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Use of snow-tracking methods to estimate the abundance of otter (*Lutra lutra*) in Finland with evaluation of one-visit census for monitoring purposes

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Special one-visit censuses (OVC) for monitoring and estimating of abundances of otters based on snow tracks was carried out in 1995–1998. The monitoring network included 16 areas, in total 37 000 km^2. The number of investigated sites was 1213–1589 per year. Ages, sizes and directions of otter tracks were examined to estimate how many otters had visited each site, and the entire study areas. We found otter tracks in every study area during all winters. Otters were most abundant in the central part of the country, and the number of all otters in Finland was estimated at 2000–2550 individuals. This study showed that OVC-snow tracking method works well, and that it could be a useful tool for monitoring otter populations on the national scale in Finland.

Introduction

Between the 1950s and 1980s, otter (*Lutra lutra*) populations declined in many parts of Europe (Macdonald & Mason 1994), and their distribution is now largely limited to isolated areas in peripheral regions of Europe (Foster-Turley *et al*. 1990, Macdonald & Mason 1994). However, since the 1990s, otter populations seem to have increased at least in some parts of Europe (Roos *et al*. 2001, Conroy & Chanin 2002, Reuther 2002, R. T. Sulkava unpubl. data), but accurate data on otter population trends in many areas are lacking. There is a need for more accurate field surveys and improved knowledge of the status of otter populations (Foster-Turley *et al*. 1990, Rassi *et al*. 1992, Anonymous 1994, Stjernberg & Väisänen 1998). It is also important where otters are abundant, since areas with viable populations are essential from the European conservation perspective (Foster-Turley *et al*. 1990, Macdonald & Mason 1994, Reuther 2002). The most widely used methods for otter surveys are based on spraints (faeces) and other traces, and they can only provide limited information on the true size and vitality of otter populations. In areas with northern climatic conditions, alternative field survey methods based on snow tracking can be used, and such methods have already been used in Finland (Lindén *et al*. 1996, Sulkava & Liukko 1999, Sulkava 2007a).

Current data on the distribution and status

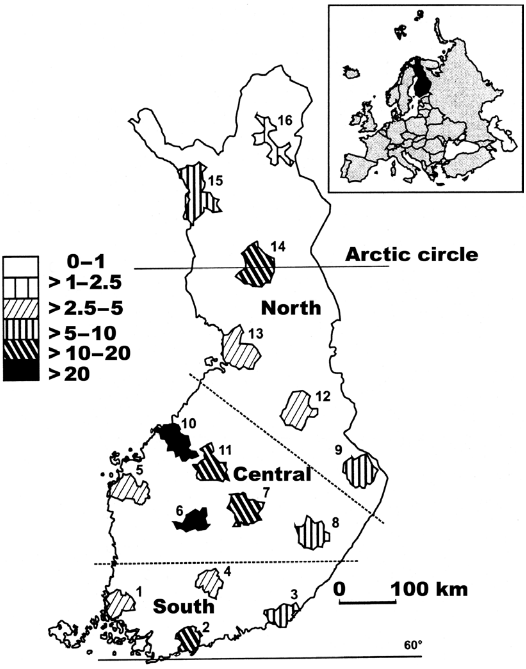

Fig. 1. The otter study network of 16 areas in Finland. Mean track indices of otters for three winters (positive sites per 100 sites) are given for each study area. Only fresh tracks (2–4 days old) were included.

of the otter in Finland are largely based on questionnaires (Stjernberg & Hagner-Wahlsten 1991), on wildlife triangles (Lindén *et al.* 1996), and on regional field surveys (e.g., Skaren & Kumpulainen 1986, Skaren & Jäderholm 1987, Sulkava & Sulkava 1989, Sulkava 1993, Sulkava & Storrank 1993, Cronström & Liukko 1999). The one-visit census (OVC) method, used in this study, has been used and tested in central Finland since 1985 (e.g., Sulkava 1993, Sulkava 2007a), but Finland's environmental authorities wanted to carry out a more detailed pilot study in 1995–1998. This study was designed to test whether OVC method is feasible for monitoring, to assess how well it can be applied by various organizations, to test its effectiveness for monitoring the otter populations in Finland. The survey was expected to provide also new data about the status of otter and American mink (*Mustela vison*) in Finland. The study was co-ordinated by the Finnish Environment Institute (SYKE). The fieldwork was carried out by staff from the regional environment centres and regional offices of the National Forest and Park Service (Metsähallitus), together with otter experts and specially trained volunteers.

