Population trends and harvest management of pine marten Martes martes in Scandinavia

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In this paper, I describe historical and present harvesting and population trends of pine marten *Martes martes* in Scandinavia, based on a literature review and analyses of harvest statistics and population indices. The pine marten population has experienced two periods of over-harvesting with subsequent large-scale declines in population density and local extinctions; in the 1500-1600s and in the early 1900s. The principal incentive for harvesting appears to have been economic (valuable pelt), but eradication efforts may have compounded the effect on the population. In the last decades, the pine marten population density has increased. At present, it is receding but pine martens are still harvested intensively. I discuss implications for management, and caution about over-harvesting of the Scandinavian pine marten population in a near future.

Key words: harvest management, historical harvest, Martes martes, over-harvesting, pine marten, population trends, Scandinavia

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Most species of the genus *Martes* are forest associates, sensitive to the conversion of natural habitats following human forest exploitation (e.g. Buskirk 1994). In addition, their fur is extraordinarily luxurious and valuable, and the history of marten harvesting is both long and intensive. Because of their generally low reproductive potentials (late maturation and small litters; Mead 1994), marten populations are particularly susceptible to increased mortality. As a result, marten populations world-wide have undergone long-term declines caused by over-harvesting and habitat loss. The sable *M. zibellina* was hunted to near-extinction in Siberia in the 1600s (Bakeyev & Sinitsyn 1994), and in China in the 1800s (Ma & Xu 1994). In North America, populations of American marten *M. americana* and fisher *M. pennanti* decreased in the early 1900s, and were locally extirpated, because of excessive harvesting in combination with extensive habitat loss (Strickland 1994). Predator control severely reduced numbers and distribution of the pine marten *M. martes* in Great Britain in the 1800s (Langley & Yalden 1977), and Grakov (1978) found that populations of pine marten in Russia decreased during periods of heavy harvest, and increased during periods of partial or total protection. Krott & Lampio (1983) described a marked decrease in the pine marten population in Finland during the first half of the 20th century, probably due to over-harvesting.

In this paper, I summarise data on harvesting and population trends of pine marten on the Scandinavian

Peninsula, including Norway and Sweden. These two countries constitute a relatively homogenous and well defined geographic area, show several similarities in history and hunting traditions, and probably share the same continuous pine marten population. I review historic accounts, compile harvesting statistics, and present some new data on the recent situation. Where possible, I separate data from northern and southern Sweden, because the hunting traditions differ between these areas (e.g. Ekman 1910), and because Lindström, Brainerd, Helldin & Overskaug (1995) noticed dissimilarities in recent population trends. I discuss implications for the management of the Scandinavian pine marten population.

Methods

Sources for historical review

The historical review was based primarily on: (i) magazines on hunting and natural history published prior to 1960 by the Swedish Association for Hunting and Wildlife Management, the Swedish Museum of Natural History, and the Norwegian Zoological Society (Tidskrift för Jägare och Naturforskare 1834-1836, Svenska Jägareförbundets Nya Tidskrift 1863-1907, Svenska Jägareförbundets Tidskrift 1908-1939, Svensk Jakt 1940-1960, Fauna och Flora 1906-1960, Fauna 1948-1960), and (ii) essays on traditional Saami and peasant hunting and trapping (Olaus Magnus 1555, Ekman 1910, Lundmark 1982, Fjellström 1985, Kjellström 1995).

Harvest statistics

The number of bounties paid in Norway during 1896-1930 were obtained from Statistics Norway (1978a), and Norwegian bag records from the period 1973-1995 were estimated in Statistics Norway (1978b, 1980, 1983, 1987, 1991, 1996). Swedish bag records for 1941-1995 were estimated by the Swedish Association for Hunting and Wildlife Management (1960-1995). During 1960-1963, Swedish bag records were separated between the six northernmost counties and the remaining 16, and from 1964 onwards they were reported by county (Fig. 1). Detailed descriptions of the methods for the bag record estimates are given in Statistics Norway (1996) and on the home page of the Swedish Association for Hunting and Wildlife Management (in Swedish; www.jagareforbundet.se/forsk/viltovervakning). I present bag records summarised for Sweden and Norway, but Swedish bag records from 1960 onwards are also presented as means per land area, separately for northern Sweden (the six northernmost counties, situated entirely within the boreal zone) and southern Sweden (the remaining 16 counties, at least partly including the boreo-nemoral or nemoral zone). Throughout the paper, winters (harvesting seasons) are denoted by the calendar year after new-year, so that the winter and harvesting season of for instance 1996/97 is denoted 1997.

