therefore the predictions are arranged by successional stage within each biogeoclimatic zone (see Table 6). Hunting, denning, and resting sites are used as the predictors of a zone's capability to provide marten habitat. This index is not synonymous with marten density, but provides a measure of potential. Any habitat alterations within the successional stages will affect the index as described in Section 4 and summarized in Tables 5a, b, and c.

Broad conclusions and predictions can be made from information presented in Tables 5 and 6. Recommendations presented in Section 6 can be used to provide empirical data to refine these predictions and to establish a data base from which HSI models for marten in British Columbia can be developed.

6 RESEARCH RECOMMENDATIONS

In the preparation of research recommendations some sort of decision criteria are usually employed. Four criteria were used in focusing the research recommendations for this problem analysis: the magnitude of the problem, the potential (realistic) management changes that could result; and the logistic and economic constraints. The potential magnitude of the impact of forestry practices on marten populations could be enormous considering the various types of habitat. However, when the current level of knowledge presented in this report is weighed, the magnitude of the problem diminishes. Realistically, any changes in management directed toward the protection or enhancement of marten habitat must be cost effective, easily implemented, and compatible with silvicultural practices. Logistic and economic constraints utlimately set limits on what can be done and are therefore weighted heavily in any recommendations set forth.

Recommendations are presented in two parts, baseline and intensive investigations. Priorities are set within these sections.

TABLE 6. Potential marten habitat use within each successional stage by biogeoclimatic zones in British Columbia

Density Distribution Zone	Biogeoclimatic Zone[a]	Successional Stages: Recent clearcut (0-3 yrs)	Shrub seedling (3-10 yrs)	Young immature (10-29 yrs)	Pole - sapling (30-49 yrs)	Young (50-79 yrs)	Mature (80 yrs)	Zone Capability[b] Index
High	Boreal white and black spruce		H D	H D	H R D	H R D	H R D	.72
High	Sub-boreal spruce			H D	H D	H R D	H R D	.56
Moderate	Coastal cedars-pine-hemlock			H	H	H D	H R D	.39
Moderate	Coastal western hemlock		H R	H R D	H R D	H R D	H R D	.78
Moderate	Engelmann spruce-subalpine fir			H	H	H R D	H R D	.44
Moderate	Interior cedar-hemlock			H	H	H R D	H R D	.44
Low	Coastal Douglas-fir		H	H D	H R D	H R D	H R D	.67
Low	Interior Douglas-fir			H	H	H R D	H R D	.44
Low	Montane spruce			H	H	H R		.22
Low	Mountain hemlock			H	H R	H R D	H R D	.50
Low	Ponderosa pine-bunchgrass						H R	.11
Low	Spruce-willow-birch			H	H	H R	H R D	.39

a Taken from Pojar 1983.
b Capability = $\frac{\text{total number of activities}}{\text{total possible activities}}$.

Key:
H = hunting
R = resting
D = denning

6.1 Baseline Investigations

These recommendations are considered high priority and are based on what must be known before any management changes can result.

1. Determination of resting and den site characteristics
   i) should be conducted in each of the three density distribution areas with priority given to coastal ecosystems.
      - Do site characteristics change with:
        a) presence of snow? (If so, does site selection vary with depth and type of snow?)
        b) different age stands?

2. Determination of food habits and hunting site characteristics
   i) should be done in each of the three density distribution areas with priority given to coastal ecosystems.
      - how do food habits change with:
        a) different prey bases?
        b) presence of snow?
        c) different age stands?
        d) sex and age of marten?
        e) season?
   ii) should be conducted concurrently with small mammal distribution and relative abundance studies.

6.2 Intensive Investigations

These recommendations should follow the completion of baseline investigations and should be done in each of the three density distribution areas.

1. Determination of how the impact of forestry practices on marten populations can be lessened.

i) Can consideration of the following reduce the initial impact of logging:

  a) method of logging
    - clearcut vs selective cutting
  b) size of cut
  c) shape of cut
    - many-sided cut vs square cut
  d) timing of cut
    - fall and winter logging and site preparations vs spring and summer logging and site preparations
  e) type of treatments used
    - broadcast burning vs landing site burning
    - patch scarification vs drag scarification

ii) Can impacts of logging and silviculture treatments be reduced by considering:

  a) establishment of a refuge for marten populations to be used as a dispersal source in disturbed sites
  b) creation of artificial hunting, resting, and den sites
    - creation of den sites by using nest boxes (for example, owl nest boxes)
    - piling logging and site treatment debris throughout the disturbed site

Perhaps the most important aspect of any research of this type is the transference of information to managers. As stated in the text the best manager of marten is the trapper. Results from any of the projects outlined could be presented to trappers through articles published in the B.C. Trappers Magazine or at talks given at their yearly convention. The most appropriate wildlife habitat manager is the forester. Knowledge presented in a simple concise manner such as in handbooks or Habitat Suitability Index Models should be used when information transfer to the forester is considered. To paraphrase Thomas (1979), the degree to which research of this type is good wildlife habitat research depends on how well the researcher can explain to the manager the relationships of wildlife to habitat.

7 CONCLUSIONS

This report has provided a collation of literature on marten and on the effects of silvicultural practices on marten populations. Evidence suggests marten productivity in British Columbia should be considered at three levels and these appear to correspond to biogeoclimatic units as defined by the Ministry of Forests and Lands. Microhabitat needs, as defined by hunting, resting, and denning requirements, were explored and hypotheses stated on the effects of forestry practices on these requirements. Research recommendations were developed based on conclusions from the text and on the hypotheses set forth in Tables 5 and 6. Baseline investigations will help define the habitat variables necessary for the further development of a Habitat Suitability Index Model for each marten density area and also provide some of the data values necessary for predictions. Intensive investigations will provide empirical data which will aid in refining predictions and provide prescriptions for both the wildlife and habitat managers to use in developing integrated timber - marten management.