Study areas, material and methods

Selection of areas and sites

Monitoring was carried out through 16 one-visit censuses (OVC) in study areas comprising a total of 37 000 km^2 of Finnish riverside and lakeland habitats (about 10% of the area of the country: *see* Fig. 1) (*see* also Sulkava 2007a). Study areas varied from 1466 km^2 to 4038 km^2 (average 2334 km^2). All the study areas and sites were designated and approved by R. Sulkava according to following criteria: (1) The study areas were selected to form a geographically representative network. (2) One or two study areas were placed in every main water system of Finland. (3) In water systems with two study areas, one was in upper tributaries and the second in the lower part of the lake and/or river system. Also differences in the quality and quantity of waters were taken into account. For example, the total area of waters varied between 2% and 32% of the total study area (areas no. 5 and 8; *see* Fig. 1). The total length of the small rivers (2–5-m wide) in the areas varied from 0.45 km per km^2 (area 9) to 0.2 km per km^2 (area 8), and the large rivers (wider than 20 m) from zero (area 4) to 0.75 km per km^2 (area 13). Practical considerations such as the location of the participating organizations also affected the selection of the study areas in some cases (in the most northern region).

We surveyed between 65 and 110 (mean = 97) permanent survey sites in each study area. The number of sites was smaller (65) in the northernmost area (in Finnish Lapland) than in other areas, due to the coarse road network and long distances between possible study sites. For the same reason, 7 sites were relocated after the first year. Study sites were typically 1–5 km apart, and usually near bridges or in other localities accessible by car. Selection of the permanent study sites was not based on knowledge about local otter populations or habitat preferences. The aim was to select a sample of typical waters inside a study area.

Field work

Fieldwork was carried out during the time when rivers and lakes were frozen (between November and April) two to four days after snowfall, i.e. within a period of two or three days. Depending on ice cover and other physical characteristics of a watercourse, at each site stretches of watercourses between 20–600 m in length were searched for otter tracks. Open parts of streams, for instance, were surveyed over longer distances than ice-covered inlets. Between 37 and 51 workers operated annually in the field, spending there a total of 406–457 hours. During the three winters (1995/1996, 1996/1997 and 1997/1998), the total numbers of sites studied were 1466, 1589 and 1213, respectively. The average total length of watercourses surveyed during each winter was about 230 km.

As most streams are covered by ice in winter, otters have to cover wide areas while searching for food (Sulkava 2006). This makes it easy to trace individual animals. At each site, the age and size of tracks and the directions of otter trails were recorded, along with the presence of any probable routes to other sites allowing surveyors to identify and separate the characteristic tracks of otter individuals. The size of an individual track (or trail) was used for separating individuals in cases of adult male otters (mean width of the footprint > 65 mm) and young otters (width < 55 mm) (Sulkava 2007c, and unpubl. data). Spraints were also recorded, but not taken into account in the results. Other recorded details included the presence of other species such as the American mink, the sizes of the rivers studied, and weather conditions (temperatures, snow depths, length of unfrozen stretches of rivers), as well as methodological details such as the amount of time spent in the field and any problems encountered. The pilot study is presented in the report of Sulkava and Liukko (1999). More details about the snow tracking method are given in Sulkava (1995), Sulkava and Storrank (1995) and Sulkava (2007a).

