Evaluating the Importance of Marten Cores to Trapper Harvests: Final Report for Phase 2

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Summary – We further investigated the relationship between marten harvest, trapper effort, climate and habitat supply using data from 30 traplines in the boreal forest of northeastern Ontario, 14 traplines from the boreal forest of northwestern Ontario, and 12 traplines from the transition forest of central Ontario. We obtained detailed information on trapper effort, as well as the age and sex of harvested martens from the 56 traplines, during the 2004/2005 trapping season. Trappers in this study harvested between 3 and 110 martens from traplines that ranged from 6,400 ha to 84,700 ha in size. Few juvenile martens were harvested during this season; an average of only 21% of the total animals harvested was juveniles. Marten harvest is described as the total catch per km^2, the total catch per 100 trap-nights (TN), the catch of juveniles per 100 TN, the catch of adult females per 100 TN, and the proportion of adults in the harvest. The number of juvenile martens harvested per 100 TN and the proportion of adult martens in the harvest varied among forest regions and were both significantly related to the proportion of crown land on traplines. The number of adult female martens harvested per 100 TN varied significantly among ecoregions. When we controlled for the number of TN of effort, only the total marten harvest per km^2 was positively related to the non-spatial supply of OWHAM pooled suitable + guideline suitable habitat. None of the other measures of marten harvest were significantly related to the non-spatial supply of suitable habitat. The total harvest of martens per km^2 was weakly related to the supply of OWHAM pooled suitable + guideline suitable habitat in medium and large patches (≥ 500 ha). The total number of martens harvested per 100 TN was negatively related to the amount of OWHAM pooled suitable + guideline suitable habitat in small patches (< 500 ha). The number of juveniles per 100 TN was negatively related to the amount of suitable habitat on traplines for one of the models which included a spatial habitat component but no model was considered a great predictor. Neither the harvest of adult females per 100 TN nor the proportion of adults in the harvest was strongly related to the supply of suitable habitat; harvest of adult females per 100 TN showed a marginally significant negative relationship with the supply of OMA suitable habitat in small patches, while the proportion of adults in

the harvest was weakly related to the supply of OMA suitable habitat in medium patches (500 – 3000 ha). Surprisingly, the number of martens harvested per km^2 of trapline was not related to the number of martens harvested per 100 TN; thus, our results suggest that the current harvest reporting data do not approximate the harvest per unit effort that is actually occurring. Our results support the conclusions of Phase 1, that suitable habitat does not necessarily have to occur in core-sized patches to support high trapper harvest of martens.

Introduction

The American marten (*Martes americana*) is an economically valuable furbearer in Ontario (Novak 1987). It is also viewed as an indicator of the sustainability of forest management practices because it is a species associated with large patches of mature and old coniferous and mixed forest (McLaren et al. 1998). In the boreal and boreal/Great Lakes – St. Lawrence transition forests of Ontario, forest management operations are modified to maintain habitat for martens. Retention of mature and old coniferous and mixed forest in large patches (3000-5000 ha) termed cores is one requirement of the current guidelines (Watt et al. 1996).

There is a large volume of information on the habitat requirements of martens. Much is known about the characteristics of den and rest sites used (e.g., Martin and Barrett 1991, Gilbert et al. 1997, Raphael and Jones 1997, Porter et al. 2005), the composition, age, and structural characteristics of forest stands preferred by martens (e.g., Thompson et al. 1989, Bowman et al. 1996, Bowman and Robitaille 1997, Payer and Harrison 2000), and the influence of landscape pattern at the scale of individual or multiple home ranges (e.g., Chapin et al. 1997, Hargis and Bissonette 1997, Potvin et al. 2000, Fuller and Harrison 2005). However, with the exception of some conceptual models (e.g., Thompson and Harestad 1994) and simulation models (e.g., Schneider 1997), there is little empirical information to suggest how habitat should be distributed across large (100s to 1000s of km^2) landscapes.

A recent thesis by Savage (2003) examined the relationship between trapper harvests of martens and the amount of area disturbed on traplines by fire, forest harvesting, and the area of conifer and deciduous forest greater than 30 years post-disturbance at various spatial scales (site region, biome, province) and among four time periods between 1972 and 1990. He found some significant but weak relationships that were inconsistent among time periods and spatial extents.

Building on Savage's work, our study was designed to investigate the relationship between the supply of habitat in core-sized patches and trappers' harvest of martens. If core-sized patches of habitat are necessary to support high trapper harvest, we hypothesized there should be a positive relationship between trapper harvest and the area of suitable habitat in patches that are at least 3000 ha in size; as a corollary, there should be no (or a weak) relationship between trapper harvest and the area of habitat in patches smaller than 3000 ha.

In Phase 1 of this project we tested our hypothesis using past harvest records from most of the boreal and boreal/Great Lakes – St. Lawrence (GLSL) transition forest of Ontario, where industrial forest harvesting is occurring. This report summarizes results from Phase 2 of this project which tests our hypothesis using detailed harvest information (on effort and harvest by age and sex) from a smaller sample of traplines in the boreal and transition forests of Ontario. Both studies are part of a larger marten research program that is a collaborative effort involving the University of Guelph, the Canadian Forest Service, the Ontario Ministry of Natural Resources (OMNR), and Ontario's forest industry (as represented by the Forest Ecosystem Science Co-operative Inc.).

Study Areas

Traplines from across the boreal forest of both northeastern and northwestern Ontario, as well as from the boreal/GLSL transition forest of central Ontario, were used in this study. Trapper effort data, marten harvest statistics, and habitat were analysed from 56 traplines located in the North Bay, Kirkland Lake, Timmins, Chapleau, Cochrane, Hearst, Wawa, Nipigon, Kenora, and Red Lake Administrative Districts of the OMNR. These traplines, situated within 23 different forest management units (FMUs), were located in site regions 4E (12 traplines), 3E (30 traplines), 3W (11 traplines), and 4S (3 traplines) (Figure 1).