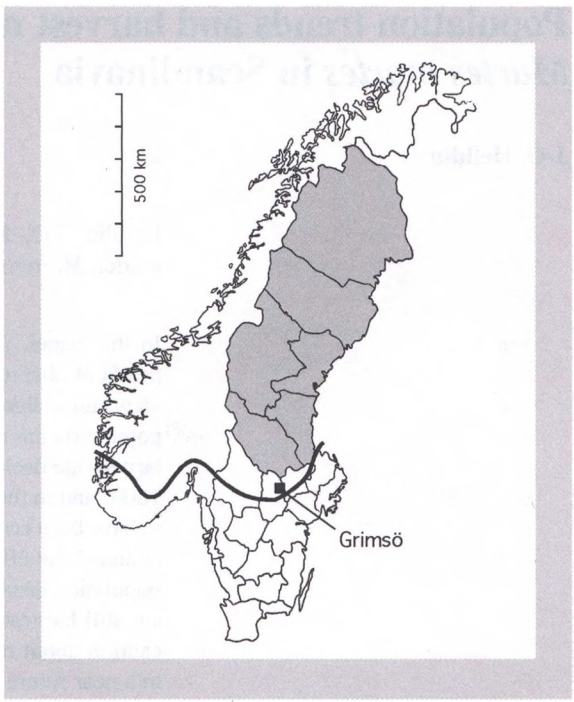

Figure 1. The Scandinavian Peninsula (Norway and Sweden), with indication of the southern border of the boreal region (bold line), the location of the counties in northern (grey) and southern (white) Sweden, and the Grimsö Wildlife Research Area (black square) in the northern part of the county of Örebro.

Marten population trends

The Swedish Association for Hunting and Wildlife Management (1960-1995) reported changes in the Swedish game populations by county in the harvesting seasons of 1960-1995, as perceived by county game managers. Based on these reports, I calculated indices of marten population change for each year by giving 'increase' a score of +1, 'stable' 0, and 'decrease' -1. I then obtained one average for the northern counties, and one for the southern (the county of Örebro excluded). Hunters (N = 150-355) in the county of Örebro (see Fig. 1) reported perceived changes in the game populations on their hunting-grounds in the harvest-

ing seasons of 1974-1997. I calculated an index of marten population change for the entire county for each year with the same procedure as above.

I also used changes in trapping success and scat counts to estimate marten population trends. I recorded marten trapping success (martens captured/100 trap-nights) in the harvest seasons of 1990-1997 for 18 marten trappers in or near the northern part of the county of Örebro with a total trapping effort of 8,000 -10,000 trap-nights/season. I counted marten scats left in the winters of 1991-1997 on four forest trails (each measuring 1.1-2.4 km) situated in a 55 km^2 untrapped wildlife reserve within the Grimsö Wildlife Research Area in the county of Örebro (see Fig. 1). Trails were cleared of scats in mid-October, and searched once or twice when snow conditions were suitable, plus once in mid-April, after the snow had melted.

Results

Historical harvest and population trends before 1900

Records of pine marten harvesting in Scandinavia date back to the Mesolithic Period (Trolle-Lassen 1986). The harvesting has probably been of great economic importance to many people, in Scandinavia most notably the Saamis, the ethnic minority in the north, for thousands of years (Fjellström 1985). The rapid human population growth starting in the 500s A. D. in Sweden, with increasing settlement in remote forest areas and conversion of forest to farmland (Berglund, Helmfrid & Hyenstrand 1994), probably resulted in pine marten densities that gradually declined over several centuries. The Swedish national law code from 1347 regulated the harvest by season; to secure pelt primeness martens should not be killed between mid-March and early November (Ekman 1910). In the 1500s, the Saamis used marten furs to pay taxes to the Swedish and Norwegian states (Olaus Magnus 1555, Lundmark 1982), and the Swedish State and Court took an interest in the marten fur trade (Anonymous 1833). At this time, marten furs were highly valued all over Europe, and were exported from both Sweden and Norway in large quantities (Olaus Magnus 1555, Fjellström 1985). In the 1600s, the pine marten was increasingly recognised as a vermin on game and poultry (Kjellström 1995), and hunting regulations stated that martens could be killed year-round, no matter where or how (Kjellström 1995). In the 1500-1600s