Estimation of otter abundance

Trained field workers made preliminary estimates of numbers of otters, using the measurements and field observations. All these observations were then compiled in a database managed by the Finnish Environment Institute. Detailed maps of the study areas, containing all positive and negative site results as well as the data from field surveys and the field workers' preliminary estimates aided in the evaluation of numbers of individuals. If the distance between fresh tracks along the same river was over 10–15 km (R. T. Sulkava unpubl. data) and the direction of the tracks differed, most likely there were two individuals. It was possible to identify more than one individual when there were tracks of different sizes (footprint width; male > 65 mm, juveniles < 55 mm, and others 55–65 mm) (Sulkava 2007c), or tracks in two opposite directions to the site, or if there were, for instance, fresh tracks on both sides of a lake but none on the ice of the lake. In case of two or more positive sites along the same river or nearby rivers, the estimation was always one otter if there was no evidence that there had been two or more individuals.

It is also significant to note that all investigations were carried out 2–4 days after snowfall, hence the fresh tracks could not be older than that. Also the aim of the used OVC method is not to find all individuals but the same proportion every time in an area.

The number of otters present in any area can be estimated quite accurately through extensive home-range mapping method (HMM) (Sulkava 1993, Sulkava 2007a), but one-visit census studies (OVC) (e.g., this study) enable accurate estimates of the minimum numbers of otters only. Reliability of the HMM was also tested with the third independent method, the segment method (SM), used by Reid *et al.* (1987). Population estimates with SM and HMM methods were identical (Sulkava 2007a). Comparisons between OVC and the more extensive HMM in central Finland 1989–2002 (area 6, Fig. 1) showed that OVC surveys revealed the presence of about 50% of all otters the extensive HMM surveys had identified (Sulkava 2007a). Otter population sizes in our OVC study areas were estimated based on this assumption.

When estimates of the total number of otters in Finland were made, population densities outside our study areas were evaluated using the results from the Finnish wildlife triangle scheme,

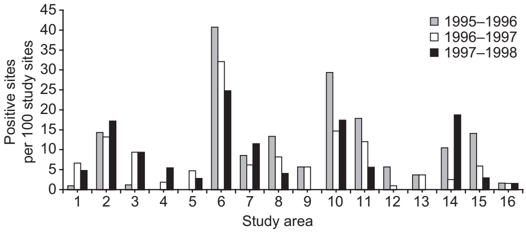

Fig. 2. The annual track index (positive sites per 100 sites) for each study area. Only fresh tracks (2–4 days old) were included.

organized by the Finnish Game and Fisheries Research Institute (Lindén *et al.* 1996, Helle *et al.* 1998), which describes the relative abundance of otters throughout the country. Using this information, the otter densities determined in this study could also be assumed to be representative for larger areas around each study area, i.e., in an area known to have similar relative otter abundance rather than within the area of the study.

Here, we studied 10 000 km^2 (areas 6, 7, 8, 10 and 11 in Fig. 1) inside the area of higher relative abundance of otters (total area 100 000 km^2), and 27 000 km^2 (other eleven areas in Fig. 1) of less densely populated areas (total area 230 000 km^2). Extrapolating estimated numbers of otters in our study areas for the entire area of the same relative otter abundance gave a possibility to estimate the population of otters in the whole of Finland.

ANOVA was used to test the differences in the abundance of otters (or minks) among areas. Three main regions were used in the test; south (study areas 1, 2, 3 and 4 in Fig. 1), central (5, 6, 7, 8, 10 and 11) and north (9, 12, 13, 14, 15 and 16). In the southernmost region, the human influence is the most intensive but it decreases towards the north, whereas, the climatic conditions are very harsh in the northernmost regions in winter and become milder towards the south.

Results

Otter tracks were found in every study area each winter. Fresh tracks were found at 169 sites during the first year (with positive results obtained at 11.5% of all sites), 141 (8.9%) sites in the second year, and 120 (9.9%) sites in the third year (Table 1 and Fig. 2). The differences between the numbers of positive site results from one year to another were not statistically significant (ANOVA: $F = 1.53$, d.f. = 2, $p = 0.24$). The estimated minimum number of otters in the 16 study areas was 121 during the first winter (8.3 individuals per 100 sites), 112 (7.0) the second winter and 101 (8.3) during the third winter (Table 1).