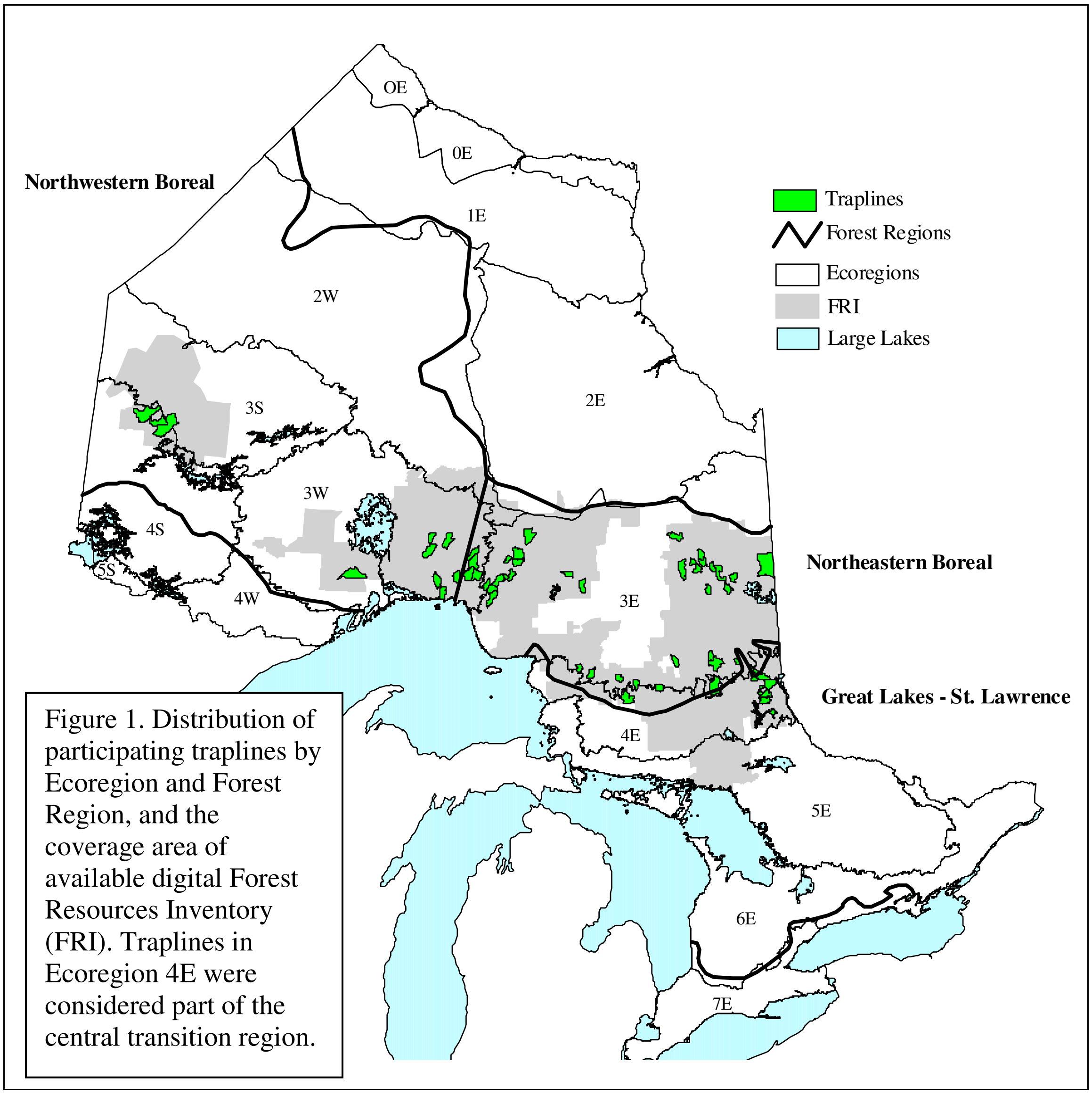

Figure 1. Distribution of participating traplines by Ecoregion and Forest Region, and the coverage area of available digital Forest Resources Inventory (FRI). Traplines in Ecoregion 4E were considered part of the central transition region.

The physiography, climate, and vegetation of each study region are well described by Baldwin et al. (2000), Mackey et al. (1996), and Rowe (1972).

In summary, both boreal regions are characterized by extensive forests of black spruce (*Picea mariana*), white spruce (*P. glauca*), jack pine (*Pinus banksiana*), balsam fir (*Abies balsamea*), trembling aspen (*Populus tremuloides*), and white birch (*Betula papyrifera*). Physiography is dominated by morainal deposits. The northeastern boreal region has extensive deep lacustrine deposits and small scattered outwash deposits. The northwestern boreal region has large areas of lacustrine and outwash deposits with some extensive areas dominated by bedrock. Mean annual temperature is about -1 to 3°C in the northwest and 0 to 3°C in the northeast. Total annual precipitation ranges from < 550 to 900 mm in the northwest and 700 to 1050 mm in the northeast.

In contrast, the central transition region is warmer (mean annual temperature 1 to 5°C) and wetter (total annual precipitation 750 to > 1100 mm) than the boreal regions. Its physiography is also dominated by morainal deposits; there are only small isolated areas of lacustrine and outwash deposits but some large areas dominated by bedrock. The forest cover is a mixture of boreal-like communities and those dominated by Great Lakes – St. Lawrence forest such as sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), white pine (*Pinus strobus*) and red pine (*Pinus resinosa*).

Methods

Trapline selection

Traplines were chosen from representative ecoregions of the northeastern boreal, northwestern boreal and central transition forests. District staff were contacted and acted as primary liaisons with local trappers to determine their level of interest and desire to volunteer for this study. Trapper volunteers were chosen in an attempt to distribute sampling across the broad range of ecodistricts in the study area. Unfortunately participating traplines were not distributed randomly or as broadly as we had originally hoped. Digital map coverages were created from data contained in the Natural Resources Values Information System (NRVIS) and from gazetted maps that identify and describe the legal boundaries of each registered trapline used in this study.

We attended local fur council meetings in September 2004 and spoke with individual trappers to explain the project and the information we required them to collect during the coming fall and winter.

Marten harvest and trapper effort data

We asked trappers to collect and submit the skull from every marten harvested from their respective traplines during the 2004/2005 trapping season (25 October 2004 to 28 February 2005). Each skull was labelled with information on the sex of the animal and the date and location (trapline) of capture.

In addition to providing biological samples, trappers were asked to maintain detailed records of their activities (effort) during the season, with respect to the duration of trapping effort (start and end dates), magnitude of effort (number of traps), and frequency (how often traps were checked). Data from harvested martens were collected from 67 individual trappers who were active on 56 registered traplines.

Age and sex determination

Following the completion of the trapping season, skulls were shipped to the Southern Science and Information Section, Ageing Laboratory in Bracebridge. Once there, a lower canine tooth was extracted from each skull, and age and sex were determined using the radiograph methods of Dix and Strickland (1986). Animals were classified as either juvenile (< 1 year old) or adult (≥ 1.5 years old), and sex was confirmed by analyzing the width of the pulp cavity, and the size of the tooth, respectively. We recognize that animals ≤ 2.5 years old may not be sexually mature, or have established home ranges (Strickland and Douglas 1987).

Selection of marten harvest variables

We investigated the relationship between habitat supply and four different measures of trapper harvest: (i) number of martens harvested per 100 trap nights (TN) of effort; (ii) number of juvenile martens harvested per 100 TN; (iii) number of adult female martens harvested per 100 TN; and (iv) the proportion of adult martens in the harvest.

We also investigated the relationship between habitat supply and the number of martens harvested per km^2 since this was the measure of trapper harvest that we used in Phase 1. We used the actual number of TN reported on each trapline to control for effort in this model.

Other variables influencing marten harvest

We calculated several other variables that previous research or expert opinion has suggested might influence marten harvest.

Most trappers use roads built by the forest industry to access their traplines and marten harvest may be positively influenced by road density (Soukkala 1983, Hodgman et al. 1994, Thompson 1994). For each trapline we measured the density of roads (km of road/km^2 of trapline) based on the current (2004) provincial digital inventory of roads obtained from the Ontario Spatial Data Exchange. Roads were divided into two groups based on their designation in forest management planning: (i) primary or secondary roads, and (ii) tertiary roads. Primary and secondary roads include provincial highways and long-term forest access roads. Tertiary roads are generally short-term roads used to access logging areas and unpaved municipal roads. Although we recognize the limitations of the data that were used, we assumed that the digital primary and secondary roads information was reasonably accurate while the digital tertiary roads information was less accurate and more variable across the province.

Since OMNR regulates forest management on crown land only, and registered traplines allow trappers access to crown land only, we determined the proportion of crown land (excluding parks) on each trapline. We considered land tenure because the proportion of non-forested land or area inaccessible to trappers may have obscured the relationship between marten harvest and habitat supply.

We expected marten quota to play a substantial role in the number of martens harvested. The marten quota for each trapline for the 2004/05 trapping season was obtained from the Fur Management Information System (FURMIS). Of the 56 traplines which were used in our analyses, 12 had an open (unlimited) quota. Included in this number were all the traplines in the Northwest Administrative Region (10) and two in the Northeast. On all other traplines a marten harvest quota was set by the OMNR District office responsible for that area.

Both temperature and snowfall are know to influence the behaviour of martens in winter (Thompson and Colgan 1994, Wilbert et al. 2000) and climatic variables have been linked to variation in marten harvest, both within and among years (Savage 2003). Weather was important in Phase 1 but weather data were not available for the time period of our study and thus were not used in Phase 2 analyses.

We investigated the possibility that differences in trapper harvest of martens were due to geographic variation. Although relationships with geography may be due to weather, they may also be a result of factors like regional differences in the application of quotas, and geographic variation in prey abundance and/or prey diversity. Categorical variables were established to identify traplines by Forest Region (Rowe 1972) and Ecoregion (Crins 2000) (Figure 1). Traplines straddling boundaries were classified based on the study region or ecoregion within which the majority of the trapline (> 50% by area) was located.