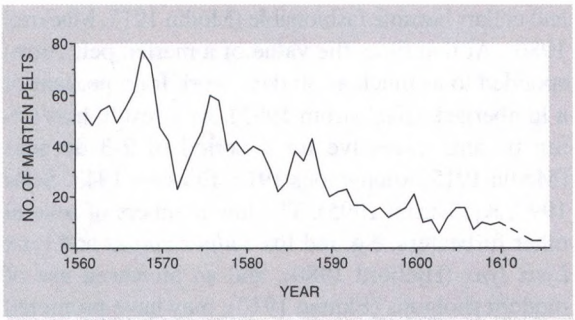

Figure 2. Number of pine marten furs acquired by the Swedish state from the Saamis in Lule Lappmark, a region of northern Sweden during 1561-1610 and 1614-1615 (redrawn after Lundmark 1982).

over-harvesting likely occurred; the number of marten furs acquired by the Swedish State from the Saamis declined (Lundmark 1982; Fig. 2), and in the late 1600s, pine martens in northern Scandinavia were rare, if not extinct (Dass ca 1670 in Selås 1990). Scattered reports (e.g. Thunberg 1798, Wergeland 1834, Modin 1917) indicate that populations remained low until the late 1800s, when numbers apparently started building up, at least locally, in boreal Scandinavia (Gustafson 1888, Modin 1917, Fjellström 1985, Kjellström 1995). Pelt prices were temporarily low at this time (Modin 1917).

Population decline during 1900-1930

In the early 1900s, a country-wide predator extermination programme was initiated in Norway (Steen, Yoccoz & Ims 1990), and also Sweden was embraced by extensive anti-predator propaganda. As part of the predator extermination programme, Norwegian authorities started paying bounties for killed pine martens, and after a few years' delay, the number of martens bountied reached a maximum (Fig. 3). Concurrently, pelt prices increased rapidly, because marten fur wraps

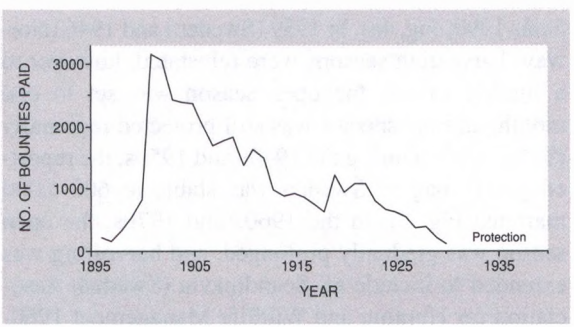

Figure 3. Number of marten bounties paid in Norway during 1896-1930 based on data from Statistics Norway (1978a).

and collars became fashionable (Modin 1917, Mackrell 1986). At that time, the value of a marten pelt corresponded to as much as 30 days work for a peasant or a lumberjack (Kjellström 1995). As a result, harvesting became excessive for a period of 2-3 decades (Modin 1915, Anonymous 1916, Eliasson 1943, Selås 1990, Kjellström 1995). The low numbers of several other furbearers, e.g. red fox *Vulpes vulpes* and lynx *Lynx lynx* (Hjeljord 1980), and an increased use of modern shotguns (Ekman 1910), may have promoted marten hunting even further. At this time, martens were mainly hunted by snow tracking, and shot after being forced out of their daybed (Ekman 1910). It was told that when a marten trail had been found, people left their occupation and went marten hunting (Modin 1915, Selås 1990). Contemporary accounts describe the hunting for pine marten as "severe persecution" (Modin 1915, author's translation) and "a ruthless war of extermination" (Anonymous 1916, author's translation).

Already in the 1910s, pine marten numbers had declined dramatically, and the species was probably exterminated from large areas in the north (Ekman 1910, Modin 1915, von Post 1925, Eliasson 1943, Selås 1990, Kjellström 1995). The decline may have been amplified by the lack of hole trees caused by the developing modern forestry (Modin 1917). From 1915, marten harvesting was regionally banned in Sweden for 5-year periods, but this apparently did not halt the trend, as pelt prices were still high, and poaching occurred (Modin 1925, 1926). The number of bounties paid in Norway declined until 1930 (see Fig. 3), at which time the bounty payment was discontinued and the species received full protection in both Norway and Sweden.