Otters were most abundant in the central region of the country (Fig. 1). There were statistically significant differences between the study areas in central Finland and those in southern Finland or northern Finland, in terms of both the number of positive sites (one-way ANOVA: $F = 9.03$, d.f. = 1, $p = 0.0005$ between central and northern Finland, and $F = 4.14$, d.f. = 1, $p = 0.05$ between central and southern Finland) and the minimum numbers of otters (central *vs.* northern: $F = 8.83$, d.f. = 1, $p = 0.006$, and central *vs.* southern: $F = 5.24$, d.f. = 1, $p = 0.03$). There were no significant differences in the abundance of otters between the south and the north (tracks: $F = 0.91$, d.f. = 1, $p = 0.35$, and individuals: $F = 0.22$, d.f. = 1, $p = 0.64$). Clear differences were evident between areas within these larger regions, however. In area 1 for example, otters were less abundant than in area 2 (one-way ANOVA: fresh tracks $F = 27.83$, d.f. = 1, $p = 0.006$; and individuals $F = 10.43$, d.f. = 1, $p = 0.03$). Otters were most abundant in areas 6 and 10.

The OVC study areas together covered 10.1% (34 281 km^2) of the total area of Finland (338 145 km^2) during the first year of the survey, 10.9% (37 001 km^2) during the second, and 8.6% (29 194 km^2) during the last year. The minimum number of otters in the study areas was 121, 112 and 101, respectively. The mean minimum density of otters in all studied areas was 0.33 individuals per 100 km^2 (0.35 during the first winter, 0.30 during the second and 0.35 during the last winter). The extrapolated minimum number of otters in Finland as a whole in those years was 1116 individuals.

Our OVC study gave the minimum number of otters in the study areas. The Finnish wildlife triangle scheme gives a relative abundance of species covering the whole of Finland (Fig. 3) (Lindén *et al.* 1996, Helle *et al.* 1998). Comparing these results makes it possible to calculate the number of otters in an other way, and to improve the accuracy of our result.

We assumed that the densities in OVC study areas were representative for larger regions around each study area, i.e., in a region, which is known, based on wildlife triangle studies, to have similar relative otter abundance as the one inside our study area. According to the map of relative abundances of otters from the wildlife triangle scheme (Fig. 3), five of our study areas (6, 7, 8, 10 and 11 in Fig. 1, total extent 10 000 km^2) were situated in the region with most abundant otter population of central Finland (total extent approx. 100 000 km^2). Lower numbers were found in more southern and northern regions of the country, where the other 11 study areas (with a total extent of 27 000 km^2) were situated. The total area of these less densely populated regions was about 230 000 km^2.

The minimum number of otters recorded in the more densely populated study areas in central Finland was at least 80 individuals during the winter of 1995–1996, 64 in 1996–1997 and 53 individuals in 1997–1998. The minimum population estimates in the more sparsely populated northern and southern study areas were 41, 48 and 48, respectively. The study areas covered altogether about 10% of the entire densely populated regions in all winters. A total of 10% of the sparsely populated regions was studied during the first year, 11% during the second and 8% during the last year. Extrapolating otter abundances from the OVC study areas to cover the country as a whole provided a minimum estimate for the total population of the entire country of 1210 individuals during the first winter ([80 × 10] + [41 × 10]), 1067 during the second, and 1067 during the last winter. These results are almost exactly the same as those based on OVC study results only.

It should be remembered, however, that only about 50% of all otters were recorded with OVC methods as compared with the extensive HMM or SM studies carried out in central Finland (Sulkava 1993, Sulkava & Liukko 1999, Sulkava 2007a). For this reason, we could estimate that the real number of otters in Finland in 1995–1998 could be about twice the minimum number calculated earlier. This estimates of the population of otters vary between 2134 (1067 × 2) and 2420 (1210 × 2) individuals. The confidence limits of

Table 1. Number of study sites with fresh otter tracks, estimated minimum number of otters and otter index (otters per 100 sites) in the OVC study areas during three winters (1995–1998).