Characterizing habitat supply

Forest resources inventory (FRI) digital coverages were obtained for each FMU within which one of the 56 traplines was located (Figure 1). Additionally, one FRI coverage was obtained to facilitate spatial habitat modeling where traplines were located at the edge of a FMU. This FRI provided information on the type of habitat (e.g. water, rock, forested land, etc.), a description of forested stands (e.g. overstory species composition, stand age, stand height, etc.), and land tenure information (e.g. available crown forest, provincial parks, private or patented land, Federal Indian Reserve, etc) (see OMNR 2000, 2003). All FRI were updated to reflect the condition of the forest on 31 March 2004.

Six of the 56 traplines in the dataset were adjacent to areas for which FRI data were not available. This may have resulted in an underestimate of the amount of suitable habitat in large patches for these traplines. To test for this effect, the 6 traplines were identified in the dataset using a binary variable and the effect on the spatial habitat models was assessed. The minimum t-value for the boundary variable, in any of the models, was -1.039 and the minimum P-value for the boundary variable was 0.304; the few traplines modeled without FRI from adjacent FMUs did not affect the models so the boundary variable was excluded from further spatial analysis.

Habitat suitability of individual stands for martens was assessed using two different non-spatial models: the boreal northeast version from the Ontario Wildlife Habitat Analysis Model (OWHAM; Naylor et al. 1999) developed in the Northeast Region, and the habitat suitability models in the Ontario Marten Analyst (OMA; Elkie et al. 1999) developed in the Northwest Region. Both of these models produce two classes of suitable habitat (Table 1). In addition, OWHAM calculates a third habitat category termed “used” habitat which includes stands with intermediate conifer densities and/or immature stands. Used forest is generally poor marten habitat. Preliminary analysis suggested that the supply of used habitat had little effect on marten harvest and was subsequently excluded from further analysis.

Table 1. Description of habitat suitability classes used in the Ontario Wildlife Habitat Analysis Model and in the Ontario Marten Analyst.

Habitat Suitability Class	**Definition**
Ontario Wildlife Habitat Analysis Model (OWHAM)	
Guideline Suitable	- %[1] Sb+Sw+Bf+Ce (%SFC) ≥ 40% and stand height (HT) ≥ 15.0 m and conifer canopy closure ≥ 50% mature or old growth development stage (DS).
Suitable	- Not guideline suitable but - %SFC ≥ 30% and HT ≥ 12.0 m and total canopy closure ≥ 50% and mature or old growth DS
Ontario Marten Analyst (OMA) model	
Good Suitable	- HT ≥ 14.99 m and stocking (STKG) > 50% and age > 79 years AND - ((% Sw+Sb+Bf+Ce+Pj+Pr+Pw > 40% and Pj ≤ 40% and Sb ≤ 70% and Bf ≤ 80% and Pr ≤ 50% and Pw ≤ 70% and La = 0%) OR (Sb+Pj > 60% and Sb ≤ 80% and Pj ≤ 80% and Sb ≥ Pj and La = 0%))
Fair Suitable	- Not good suitable but - HT ≥ 14.99 m and STKG > 50% and age > 79 years AND - ((% Sw+Sb+Bf+Ce+Pj+Pr+Pw > 40% and Pj ≤ 70% and Sb ≤ 70% and Bf ≤ 80% and Pr ≤ 50% and Pw ≤ 70% and La ≤ 20%) OR (Sb+Pj > 60% and Sb ≤ 80% and Pj ≤ 80% and Pj > Sb) OR (Sb > 80% and site class = X, 1, 2, or 3))

[1]Percent of overstory comprised of various tree species: Bf = balsam fir; Ce = cedar; La = larch; Pj = jack pine; Pr = red pine; Pw = white pine; Sb = black spruce; Sw = white spruce.

For the spatial analysis component, stands were then grouped into patches of suitable habitat in three size ranges: small (less than the size of a male marten's home range - 500 ha), medium (at least the size of a home range but smaller than a core based on the marten guidelines [Watt et al. 1996] - 500 to 3000 ha), and large (at least the size of a core – 3000 ha +). These patches were delineated using the core-building algorithm in OWHAM (Naylor et al. 1999). The algorithm identifies patches of forest that meet the specified minimum size threshold and contain at least 75% suitable marten habitat. Suitable habitat separated by "used" habitat, or patches of unsuitable habitat less then 200 m across, is considered contiguous. Because OMA does not have a "used" habitat category we expected there to be fewer large cores produced when we used OMA than when we used OWHAM to classify the same landbase.

For both the non-spatial and spatial analyses, suitable habitat was expressed as the proportion of the trapline in different habitat classes and size patches.

Relationship between marten harvest per unit of effort and the relative marten harvest variable applied in Phase 1

In Phase 1, marten harvest per area of trapline, corrected for variation among years, was presented as a measure of relative marten harvest. This variable was strongly correlated to the proportion of beaver quota attained, which was included in all subsequent models as an index of trapper effort. Road density and/or climate variables, depending on the study region investigated, were also correlated with relative marten harvest. In Phase 2, the collection of more detailed information from trappers allowed for the direct calculation of harvest per unit of effort. All the information used in Phase 1 is readily available for all non-aboriginal traplines in Ontario from the FURMIS database and other existing and maintained databases. In contrast, trappers are not required to submit the amount of trapping effort exerted such that collecting this information required trapper co-operation and, even for the small sample obtained, a significant number of man-hours on our part. We explored the relationships between the number of martens harvested per km^2 and our measures of harvest per unit effort using correlation analyses.

Data analysis

All spatial analyses were conducted using ArcView® (Version 3.2, ESRI Inc.), and SPSS® (Version 14.0, SPSS Inc.) was used for all statistical analyses.

The following steps were applied to each of the five dependent variables representing marten harvest (number of martens/km^2, number of martens/100 TN, number of juveniles/100 TN, number of adult females/100 TN, and proportion of adults in the harvest). First, we explored the relationship between road densities, total land area, proportion of crown land, and quota and marten harvest using correlation analysis. Variables with significant ($P < 0.05$) correlations were then carried forward into the habitat models.

The five harvest variables were compared among forest regions and ecoregions using ANOVA. Those factors that appeared to have an effect were carried forward into the habitat models ($P < 0.05$ and clear grouping delineation). Dummy variables representing regions or ecoregions were included in all subsequent models.

Then, we developed a suite of models to explore the relationship between the five marten harvest variables (controlling for any significant variables already identified) and the proportion of a trapline deemed to be suitable marten habitat (non-spatial) based on the suitability definitions in OWHAM and OMA. In all cases we used the pooled supply of suitable + guideline suitable habitat (OWHAM) or fair suitable + good suitable habitat (OMA) because it was identified as the most important predictor of relative marten harvest in Phase 1. To evaluate our hypothesis that core-sized patches are necessary to support high trapper harvest of martens we then developed a suite of models relating the five marten harvest variables to the proportion of a traplines in small, medium, and large patches of functionally suitable habitat. In all cases, we used an information theoretic approach (Akaike's Information Criterion – AIC) to select the most parsimonious models (Anderson et al. 2000).

Most data were transformed to meet the assumptions of the various statistical tests used; natural logarithm, arcsine and/or square-root transformations were applied. Outliers were assessed based on Cook's Distance and Centered Leverage values and extreme values were dropped from the models in question.

Results

Descriptive statistics for marten harvest data from the 56 participating traplines, including the suite of dependent and independent variables used in the investigation of the effect of marten habitat on marten harvest, are presented in Appendix 1. The traplines ranged in land area from 5,900 ha to 84,000 ha with a total harvest (per trapline) in the 2004/2005 trapping season ranging from 3 to 110 martens. The proportion of crown land within traplines was high, averaging 85%, with a mean proportion of area in suitable marten habitat of roughly 25%.

The mean percent of juveniles in the harvest from the 56 traplines in our analysis was 21% (Appendix I). The low number of young-of-the-year observed in the sample of martens obtained from the 2004/2005 trapping season appears to reflect a recruitment failure over a large geographic range. The highest proportion of juveniles in the harvest was observed in traplines along the boundary of ecoregions 3E and 4E (central transition), with the exception of one trapline along the boundary of ecoregions 3S and 4S (Figure 2).