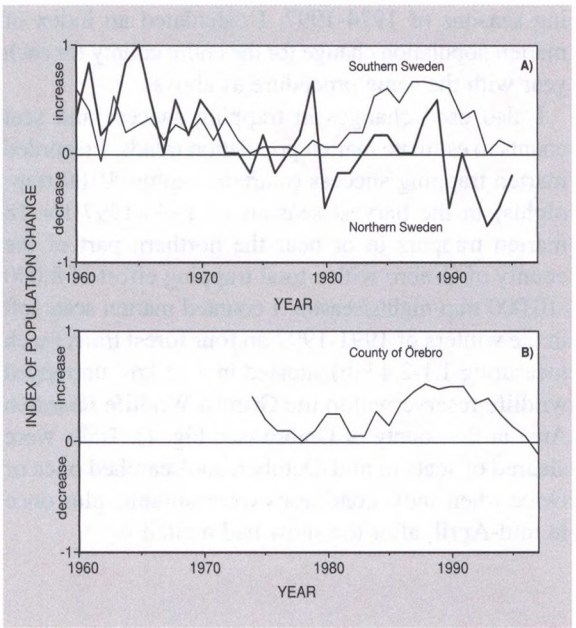

Figure 4. Perceived changes in the population density of pine marten in Sweden during 1960-1997, based on annual reports from hunters; A) for southern Sweden (the county of Örebro excluded; —) and northern Sweden (—) , reports by county were obtained from the Swedish Association for Hunting and Wildlife Management (1960-1995); B) for the county of Örebro, reports were supplied by local hunters during 1974-1997. Reports of 'increase' were given a score of +1, 'stable' 0, and 'decrease' -1, and the index gives the average value for all counties or hunters.

General population increase during 1930-1990

Soon after the protection, pine marten numbers started to increase, and continued to do so through the 1960s (von Essen 1941, Dahl 1943, Eliasson 1943, Selås 1990; Fig. 4a). In 1939 (Sweden) and 1946 (Norway) harvesting seasons were reinstated, however to a limited extent; the open season was set to one month, and the species was still protected regionally (Selås 1990). During the 1940s and 1950s, the reported yearly bag in Sweden was stable at 600-1,000 martens (Fig. 5). In the 1960s and 1970s, the open season was gradually prolonged, and harvesting was extended to include all Scandinavia (Swedish Association for Hunting and Wildlife Management 1960-1995, Selås 1990). Bag records increased slowly in northern Sweden (Fig. 6a), but remained stable at a low level in southern Sweden (see Fig. 6b). The latter was probably due to a low interest in marten hunting in southern Sweden, as the marten population was generally reported to increase in the 1960s (see Fig. 4a). In Norway the situation was probably similar to

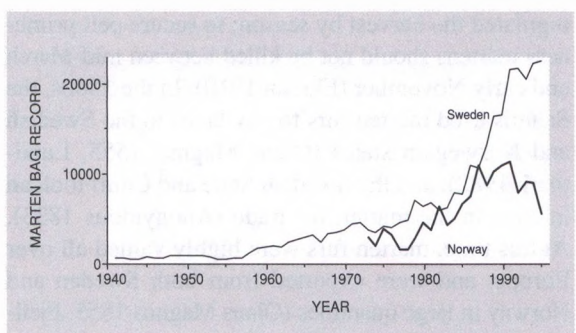

Figure 5. Bag records of pine marten in Sweden during 1941-1995 (—) and in Norway during 1973-1995 (—) based on data from Swedish Association for Hunting and Wildlife Management (1960-1995) and Statistics Norway (1978b, 1980, 1983, 1987, 1991, 1996).

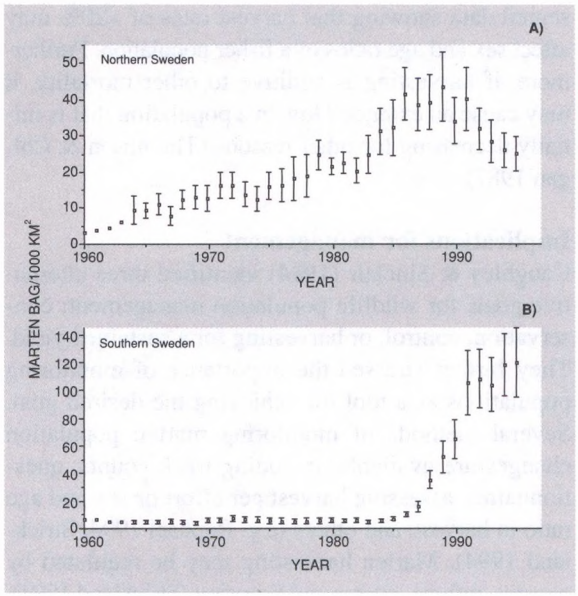

Figure 6. Pine marten bag/1,000 km² (±SE of the mean) in the Swedish counties during 1960-1995 for: A) six counties in northern Sweden, and B) 16 counties in southern Sweden based on data from the Swedish Association for Hunting and Wildlife Management (1960-1995).

that in northern Sweden (see Fig. 5). In the 1940s pelt prices were still relatively high (Bergkvist 1944), but subsequently decreased.