Area	Number of sites with tracks			Estimated number of otters			Otter index (otters per 100 sites)		
	1995–1996	1996–1997	1997–1998	1995–1996	1996–1997	1997–1998	1995–1996	1996–1997	1997–1998
1	1	7	5	1	5	3	1.0	4.7	2.9
2	14	14	11	8	10	10	8.2	9.4	15.6
3	1	10	10	1	8	8	1.2	7.5	7.5
4	0	2	6	0	2	6	0	1.8	5.5
5	–	5	3	–	4	3	–	3.8	2.8
6	44	35	27	26	24	19	24.1	22.0	17.4
7	9	13	12	8	12	11	7.6	13.3	10.6
8	12	8	4	10	7	3	11.1	7.1	3.1
9	6	6	–	6	6	–	5.7	5.7	–
10	32	16	19	23	11	15	21.1	10.1	13.8
11	18	12	5	13	10	5	12.9	10.0	5.6
12	6	1	–	6	1	–	5.7	0.9	–
13	4	4	–	4	4	–	3.7	3.7	–
14	9	2	15	7	2	15	8.1	2.5	18.8
15	12	5	2	7	5	2	8.2	5.9	2.9
16	1	1	1	1	1	1	1.6	1.5	1.6
Total	169	141	120	121	112	101	8.25	7.05	8.33

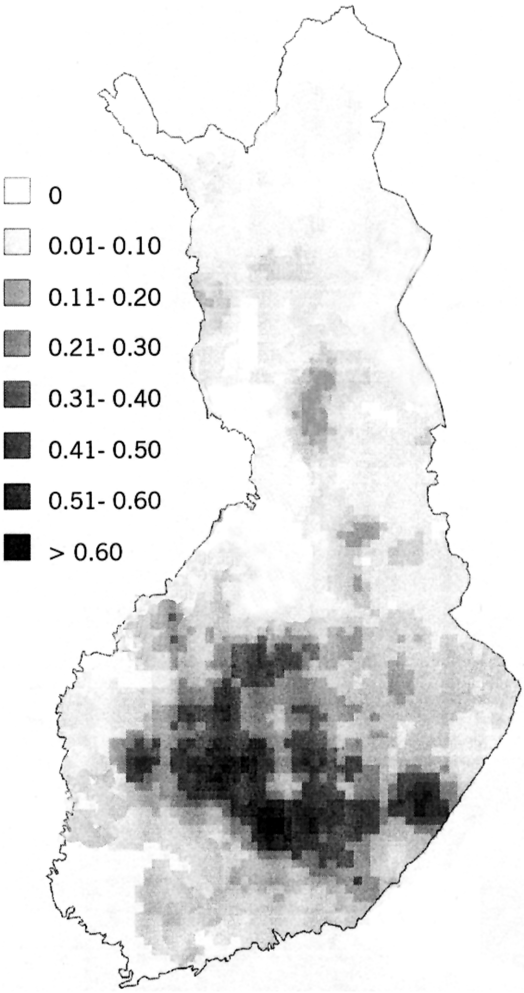

Fig. 3. Index of the relative abundance of otters (tracks crossing the transect line per 10 km and 24 hrs), based on the Finnish wildlife triangle scheme 1989–1996 (Wikman 1996).

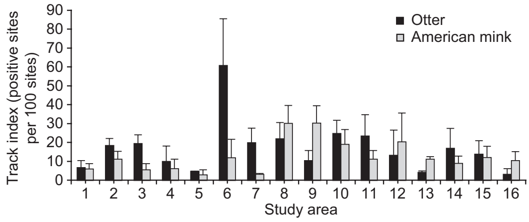

Fig. 4. Track index of the otter and the American mink (positive sites per 100 sites) based on both old (> 4 days old) and fresh (2–4 days old) tracks recorded in study areas during the winters 1995–1998 (mean values of three winters).

all separate OVC trackings carried out in central Finland during in 1989–2003 were about 5% (Sulkava 1993, Sulkava 2007a), so the estimate of the total Finnish otter population in 1995–1998 reaches up to 2000–2550 individuals.