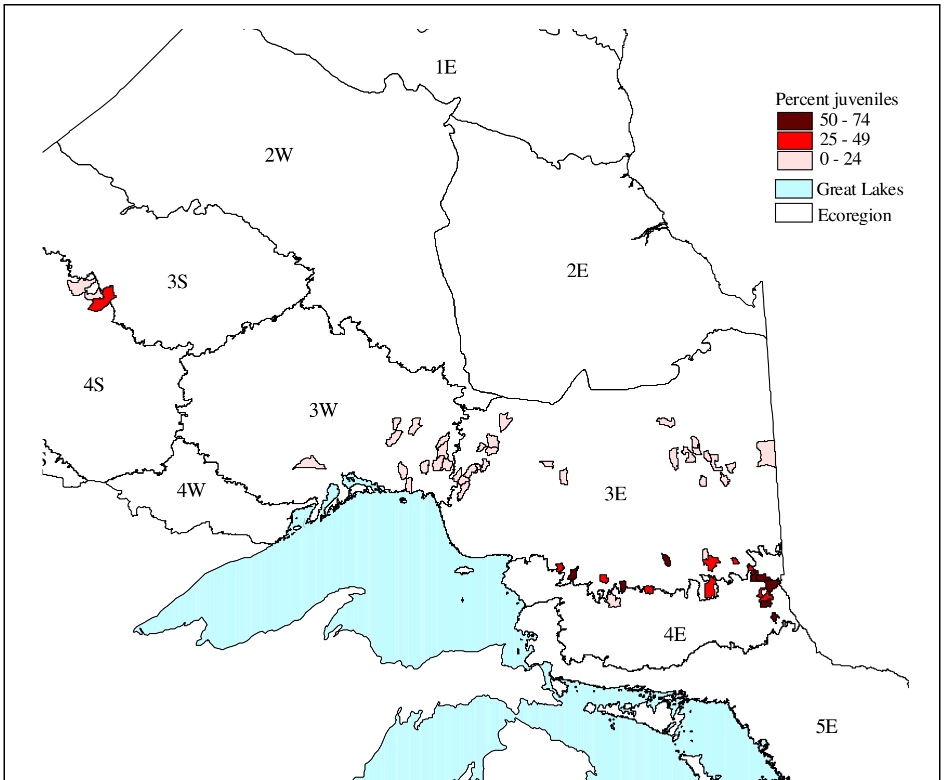

Figure 2. Percent juvenile (< 1 year old) martens in the trapper harvest from samples obtained from 56 traplines during the 2004/2005 trapping season.

Influence of access, total land area, proportion of crown land, and quota on marten harvest

None of the marten harvest variables was significantly correlated with road densities or the total land area within a trapline (Table 2). The number of juveniles harvested per 100 TN and the proportion of adults in the harvest were both highly correlated with the proportion of crown land in traplines. Of the suite of dependent variables reflecting marten harvest, total harvest per km^2 was strongly related to marten quota while juveniles harvested per 100 TN was weakly correlation with marten quota. Given the very strong correlation between effort and marten quota (r = 0.794, P < 0.0001) it is expected that the effect of quota is accounted for in the variables that include an index of effort. Generally, traplines in the northwestern boreal have open quotas on martens while traplines in the northeastern boreal and central transition area have limited quotas. The effect of quotas in the northeastern boreal and central transition, and the lack thereof in the northwestern boreal may be accounted for in the Regional variable discussed in the following section.

Table 2. Correlations between the suite of marten harvest variables and marten quota, access, and land base descriptors for the 56 traplines in the study.

	Total harvest/km^2 of trapline	Harvest/100 TN	Juveniles harvested/100 TN	Adult Females harvested/100 TN	Prop of adults in harvest
Total effort (TN)	r = 0.496***	n/a	n/a	n/a	n/a
Km of primary road/km^2 of land in trapline	r = 0.032	r = -0.047	r = 0.080	r = 0.034	r = -0.023
Km of tertiary road/km^2 of land in trapline	r = -0.167	r = -0.068	r = 0.135	r = -0.108	r = -0.154
Km of total roads/km^2 of land in trapline	r = -0.127	r = -0.101	r = 0.173	r = -0.089	r = -0.181
Total land area (ha)	n/a	r = 0.087	r = -0.068	r = 0.096	r = 0.123
Prop of trapline that is crown land [1]	r = 0.259*	r = -0.250*	r = -0.450***	r = -0.067	r = 0.428***
Marten quota [2]	r = 0.569***	r = -0.068	r = -0.309*	r = 0.032	r = 0.238

[1] does not include parks
[2] *n*=44 for correlation analysis of dependent variables versus marten quota; the remaining 12 traplines had an open quota and could not be included.
* P < 0.1
** P < 0.05
*** P < 0.01

Influence of forest region and ecoregion on marten harvest

The five harvest variables were compared among forest regions and ecoregions using ANOVA. The mean number of juveniles harvested per 100 TN, adult females harvested per 100 TN, and the proportion of adults in the harvest varied significantly among regions and/or ecoregions (Table 3). Thus, dummy variables representing regions or ecoregions were included in all subsequent models for juveniles per 100 TN and adult females per 100 TN, respectively. Although it appears that the difference in the proportion of adults in the harvest is greater by ecoregion than region, ecoregion 4S does not clearly lie in one of the groupings (Figure 3); therefore, region was the variable selected to be carried forward into the habitat models for the proportion of adults in the harvest.

Table 3. ANOVA results for the suite of marten harvest variables by Forest Region and Ecoregion categories for the 56 traplines in the study.

	Total harvest/km^2 of trapline	Harvest/100 TN	Juveniles harvested/100 TN	Adult Females harvested/100 TN	Prop of adults in harvest
Region[1]	F = 1.737	F = 1.251	F = 11.735***	F = 1.476	F = 9.219***
	Mean (± SD)	**Mean (± SD)**	**Mean (± SD)**	**Mean (± SD)**	**Mean (± SD)**
NE	0.219 (± 0.146)	2.6 (± 1.8)	0.4 (± 0.5)	1.0 (± 0.8)	0.8 (± 0.2)
NW	0.329 (± 0.186)	3.8 (± 2.8)	0.7 (± 0.8)	1.4 (± 0.9)	0.8 (± 0.1)
GLSL	0.242 (± 0.132)	3.1 (± 0.9)	1.7 (± 0.8)	0.7 (± 0.3)	0.4 (± 0.2)
Ecoregion	F = 2.036	F = 0.979	F = 5.957***	F = 3.428**	F = 10.430***
	Mean (± SD)	**Mean (± SD)**	**Mean (± SD)**	**Mean (± SD)**	**Mean (± SD)**
4E	0.185 (± 0.117)	2.3 (± 1.1)	1.1 (± 0.9)	0.5 (± 0.3)	0.5 (± 0.2)
3E	0.235 (± 0.154)	2.8 (± 2.0)	0.4 (± 0.6)	1.1 (± 0.8)	0.8 (± 0.2)
3W	0.335 (± 0.174)	3.4 (± 2.7)	0.4 (± 0.7)	1.4 (± 0.9)	0.9 (± 0.1)
4S	0.180 (± 0.153)	4.1 (± 0.6)	1.0 (± 0.5)	1.4 (± 0.2)	0.8 (± 0.1)

[1]NE = northeastern boreal, NW = northwestern boreal, and GLSL = central transition zone