In the 1970s, the increase in marten numbers ceased in northern Sweden; the hunter's index of population change fluctuated around zero (see Fig. 4a). Also in southern Sweden the increase was temporarily slowed down (see Fig. 4), although harvest was low (see Fig. 6b). From the early 1980s, the increase in pine marten numbers was amplified, at least in southern Sweden (Lindström et al. 1995; see Fig. 4). In northern Sweden indices of population change still fluctuated around zero (see Fig. 4a). During this time, bag records also increased, most pronouncedly in southern Sweden (see Figs 5 and 6). In Norway and northern Sweden harvesting reached a maximum in the late 1980s (see Figs 5 and 6a). Trapping gained increased attention (Ødegård, Pedersen & Oppegård 1994, Helldin 1994), and as pelt prices were low, predator control was the main objective for the trapping (Ødegård et al. 1994).

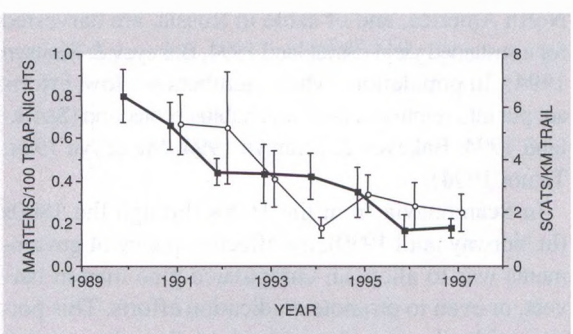

Figure 7. Trapping success expressed as martens captured/100 trap-nights (±SE of the mean; — /■) of 18 marten trappers in or near the northern part of the county of Örebro, Sweden 1990-1997, and number of scats found/km trail (±SE of the mean; — /○) along four forest trails in the Grimsö Wildlife Research Area, the county of Örebro, Sweden, in winters 1991-1997.

Harvest and population trend in the 1990s

Indices of population change imply that marten numbers have decreased in northern Sweden after 1990, and that the increase has ceased in southern Sweden (see Fig. 4). Between 1990 and 1997, pine marten trapping success in the county of Örebro declined (Friedman's test, $\chi^2 = 25.1$, df = 7, P = 0.007; Fig. 7), and scat counts also showed a declining trend, however not significant (Friedman's test, $\chi^2 = 9.84$, df = 6, P = 0.13; see Fig. 7). This suggests that marten density decreased also in southern Sweden. The bag records decreased in Norway and northern Sweden, but were still high relative to before 1980 (see Figs 5 and 6a). Bag records remained high in southern Sweden; harvest per unit area in the south was 3-4 times as high as in the north (see Fig. 6b).

Discussion

The historic accounts and data presented suggest that the population density of pine marten in Scandinavia has been largely governed by harvesting intensity in most historic time. The population has experienced two periods of over-harvesting with subsequent large-scale declines in population density and local extinctions; in the 1500-1600s and in the early 1900s. The main incentive for harvesting appears to have been economic, as marten numbers have recovered in times of low pelt prices. However, eradication efforts may have compounded the effect on the marten population.

Recent research has suggested that Scandinavian pine marten population density since the 1970s has been limited by red fox predation (Storch, Lindström & de Jounge 1990, Lindström et al. 1995), possibly in combination with modern forestry practices (Brainerd 1997). Structurally diverse forests supply martens with escape cover from enemies such as the red fox,

as well as shelter at harsh weather (Overskaug 1992, Brainerd, Helldin, Lindström, Rolstad, Rolstad & Storch 1995, Eide 1995, Gundersen 1995). Several authors (Grakov 1972, Overskaug 1992, Thompson & Harestad 1994, Brainerd 1997) have also hypothesised that marten foraging success increases with structural diversity. However, Clevenger (1994) suggested that the pine marten, due to its generalised diet, should not be food limited, and Helldin (1999) supported this with data indicating that pine marten density was independent of prey abundance. Forest fragmentation could adversely affect pine marten density (Grakov 1972, Bjärvall, Nilsson & Norling 1977, Brainerd 1997), but may favour red foxes through increased small mammal abundance (Christiansen 1979, Christensen 1985, Henttonen 1989, Gundersen 1995). Accordingly, the red fox populations increased along with the development of the clear-cutting practices in the 1950s and 1960s (Christiansen 1979, Hjeljord 1980). This may explain the interrupted increase in the pine marten population in the 1970s. In the 1980s, the red fox population declined dramatically due to an epizootic of sarcoptic mange, and the increase in the marten population was linked to this decline in both time and amplitude (Lindström et al. 1995).