Otter litters were observed in seven study areas covering all regions of the country (areas 2, 3, 6, 9, 10, 11 and 14; Fig. 1). In many areas, only one or two litters were observed each year. In addition to this, in 33 otter groups (53% of all observations) there was an unconfirmed litter.

The average numbers of sites with otters and American minks are shown in Fig. 4. In the eastern parts of Finland (study areas 8, 9, 12), minks were found more commonly than in other parts of the country. The differences were significant between eastern regions and central Finland (one-way ANOVA: $F = 7.71$, d.f. = 1, $p = 0.01$), and between eastern regions and the west coast (study areas 5, 10, 13); $F = 9.04$, d.f. = 1, $p = 0.01$). There was no correlation between yearly abundance of mink and otter in all the study areas (Pearson Correlation in all cases $p > 0.05$).

The effectiveness of the OVC method was good, and feedback from participating organizations and workers was positive. Only the short and often quite snowless winters of most southern coastal areas and the darkness of the northernmost areas in mid-winter shortened the period when fieldwork could be carried out, and for that reason, there were some problems with completing the fieldwork during the best time and weather. It seems that the most essential factor is standardization of the expertise of the field workers. This is possible by training. No major problems occurred regarding fieldwork in various parts of Finland.

Discussion

The results of this study support the assumption that in European terms Finland hosts a viable otter population (Storrank *et al.* 2002). Otters were present in all the areas studied, with populations most abundant in the central part of the country. The archipelago region was not studied, since the snow-tracking method has not been tested along seashores, where it is unlikely to give accurate results. However, in other studies the number of otters observed to remained very low in the coastal areas of southwestern Finland (Helle *et al*. 1998, Stjernberg & Väisänen 1998, Liukko 1999). Otter densities were also low in northernmost Finland (Finnish Lapland), where winter conditions are probably too harsh for otters to thrive, since most areas have little or no open water. Across the border in Russia, the otter is absent from the tundra zone of the Kola Peninsula (Tumanov 2002), which lies just east of the northernmost Finnish study area but at the same latitudes.

The OVC method used in this pilot study was specifically developed for the monitoring of otter populations (Sulkava 2007a). Because of the short monitoring period (only three years), it was not possible to detect any significant ongoing changes in the size and distribution of the otter population. However, the study did produce new information on the present status of the otter population, which can be referred to if such surveys are conducted again in the future. Other results obtained here, such as the track index (number of positive sites per 100 sites) and the otter index (number of otters per 100 sites) can also be used as indices for monitoring purposes.

Although all field workers were carefully trained, there may still be differences between the abilities of individual surveyors to find tracks and to distinguish the individual otters that left them. This is a typical problem in all studies conducted by many researchers. It takes time to learn tracking skills, and the “training” may produce errors if, for instance, researchers become more proficient towards the end of a survey period. However, since the total number of positive site reports in this study actually decreased during the study period (Fig. 2 and Table 1), it can be assumed that the training probably did not affect the results. For field workers, the biggest problem was to arrange their timetable according to the changing weather conditions. When the weather is good, surveyors should go into the field immediately. Timing is an essential element in this kind of OVC snow tracking method. There were problems in this respect in some areas during the second and third winters, when the weather was milder than usual, but it is unlikely that these problems had much impact on the results respective to the minimum numbers of otters (Sulkava & Liukko 1999).