* P < 0.1

** P < 0.05

*** P < 0.01

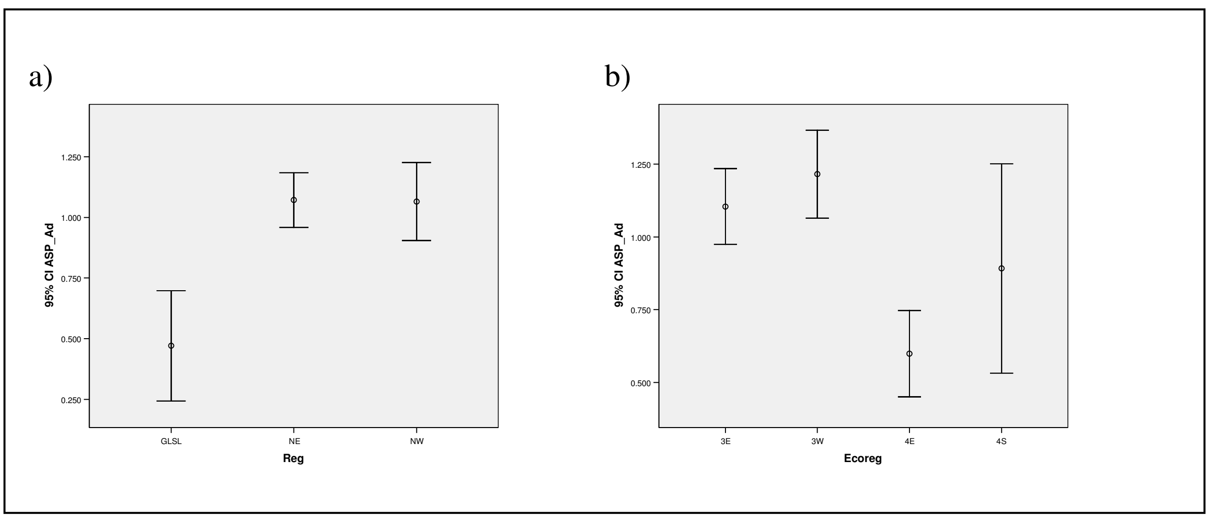

Figure 3. Proportion of adults in the harvest by forest region (a) and ecoregion (b). Solid dots represent means and vertical lines represent 95% confidence intervals. NE = northeastern boreal, NW = northwestern boreal, and GLSL = central transition zone.

In the subsequent suite of models investigating the relationship between the group of marten harvest variables and habitat, variation in the harvest of martens per km^2 attributed to effort is controlled. Variation in the number of juveniles per 100 TN and the proportion of adults in the harvest attributable to region and to the proportion of crown land on traplines is also controlled as is variation in the number of adult females per 100 TN attributable to ecoregion is controlled.

Influence of habitat supply on marten harvest

Non-spatial supply of habitat

Number of martens harvested per km^2

The regression model relating marten harvest per km^2 to the non-spatial supply of OWHAM pooled suitable + guideline suitable habitat was significant ($P < 0.05$) and explained 32% of the variation in marten harvest (Table 4; pooled area of small, medium and large patches). There was no significant relationship between marten harvest per km^2 and the supply of OMA pooled fair suitable + good suitable habitat.

Number of martens harvested per 100 TN

None of the regression models relating martens harvested per 100 TN to various non-spatial estimates of the supply of suitable habitat were even marginally significant ($P > 0.10$) irrespective of whether OMA or OWHAM was used. The effect of habitat on marten harvest per unit effort is investigated further in the section on the effect of spatial distribution of habitat.

Number of juvenile martens harvested per 100 TN

None of the regression models relating juveniles harvested per 100 TN to various non-spatial estimates of the supply of suitable habitat were even marginally significant ($P > 0.10$) irrespective of whether OMA or OWHAM was used. The effect of habitat on juvenile harvest per unit effort is investigated further in the section on the effect of spatial distribution of habitat.

Number of adult females harvested per 100 TN

None of the habitat terms in the suite of regression models relating adult females harvested per 100 TN, controlled for the ecoregion in which the trapline lies, and non-spatial suitable habitat supply were even marginally significant ($P > 0.10$). The effect of habitat on this component of marten harvest is investigated further in the section on the effect of spatial distribution of habitat.

Proportion of adult martens in the harvest

None of the regression models relating the proportion of adult martens in the harvest to various non-spatial estimates of the supply of suitable habitat were even marginally significant ($P > 0.10$) irrespective of whether OMA or OWHAM was used. The effect of habitat on the proportion of adults is investigated further in the section on the effect of spatial distribution of habitat.

Influence of patch size

Number of martens harvested per km^2

AIC analysis suggested that the model considering the total pooled supply of OWHAM suitable habitat, irrespective of spatial distribution, was the best predictor of the number of martens harvested per km^2 of trapline (36% likelihood) and explained 32% of the variation in marten harvest (Table 4). The model considering the pooled supply of OWHAM suitable habitat in patches at least 500 ha in size had a 13% likelihood of being the best model and explained 29% of the variation.

Table 4. Summary statistics for regression models predicting the number of martens harvested per km^2 of trapline based on the proportion of the trapline that is in small (<500 ha), medium (500 - 3000 ha), and large (3000+ ha) patches of suitable habitat. Suitability is based on definitions in OMA and OWHAM. All models control for the number of trapnights of effort.

Model	**Habitat variables**[1]	**Model F**	**Model P**	**Model R^2**	**AIC_c weight**
No Habitat variable		17.633	0.000	0.246	0.07
OWHAM –pooled Suitable and Guideline suitable					
Small patches	NS	9.088	0.000	0.255	0.03
Medium patches	NS	8.669	0.001	0.246	0.02
Large patches	NS	10.226	0.000	0.278	0.07
Pooled area of small, medium, and large patches	++	12.337	0.000	0.318	0.36
Pooled area of medium and large patches	+	10.923	0.000	0.292	0.13
Small patches Medium patches Large patches	NS NS +	5.383	0.001	0.297	0.01
Medium patches Large patches	NS +	7.138	0.000	0.292	0.04
OMA –pooled Fair suitable and Good suitable					
Small patches	NS	8.741	0.001	0.248	0.02
Medium patches	NS	8.703	0.001	0.247	0.02
Large patches	NS	9.800	0.000	0.270	0.05
Pooled area of small, medium, and large patches	NS	10.442	0.000	0.283	0.09
Pooled area of medium and large patches	NS	9.732	0.000	0.269	0.05
Small patches Medium patches Large patches	NS	4.945	0.002	0.279	0.01
Medium patches Large patches	NS	6.478	0.001	0.272	0.02

[1]Significance and slope of habitat terms: NS = not significant (P>0.10); + = positive slope; - = negative slope; and the number of signs refer to the level of significance: one = P<0.10; two = P<0.05; and three = P<0.01.

Number of martens harvested per 100 TN

AIC analysis suggested that models considering the pooled supply of either OWHAM suitable (51% likelihood) or OMA suitable (24% likelihood) in small patches were the best predictors of the number of martens harvested per 100 TN (Table 5). In both cases the relationships were negative and explained 12-14% of the variation in marten harvest. The inverse was not found; in only one case was there even a marginally significant positive effect of large patches on the number of martens harvested per 100 TN. There was a large difference between the regression coefficient for the proportion of habitat in small patches (-5.876 ± 1.952) and the proportion of habitat in large patches (0.998 ± 0.552), using the pooled suitable habitat defined in OWHAM, suggesting that the proportion of the trapline in small patches had much more influence on the number of martens harvested per unit of effort than did large patches.

Table 5. Summary statistics for regression models predicting the number of martens harvested per 100 TN based on the proportion of the trapline that is in small (<500 ha), medium (500 - 3000 ha), and large (3000+ ha) patches of suitable habitat. Suitability is based on definitions in OMA and OWHAM.

Model	**Habitat variables**[1]	**Model F**	**Model P**	**Model R^2**	**AIC_c weight**
OWHAM –pooled Suitable and Guideline suitable					
Small patches	---	9.057	0.004	0.144	0.51
Medium patches			NS		
Large patches	+	3.271	0.076	0.057	0.03
Pooled area of small, medium, and large patches			NS		
Pooled area of medium and large patches			NS		
Small patches Medium patches Large patches	-- NS NS	3.319	0.027	0.161	0.08
Medium patches Large patches			NS		
OMA –pooled Fair suitable and Good suitable					
Small patches	---	7.427	0.009	0.121	0.24
Medium patches			NS		
Large patches			NS		
Pooled area of small, medium, and large patches			NS		
Pooled area of medium and large patches			NS		
Small patches Medium patches Large patches	--- NS -	3.647	0.018	0.174	0.13
Medium patches Large patches			NS		

[1]Significance and slope of habitat terms: NS = not significant (P>0.10); + = positive slope; - = negative slope; and the number of signs refer to the level of significance: one = P<0.10; two = P<0.05; and three = P<0.01.