Lindström et al. (1995) predicted that the pine marten population density should decrease with the recovery of the red fox population in the 1990s. Although the data presented here support this prediction, I cannot exclude the possibility that the intensive harvesting has contributed to the depression of the pine marten population density during the 1990s. Based on a combination of radio-tracking data, harvest records, and age structure in the harvest, I estimated the harvest rate in the county of Örebro and surroundings to be about 6% of the autumn population during 1989-1993 (Helldin 1994), which could probably be considered low, despite the marten's low reproductive capacity. Since then (i.e. between the median year of that study, 1991, and 1997), trapping success and the number of scats found in the area have declined to about one-third or one-fourth of the previous level (bearing in mind that the trend for the scat count was not significant; see Fig. 7). If these measurements represent the actual population change, and the number of martens harvested is constant (as reported from southern Sweden; see Fig. 6b), then the present harvest rate may be 3-4 times higher than that reported for 1989-1993, i.e. around 20%. Although Bakeyev & Sinitsyn (1994) suggested that populations of sable can sustain harvest rates as high as 25-30%, Strickland (1994) presented data showing that harvest rates of >20% may affect sex and age ratios of a fisher population. Furthermore, if harvesting is additive to other mortality, it may cause an extended low in a population that is initially decreasing for other reasons (Thompson & Colgan 1987).

Implications for management

Caughley & Sinclair (1994) identified three alternative goals for wildlife population management: conservation, control, or harvesting for a sustained yield. They further stressed the importance of monitoring populations as a tool for achieving the desired goal. Several methods of monitoring marten population changes are available, including track counts, questionnaires, assessing harvest per effort or sex and age ratio in harvest, and others (e.g. Raphael 1994, Strickland 1994). Marten harvesting may be regulated by seasons, refugia, quotas and licensing (Strickland 1994). Juveniles generally dominate the catch early in the season, whereas the proportion of adults increases in late winter (Strickland & Douglas 1987, Helldin 1994). In late winter there is also a higher risk that harvesting is additive to other winter mortality. Hence, a concentrated catch soon after pelts are prime (late October) may affect the population less than if the catch was distributed over the winter. Martens are territorial, and a system of untrapped refugia larger than twice the size of a mean marten home range may secure a population 'reservoir', and allow a fast recolonisation of trapped areas (Strickland 1994).

Today the need for careful management of populations of all marten species is widely recognised (Bakeyev & Sinitsyn 1994, Fortin & Cantin 1994, Strickland 1994). Populations of American marten and fisher in North America, and of sable in Russia, are harvested for a sustained yield (Strickland 1994, Bakeyev & Sinitsyn 1994). In populations where numbers are low, efforts are put into reintroductions and habitat protection (Strickland 1994, Bakeyev & Sinitsyn 1994, Ma & Xu 1994, Tatara 1994).

In Scandinavia from the 1600s through the 1800s (in Norway until 1930), the effective policy of governments was to allow an unregulated pine marten harvest, or even to promote eradication efforts. This policy evidently was detrimental to the pine marten population. Present legislation restricts harvesting only by season, primarily for ethical reasons; martens should not be regularly trapped or hunted in the period in which young may depend on their mother. Furthermore, there is practically no monitoring of popula-

tion changes. With the current low pelt prices, the economic incentives for marten harvesting is largely eliminated, which probably leads to a self-regulating harvest rate. On the other hand, predator control is put forward as an important objective for present marten harvesting, which implies that trappers actually intend to depress the marten population.

Intensive harvesting of a population with a low rate of increase, in a fluctuating environment, may eventually lead to its extinction or severe depletion, irrespectively of the density of the harvested population (Lande, Engen & Sæther 1995). To secure maintained viable populations of pine marten, future management should include carefully considered goals, reliable continuous monitoring of population changes, and tools efficient in regulating the harvest.

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