Estimating the sizes of otter populations is always difficult. The methods used were developed and tested in study area 6 in central Finland, where they evidently worked well (Sulkava 2007a, R. T. Sulkava *et al*. unpubl. data). Although the population sizes can be estimated in well-researched study areas, perhaps it is not possible to generalise these results to cover other study areas outside the studied one, and therefore extrapolated estimates of the true numbers of otters may not be exact. Nevertheless, the same methods will most likely work in other study areas under similar conditions. Geographical and climatic conditions were approximately the same in most of our study areas in central and southern Finland. In this study, the abundance of otters seems to be the highest in central Finland. Also in other recent studies, otters were the most abundant in central Finland (Stjernberg & Hagner-Wahlsten 1991, Wikman 1996, Lindén *et al*. 1996, Helle *et al*. 1998). Probably more than 50% of otters in Finland lived in the central region of the country (Fig. 1), where the OVC method works well. For these reasons, we believe the estimate for the total otter population closely reflects the actual numbers.

This study and all regional Finnish otter studies (e.g., Skaren & Kumpulainen 1986, Storrank 1993, Mäkelä & Rajala 1995, Höglund 1996, Helle *et al*. 1998, Ludwig *et al*. 2002, E. Rajala unpubl. data) provide the same kind of picture for regional otter populations as this study does. Also, this supports the assumption that the estimate produced here for the total number of otters in Finland (2000–2550 individuals) is reliable.

It is thought that in Finland otter cubs are always born in summer (Sulkava 2007b), so otter groups observed in late autumn or early winter are usually females with cubs. In central Finland, tracks of females and young otters can be distinguished until the end of December (Sulkava 2007b), but later in the winter this often becomes impossible. In this study, the litters should have been confirmed using the size of the tracks. However, most of the fieldwork was done between January and March, and 33 observations of litters (53%) remained unconfirmed. This uncertainty makes it impossible to assess the vitality of otter populations in most of the areas studied. In order to assess the vitality of the population accurately, all field studies should be conducted earlier in the winter. This was indeed recommended in the instructions included in this study, but it appeared to be impossible to be put into practice in southern Finland, because there was no snow before Christmas in all winters.

The OVC method as described here is not designed for evaluations of the status of mink. However, this study offered a similar picture of mink populations to that of the Finnish wildlife triangle scheme (Kauhala 1996).

The snow tracking methods differ considerably from the standard survey method based on spraints (IUCN 2000). The proportion of positive sites detected using snow tracking should therefore not be compared with results from studies based on spraints. The oldest identified spraints may be many weeks or even months old. Tracks in snow, in contrast, can be defined more exactly according to the date of previous snowfall, and are usually only a few days old.

The methodological problems associated with standard methods and other methods have been widely discussed (e.g., Jenkins & Burrows 1980, Kruuk & Conroy 1987, Mason & Macdonald 1987, Reid *et al*. 1987, Conroy & French 1991, Mason & Macdonald 1991, Romanowski *et al*. 1996, Kranz & Knollseisen 1998, IUCN 2000, Ruiz-Olmo *et al*. 2001). It is known, for example, that there is considerable variation in sprainting activity between seasons and areas, and there may also be variations according to the sex and age of individuals (Kruuk *et al*. 1986, Mason & Macdonald 1986, Conroy & French 1987, Macdonald & Mason 1987, Kruuk 1995, IUCN 2000). In central Finland, there was clear evidence of seasonal variations in sprainting activity, with most activity in the autumn (Sulkava 2006). Many other methodological problems that can affect results obtained through the standard method have also been pointed out, relating to field workers' skills (Sulkava & Storrank 1993, IUCN 2000), bankside vegetation (Romanowski & Brezezinski 1997, Elmeros & Bussenius 2002) and the presence of bridges suitable for sprainting (IUCN 2000). In Finnish climatic conditions, snow tracking studies are much easier to carry out and they provide more information than the standard method (Sulkava & Storrank 1993, Sulkava & Liukko 1999, Sulkava 2006, 2007a).

A certain degree of uncertainty is inevitably connected to all field methods for surveying otter populations. However, the conclusions drawn from this study indicate that the OVC method works well in Finnish climatic conditions, at least on the national scale. The results are also more widely applicable. The OVC method as evaluated in this study can also be a useful tool for monitoring otter populations in other regions during winters with snow and ice.

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