Number of juveniles harvested per 100 TN

No model emerged as clearly the best predictor of the number of juveniles harvested per 100 TN; AIC analysis yielding roughly equal weight to many of the models (Table 6). The model that did not contain a habitat term was at least as likely (15% likelihood) as several other models (8-11% likelihood) to be the best predictor of the number of juveniles harvested per 100 TN. In the model that contained habitat terms for each patch size both small and large patches were significant and negatively related to the harvest of juveniles per 100 TN. There was a 10% chance this model was the best predictor.

Table 6. Summary statistics for regression models predicting the number of juveniles harvested per 100 TN based on the proportion of the trapline that is in small (<500 ha), medium (500 - 3000 ha), and large (3000+ ha) patches of suitable habitat. Suitability is based on definitions in OMA and OWHAM. All models control for the Region in which the trapline lies and the proportion of crown land within the trapline.

Model	Habitat variables[1]	Model F	Model P	Model R^2	AIC_c weight
No Habitat variable		10.656	0.000	0.381	0.15
OWHAM –pooled Suitable and Guideline suitable					
Small patches	NS	8.417	0.000	0.398	0.09
Medium patches	NS	7.839	0.000	0.381	0.04
Large patches	NS	7.961	0.000	0.384	0.05
Pooled area of small, medium, and large patches	NS	8.438	0.000	0.398	0.09
Pooled area of medium and large patches	NS	7.990	0.000	0.385	0.05
Small patches Medium patches Large patches	-- NS --	6.787	0.000	0.454	0.10
Medium patches Large patches	NS NS	6.280	0.000	0.386	0.01
OMA –pooled Fair suitable and Good suitable					
Small patches	NS	7.906	0.000	0.383	0.05
Medium patches	NS	8.076	0.000	0.388	0.06
Large patches	NS	8.337	0.000	0.395	0.08
Pooled area of small, medium, and large patches	NS	8.558	0.000	0.402	0.11
Pooled area of medium and large patches	NS	8.181	0.000	0.391	0.07
Small patches Medium patches Large patches	NS NS -	6.133	0.000	0.429	0.03
Medium patches Large patches	NS NS	6.662	0.000	0.400	0.03

[1]Significance and slope of habitat terms: NS = not significant (P>0.10); + = positive slope; - = negative slope; and the number of signs refer to the level of significance: one = P<0.10; two = P<0.05; and three = P<0.01.

Number of adult females harvested per 100 TN

AIC analysis suggested that models considering the pooled supply of fair suitable and good suitable habitat in small patches (23% likelihood) was the best predictor of the number of adult females harvested per 100 TN (Table 7). The relationship was negative and explained about 22% of the variation in the adult female component of the harvest.

Table 7. Summary statistics for regression models predicting the number of adult females harvested per 100 TN based on the proportion of the trapline that is in small (<500 ha), medium (500 - 3000 ha), and large (3000+ ha) patches of suitable habitat. Suitability is based on definitions in OMA and OWHAM. All models control for the Ecoregion in which the trapline lies.

Model	**Habitat variables**[1]	**Model F**	**Model P**	**Model R^2**	**AIC_c weight**
No Habitat variable		3.428	0.024	0.165	0.13
OWHAM –pooled Suitable and Guideline suitable					
Small patches	NS	2.981	0.027	0.126	0.09
Medium patches	NS	2.571	0.049	0.168	0.04
Large patches	NS	2,940	0.029	0.187	0.08
Pooled area of small, medium, and large patches	NS	2.800	0.035	0.180	0.06
Pooled area of medium and large patches	NS	2.934	0.029	0.187	0.08
Small patches Medium patches Large patches	NS NS NS	1.952	0.091	0.193	0.01
Medium patches Large patches	NS NS	2.309	0.058	0.188	0.02
OMA –pooled Fair suitable and Good suitable					
Small patches	-	3.537	0.013	0.217	0.23
Medium patches	NS	2.580	0.048	0.168	0.04
Large patches	NS	2.525	0.052	0.165	0.04
Pooled area of small, medium, and large patches	NS	2.669	0.043	0.173	0.05
Pooled area of medium and large patches	NS	2.522	0.052	0.165	0.04
Small patches Medium patches Large patches	NS NS NS	2.862	0.018	0.260	0.08
Medium patches Large patches	NS NS	2.024	0.091	0.168	0.01

[1]Significance and slope of habitat terms: NS = not significant (P>0.10); + = positive slope; - = negative slope; and the number of signs refer to the level of significance: one = P<0.10; two = P<0.05; and three = P<0.01.

Proportion of adult martens in the harvest

AIC analysis suggested that that the model without a habitat term (15% likelihood) and the model that considered the supply of OMA suitable habitat in medium sized patches (19% likelihood) were the best predictors of the proportion of adults in the harvest (Table 8).

Table 8. Summary statistics for regression models predicting the proportion of adult martens in the harvest based on the proportion of the trapline that is in small (<500 ha), medium (500 - 3000 ha), and large (3000+ ha) patches of suitable habitat. Suitability is based on definitions in OMA and OWHAM. All models control for the Region in which the trapline lies and the proportion of crown land within the trapline.

Model	**Habitat variables**[1]	**Model F**	**Model P**	**Model R^2**	**AIC_c weight**
No Habitat variable		9.700	0.000	0.368	0.15
OWHAM –pooled Suitable and Guideline suitable					
Small patches	NS	7.133	0.000	0.368	0.04
Medium patches	NS	7.134	0.000	0.368	0.04
Large patches	NS	7.442	0.000	0.378	0.06
Pooled area of small, medium, and large patches	NS	7.683	0.000	0.385	0.09
Pooled area of medium and large patches	NS	7.509	0.000	0.380	0.07
Small patches Medium patches Large patches	NS NS NS	5.059	0.000	0.392	0.01
Medium patches Large patches	NS NS	5.968	0.000	0.383	0.02
OMA –pooled Fair suitable and Good suitable					
Small patches	NS	7.416	0.000	0.377	0.06
Medium patches	-	8.251	0.000	0.402	0.19
Large patches	NS	7.631	0.000	0.384	0.08
Pooled area of small, medium, and large patches	NS	7.243	0.000	0.372	0.05
Pooled area of medium and large patches	NS	7.331	0.000	0.374	0.05
Small patches Medium patches Large patches	NS NS NS	5.523	0.000	0.413	0.02
Medium patches Large patches	NS NS	6.728	0.000	0.412	0.08

[1]Significance and slope of habitat terms: NS = not significant (P>0.10); + = positive slope; - = negative slope; and the number of signs refer to the level of significance: one = P<0.10; two = P<0.05; and three = P<0.01.

Relationship between total harvest per area of trapline and martens harvested per 100 TN

The number of martens harvested per km^2 of trapline was significantly correlated with the number of adult females harvested per 100 TN ($r = 0.344$, $P = 0.009$) and with the proportion of adults in the harvest ($r = 0.321$, $P = 0.016$). However, there was no significant correlation of total harvest per km^2 with the total number of martens harvested per 100 TN ($r = 0.199$, $P = 0.142$) and the number of juvenile martens harvested per 100 TN ($r = -0.117$, $P = 0.389$).

In Phase 1 the proportion of beaver quota attained was significantly correlated with relative marten harvest and was included in all habitat models as an index of trapper effort. The data from Phase 2 do not show a relationship between total harvest per km^2 and the proportion of beaver quota attained ($r = -0.005$, $P = 0.969$) but there is a significant correlation between total harvest per km^2 and total effort (TN) on a trapline ($r = 0.496$, $P = 0.000$). We did not find a relationship between TN and proportion of beaver quota attained ($r = -0.039$, $P = 0.780$) which suggests that the index of effort used in Phase 1 may not be analogous to the actual effort expended by trappers.