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APPENDIX 1. Trapper questionnaire analysis

The mail questionnaire was initiated to obtain information concerning marten/forestry interactions from British Columbia trappers. Although trappers are a ready source of information, they are usually not used largely because of to the logistic problems of reaching such a large audience. Skepticism regarding the highly subjective nature of the data has also influenced managers to reject this data source. Recent studies, however, have shown that data obtained from trappers can have an important scientific value (Kieth and Windberg 1978; Berg et al. 1983).

The survey was restricted to non-native trappers since a mailing list for native trappers was not available. The questionnaire, covering letter, and addressed, stamped return envelope was mailed to 2 551 trappers. A total of 836 or 32.8% of the questionnaires were returned which is comparable to other resource user surveys (Kieth and Windberg 1978). Approximately 2.8% were returned as undelivered.

The questionnaire consisted of 14 questions (see questionnaire). Some questions were designed to provide information on the topic of concern, some (such as 3 and 4) to act as qualifiers, and others (such as 14) to allow the trapper to introduce issues that he felt were important and not covered by the questionnaire.

Of the trappers who responded, approximately 68.8% of those questionnaires returned actively trapped marten. Of these returns 8% were from Ministry of Environment and Parks region 1; 3.5% from region 2; 7.7% from region 3; 7.0% from region 4; 10.4% from region 5; 21.7% from region 6; 37.7% from region 7; and 3.5% from region 8.

The majority of trappers responding to the questionnaire in regions 1, 4, and 6 felt that marten populations in their area were stable. Only trappers in region 8 felt populations were decreasing, and cited logging as the major reason. Trappers in regions 2, 3, 5, and 7 were equally divided between interpreting a decreasing or stable population in their areas. The major reason cited for decreasing populations was logging. Overall, 19% of the trappers felt that populations were increasing, 37.3% felt that populations

Pine Marten Questionnaire

Trapline location (Fish and Wildlife Management Unit): ____________________

Number of years spent trapping: ____________________

1. Do you have any marten in the area you trap? ____________________

2. What percent of time do you use these traps for marten? (Total should equal 100)

   _____ Snares   _____ Foot traps   _____ Conibears   _____ Others

3. Approximately how many marten do you trap each year? (Please circle)

   0 - 15   15 - 30   30 - 50   greater than 50

4. Has the number of marten you've trapped each year changed within the last 10 years? (Please circle)

   increased   decreased   stayed the same

5. If there has been a change in the number of marten you trap why do you think it has changed? ____________________

   ____

   ____

   ____

6. What age of forest do you trap most of your marten in? (Please circle)

   0 - 10 yrs.   10 - 20 yrs.   20 - 60 yrs.   60 - 120 yrs.   old growth

7. Has there been any logging in the area you trap? ____________________

8. How long ago did logging begin in your area? ____________________

9. Does logging occur in your area now? ____________________

10. What affect has logging had on your marten populations? ____________________

    ____

    ____

11. Have there been any recent (less than 20 yrs.) forest fires in your area?

    ____

12. Do marten live in second growth forests in your area? ____________________

13. What do marten in your area eat? ____________________

    ____

14. Any comments? ____________________

    ____

were decreasing, and 43.5% felt that populations were stable. It is interesting to note that in areas with stable populations, logging had occurred in the past in 64.2% of the areas.

Data from the mail survey provided information on marten density distribution as discussed in Section 1.1; information was also obtained on food habits. Interpretations by the trappers did not vary much between regions. Approximately 56% of the trappers believed that squirrels were the major food item, while only 27.2% believed that small mammals (mainly mice) are a major food source.

There appeared to be no correlation between the number of harvested marten and the age of the forest in which they were trapped. However much of the stand age data had to be discarded since many trappers indicated they trapped in stands of different ages. The data analyzed showed be the majority of trappers used 60 to 120 year-old stands.

Approximately 17% of the trappers introduced issues they felt should be investigated. Sixty-six percent felt that clearcutting in marten habitat should be prevented. Fifteen percent felt that only selective logging should should be used in marten habitat, 13% felt leave strips were important when logging marten habitat, and 6% recommended reforestation.

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APPENDIX 2. Personnel contacted

R. Archibald, Ministry of Environment and Parks, Victoria, B.C.

G. Burnett, Private Consultant, Missoula, Montana.

R. Ellis, Ministry of Forests and Lands, Victoria, B.C.

L. Friis, Ministry of Environment and Parks, Victoria, B.C.

G. Hazelwood, Private Consultant, Prince George, B.C.

J. Kelly, British Columbia Hydro, Vancouver, B.C.

D. Lindsay, British Columbia Forest Products, Crofton, B.C.

R. McLaughlin, MacMillan Bloedel, Ltd., Nanaimo, B.C.

L. Merkel, Ministry of Forests and Lands, Prince George, B.C.

D. Nagorsen, British Columbia Provincial Museum, Victoria, B.C.

R. Page, Ministry of Forests and Lands, Victoria, B.C.

B. Saunders, Ministry of Environment and Parks, Victoria, B.C.

D. Steventon, Ministry of Environment and Parks, Smithers, B.C.

APPENDIX 3. Glossary of terms

voles - term used to include mice, voles and shrews

edatopic - moisture and nutrient values of a forest site

fecundity - the reproductive potential of a species

subnivean - under the snow surface

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