Discussion

Trapper harvest of martens

Trappers in northern Ontario harvested more martens than in the past several years (OMNR, unpublished data), during the 2004/2005 trapping season. Trappers participating in our study harvested over 2400 martens in 2004/2005 and caught between 693 and 1609 martens in each of the previous 3 trapping seasons. Catch per unit of effort ranged between 0.3 and 10.0 martens per 100 TN (mean = 2.9 martens/100 TN). Effort data from other years in this study area were not available for comparison. Trapping success from our study was higher than levels reported by Fortin and Cantin (1994, 2004) for Quebec (0.6 to 1.9 martens per 100 TN) and Katnik et al. (1994) for Maine (1.6 martens per 100 TN) but lower than levels reported by Soutiere (1979) for Maine (3.8 martens per 100 TN). During a period of low food abundance, Thompson and Colgan (1987) found that trapping success for martens was unexpectedly high as a result of dispersal of resident animals, though they did not report the number of martens harvested per 100 TN. Even with higher than expected trapping success, Thompson and Colgan (1987) showed that population density based on live-trapping and snow-tracking indices was low during this period.

There is some evidence that martens will increase home range size during periods when food is scarce (Thompson and Colgan 1987, Thompson 1994). During the 2004/2005 trapping season, small mammal densities were low in some parts of the province (OMNR, unpubl. data; Ian Thompson, pers. comm.), and snowshoe hare abundance was near the low end of the population cycle. The potential effects of this shortage of food were evident in the Kapuskasing area, where radio-collared adult martens abandoned established territories and traveled great distances, presumably in search of food (Ian Thompson, pers. comm.). Extensive wandering in search of food and the availability of bait at trap sets may have increased the vulnerability of martens to trapping, resulting in the high relative harvest during the 2004/2005 trapping season.

Although the total number of animals harvested was high, the proportion of juveniles in the harvest was low (mean = 21%). The low number of juvenile martens in the harvest is likely the result of a recruitment failure in the spring of 2004. This failure could be due to a variety of reasons, but we hypothesize is a result of low prey abundance. Small mammal trapping showed low abundance of most microtine rodents prior to, and during the spring and summer of 2004 (OMNR, unpubl. data; Ian Thompson, pers. comm.). Also snowshoe hare (*Lepus americanus*) abundance was at the low end of the cycle, and not expected to peak again until approximately 2008-2010. Thompson and Colgan (1987) and Poole and Graf (1996) showed that the proportion of juvenile martens in trapper harvest declined in the years following a crash in the snowshoe hare population. The analyis of the winter diet of martens indicated that juveniles took proportionally more snowshoe hares, while adults took more microtine rodents (Poole and Graf 1996). This may help to explain why there were so few juveniles collected during our study.

Trapper harvest as an index of abundance

Our study was motivated in part by work done by Savage (2003) that showed a weak but significant relationship between trapper harvest of martens and habitat supply at a landscape scale. In Phase 1 we assumed that marten harvest reflected relative marten abundance on traplines and believe that this assumption is valid. Although we recognize that changes in trapper or hunter harvest per unit effort may not directly reflect changes in measured or actual abundance between years (see Thompson and Colgan 1987), the number of martens harvested is expected to reflect the relative density of martens among traplines, within the same year; we believe that our index of harvest per 100 TN was an appropriate index of relative marten density. This is consistent with Thompson (1994) and others, where similar trapping methods and effort, in different areas, allowed for comparisons between density indices.

In Phase 1, we examined the relationship between habitat supply and the total number of martens harvested per km^2, controlling for effort, access and/or climate variables. In Phase 2 we used detailed information on trapper effort as well as the age and sex of the harvest to examine similar relationships. Effort was an important component of our models. In Phase 1, we used the proportion of beaver quota attained as an index of trapper effort but were able to use actual effort data for our analyses in Phase 2. The lack of a significant relationship between the proportion of beaver quota attained and the number of TN of effort reported by trappers suggests that our index of effort in Phase 1 may not be analogous to the effort which is actually occurring on marten traplines. Harvesting records can be useful in monitoring furbearer populations, but can be misleading if trapping effort is not considered (McDonald and Harris 1999).

Whether harvest data are to be used to study population trends or to investigate a relationship with habitat supply, trapper effort is an important factor to consider. When effort data are not available, researchers must make assumptions on the variation in effort over time or geography and are unable to evaluate potential biases (Fryxell et al. 2001). Of three marten population indices determined by Thompson and Colgan (1987), two relied on trapping data and both of these considered trapping effort. Although collecting effort data may be cost prohibitive in some cases, attempts should be made to obtain this information whenever possible.

Trapper behaviour as well as marten behaviour may have confounded our assumptions, since we do not yet fully understand either. At the scale of an individual trapline, many martens may have home ranges in which trapping effort is expended. Unfortunately, trapper behaviour, and the associated knowledge of marten behaviour dictates where traps will be set. These set locations are very rarely, if ever, randomly selected. Marten researchers employ similar tactics when live-trapping, using the behavioural traits of the species they seek to increase their trapping success. Although estimates of actual effort (trap-nights) may be comparable between traplines, how that effort is apportioned across a trapline is rarely known. When traplines are composed mainly of suitable marten habitat, access is often restricted. In other cases, traplines have abundant access but have been extensively logged. Trappers on these traplines target residual patches of older forest (Thompson 1994), or suitable marten habitat, and can often harvest more martens than would be expected based on a landscape-level analysis of suitable habitat. Because trapper effort may be contained within a geographic area but not equally apportioned over the entire area, harvest per unit of effort (e.g. martens/100 TN) may be a better index of marten abundance than harvest per unit of area (e.g. martens/km^2).

Habitat supply and marten harvest

Similar to Phase 1, the harvest of martens (e.g. number of martens harvested per 100 TN) is weakly related to the supply of suitable habitat on traplines. Like in Phase 1, habitat supply in Phase 2 was a weak predictor of marten harvest; models containing habitat terms only explained about 5% more variation in marten harvest than models without habitat terms. Even when relationships were significant, low R^2 values indicate that there was a substantial amount of variation in marten harvest that we were unable to explain using habitat supply or by controlling for a variety of other factors.

In Phase 1, harvest of martens was strongly related to the total amount of suitable habitat on traplines and to the amount of suitable habitat in medium and large patches. In Phase 2, a similar measure of marten harvest (number of martens harvested per km^2) resulted in a similar relationship; harvest of martens per km^2 is related to the total amount of OWHAM pooled suitable + guideline suitable habitat on traplines, and is weakly related to the amount of suitable + guideline suitable habitat in medium and large patches.

The number of martens harvested per 100 TN is negatively related to the amount of suitable habitat in small patches but only explains approximately 12 to 14% of the variation in marten harvest; this relationship was true whether habitat was classified using OWHAM or OMA. Because we classified all habitat patches as either small, medium, or large, these results are consistent with the Phase 1 results.

Martens have long been considered a species that has specific habitat requirements, including large contiguous, “core” habitat areas dominated by mature and older coniferous and mixed forests (Buskirk and Powell 1994, Thompson 1994, Thompson and Colgan 1994, Payer and Harrison 2003, etc.). During a study in Maine, all of the resident, adult martens radio-collared by Chapin et al. (1998) maintained home ranges composed mainly of forest cover over 6m in height, with more than half the area of individual home ranges composed of a single, contiguous patch of suitable habitat. Marten territories often include sub-optimal habitat, but their home ranges are generally thought to overlap with large tracts of good habitat. Since martens may avoid large open areas, and prefer to rest in residual patches of forest (Soutiere

1978, 1979; Steventon and Major 1982; Thompson and Colgan 1994; Poole et al. 2004; Bull et al. 2005; Fuller and Harrison 2005), providing patches at least the size of a marten home range should minimize any adverse effects associated with large open areas, such as areas of recent forest harvesting where sufficient regeneration has not yet occurred. Our findings suggest that marten harvests are lower in areas where habitat occurs in proportionally more small patches, or where small patches of good habitat are interspersed too greatly with unforested areas, or forested patches that do not provide good marten habitat. Sufficient area should thus be maintained in contiguous medium (5 to 30 km^2) or large (30 to 50 km^2) patches of suitable habitat.

Habitat supply and differences among age groups

Of all the martens collected for this study, only 21% were juveniles, aged at < 1 year old based on the radiograph method (Dix and Strickland 1986). This was surprising, considering more than 50% of harvested martens are usually juveniles (Strickland and Douglas 1987). Data from Fryxell et al. (2001) showed an average of 55% juveniles over 20 years of marten harvest in the Algonquin region of Ontario. There were fewer than 50% juveniles in only 3 of the 20 years reported, and never fewer than 31% juveniles in any given year. In Quebec, Fortin and Cantin (2004) found that on average, the marten harvest in their study area was 59% juveniles. There were fewer than 50% juveniles in only 2 of the 12 years of their study, and never fewer than 33% juveniles in any given year. Although we saw a greater proportion of adults than one would expect based on previous studies, a decline in marten abundance can be associated with a low proportion of juveniles in martens harvested by trappers (Thompson and Colgan 1987).

Some studies (e.g. Soutiere 1979, Thompson 1994) suggest that good habitat has more martens than poor habitat but that there are similar proportions of adults and juveniles in both types of habitat during the fall and winter. The lack of a significant relationship between the number of juveniles harvested per 100 TN and the amount of suitable habitat on a trapline is likely a result of the low number of juveniles harvested. The mean harvest of juveniles was 0.570 per 100 TN (range 0.000 to 3.258 per 100 TN, Appendix I). On traplines in our study area, juvenile martens were either present and were harvested, or were not present and were not harvested. Trappers often harvested no juveniles, irrespective of the supply or spatial arrangement of suitable habitat on their trapline.

Adult female martens maintain a smaller home range than males (Buskirk and McDonald 1989, Latour et al. 1994, Phillips et al. 1998) and their movements may be significantly restricted during the spring and summer when young-of-the-year are still dependent and unable to move great distances (Wynne and Sherburne 1984, Katnik et al. 1994). The limitations suggest that adult females should seek and remain within habitat that provides optimal foraging opportunities and suitable maternity dens. This is supported by Payer and Harrison (1999) who found three times more lactating females in uncut, mature forest than in extensively clearcut forest. We expected that the number of adult females in optimal habitat would be greater than in low quality habitat and that this variation in density should be reflected in the number of adult females harvested by trappers.

The number of adult females harvested per 100 TN was weakly related to suitable habitat in small patches. The relationship was negative, which is consistent with the relationship between the total number of martens harvested per 100 TN and suitable habitat in small patches. This provides further support to the idea that patches of suitable habitat should be at least the size of an adult marten home range. Since they have specific requirements for maternal den sites, in addition to requirements for food resources, adult females may be less likely to expand home ranges during food shortages, choosing to abandon current territories in search of areas where both food and denning requirements can be met (Phillips et al. 1998). We do not have evidence that this occurred beyond the Kapuskasing area, but similar home range abandonment (or dispersal in search of food) may have occurred in other parts of our study area. Without established territories, transient martens may have been trapped in areas of sub-optimal habitat as they searched for food and new home ranges, diluting any association with suitable habitat.

Alternatively, our method of ageing marten skulls (Dix and Strickland 1986) may have been too coarse, since we were only able to distinguish martens as young-of-the-year or older. Using a more accurate ageing method, such as sectioning teeth and counting cementum annuli can provide information on the actual age of the animal. Sexually mature (> 2.5 years old) adult female martens may be more likely to have established territories in suitable habitat, and may have been more significantly related to the amount of suitable habitat on a trapline. Some of the non-juvenile females in our study may not have been sexually mature, and may have established territories in sub-optimal habitat (Paragi 1996, Payer and Harrison 1999) thus diluting any effects of habitat on the harvest of sexually mature, adult female martens. Future studies may benefit from detemining the number of females > 2.5 years old, which is a more accurate representation of adult animals.

Considerations and recommendations

Although detailed harvest effort, age and sex data of trapper-harvested martens did not greatly improve our ability to predict marten harvest from habitat supply, our data may have been confounded by only covering a single trapping season, particularly one with a relatively high harvest and a relatively low proportion of juveniles in the harvest. There is often annual variation in harvest that does not necessarily reflect abundance (Fortin and Cantin 1994) or population trends (Thompson and Colgan 1987). If one considers aspects of wildlife management beyond the provision of habitat, there are many other benefits to collecting such detailed information on the demography of harvested martens, and the effort required to catch them. With increasing fur prices, demand for martens and effort expended will likely increase (Chris Heydon, pers. comm.), causing further pressure on the population.

The results of Phase 1 (9 years harvest data; 1994-2003) and Phase 2 (1 year detailed harvest and effort data; 2004-2005) both suggest habitat on individual traplines influences marten harvest; therefore, planning at this scale may be important to support high harvest of martens on all traplines. Both Phase 1 and Phase 2 of our study failed to support the need for large cores but suggest that suitable habitat should be arranged in patches at least the size of an average marten home range, or 5 km^2 (500 ha).

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Appendix I. Descriptive statistics for marten harvest data from the 56 participating traplines, including the suite of dependent and independent variables used in the investigation of the effect of habitat on marten harvest.

	Min	Max	Average	Stdev	Median
Trapline area (ha)	6,419	84,746	21,071	14,562	16,591
Total land area in trapline (ha)	5,911	84,109	19,409	13,013	15,967
Total marten harvest	3	110	45	32	38
Total marten aged	2	110	40	28	35
Total trap-nights	37	9519	1988	1918	1319
Total number of juveniles in aged samples	0	26	6	6	4
km of primary or secondary roads per km^2 of land area	0.000	1.143	0.264	0.213	0.225
km of tertiary roads per km^2 of land area	0.000	1.878	0.589	0.457	0.501
Total km of roads per km^2 of land area	0.016	2.129	0.853	0.570	0.708
Proportion of trapline that is crown land (excluding parks)	0.345	0.992	0.848	0.149	0.899
Total marten harvested per ha of trapline	0.000	0.007	0.002	0.002	0.002
Total marten harvested per km^2 of trapline	0.025	0.706	0.242	0.156	0.209
Total marten harvested per ha of land in trapline	0.000	0.008	0.003	0.002	0.002
Total marten harvested per km^2 of land in trapline	0.026	0.843	0.261	0.172	0.227
Number of martens harvested per 100 trap-nights	0.341	10.038	2.901	1.963	2.404
Number of Juvenile martens harvested per 100 trap-nights	0.000	3.258	0.570	0.720	0.310
Number of adult female martens harvested per 100 trap-nights	0.000	3.346	1.052	0.802	0.841
Proportion adult martens in harvest	0.257	1.000	0.791	0.214	0.860
Proportion of trapline that is OMA Fair Suitable	0.003	0.356	0.099	0.066	0.102
Proportion of trapline that is OMA Good Suitable	0.013	0.324	0.122	0.077	0.104
Proportion of trapline that is OMA pooled Fair Suitable and Good Suitable	0.082	0.585	0.221	0.099	0.195
Proportion of trapline that is OWHAM Suitable	0.038	0.588	0.193	0.099	0.187
Proportion of trapline that is OWHAM Guideline Suitable	0.001	0.231	0.065	0.048	0.054
Proportion of trapline that is OWHAM pooled Suitable and Guideline Suitable	0.040	0.657	0.258	0.120	0.241
Proportion of trapline that is OMA pooled Fair Suitable and Good Suitable					
Small patches (<500 ha)	0.014	0.210	0.112	0.040	0.112
Medium patches (500 - <3,000 ha)	0.000	0.154	0.040	0.036	0.034
Large patches (3000+ ha)	0.000	0.571	0.068	0.121	0.005
Pooled Medium and Large patches (500+ ha)	0.000	0.571	0.108	0.121	0.071
Proportion of trapline that is OWHAM pooled Suitable and Guideline Suitable					
Small patches (<500 ha)	0.002	0.207	0.090	0.045	0.086
Medium patches (500 - <3,000 ha)	0.000	0.187	0.027	0.038	0.013
Large patches (3000+ ha)	0.000	0.655	0.141	0.162	0.081

	Min	Max	Average	Stdev	Median
Pooled Medium and Large patches (500+ ha)	0.000	0.655	0.168	0.148	0.123
Proportion of trapline that is OWHAM Guideline Suitable					
Small patches (<500 ha)	0.000	0.067	0.024	0.017	0.021
Medium patches (500 - <3,000 ha)	0.000	0.040	0.007	0.010	0.002
Large patches (3000+ ha)	0.000	0.216	0.034	0.052	0.014
Pooled Medium and Large patches (500+ ha)	0.000	0.217	0.041	0.050	0.025