Errors associated with moose-hunter counts of occupied beaver *Castor fiber* lodges in Norway

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In Norway, Sweden and Finland moose *Alces alces* hunting teams are often employed to survey occupied beaver (*Castor fiber* and *C. canadensis*) lodges while hunting. Results may be used to estimate population density or trend, or for issuing harvest permits. Despite the method's increasing popularity, the errors involved have never been identified. In this study we 1) compare hunting-team counts of occupied lodges with total counts, 2) identify the sources of error between counts and 3) evaluate the method's management potential. The study was conducted in Bø Township (266 km^2), Telemark County, Norway during 1995. Hunters reported the number of occupied lodges seen daily while hunting moose (25 September - 31 October). Teams (n = 12) under-counted occupied lodges in the township by 62% because 1) the probability of observing an occupied lodge within areas actually hunted on was 0.77, 2) 37% of the moose-hunting units were not hunted on and 3) 21% of the occupied lodges occurred in cultivated landscapes outside of moose-hunting units. Hunters had difficulty distinguishing between occupied and unoccupied lodges. Measures of precision and bias should be determined before using the method for practical management. Moose-hunting team surveys may be better suited for obtaining indexes of population change than estimates of occupied lodge number.

Key words: beaver, Castor canadensis, Castor fiber, Norway, population survey.

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INTRODUCTION

The high costs of assessing game population size has led to the development of survey methods based on information gathered by voluntary observers such as hunters (Lancia et al. 1994). In the Nordic countries of Norway, Sweden and Finland thousands of hunters annually cover large areas while hunting moose *Alces alces* Linneaus, 1758 and other game. For many years observations conducted by organized teams of moose hunters here have been used to monitor moose populations (Hagenrud et al. 1987, Jaren 1992, Nygren Pesonen 1993). Not surprising, there has been an increasing interest in employing moose hunters to simultaneously gather population information on other species as well, including Eurasian *Castor fiber* Linneaus, 1758 and North American *C. canadensis* Kuhl, 1820 beaver.

In Norway, Sweden and Finland beaver populations are expanding and beaver are presently being hunted and trapped in all three countries (Rosell & Parker 1995, Nolet & Rosell 1998). This has created a need for methods of monitoring population density and change for both research and management purposes. Though individual beaver are difficult to count, sign of their presence in the form of e.g. dams, felled trees, food caches and lodges is highly visible. Consequently, a count of occupied territories, usually referred to as occupied lodges or active colonies, is the chief parameter in most beaver surveys (Novak 1987). Counts are commonly conducted during autumn when preparation for winter creates a multitude of fresh sign (Novak 1987) though spring counts have also been employed (Lavsund 1979a, b).

Moose hunters have been engaged in various ways to survey occupied lodges. In southeast Finland the density of both individual beaver and occupied lodges has been estimated annually for many years based on information from questionnaires sent to local hunting clubs (Härkönen 1999). The questionnaires are answered by hunting club leaders based on their own observations, and the observations of club members, while hunting moose, small game and beaver, or while engaged in other activities throughout the year (S. Härkönen, pers. comm.). Similarly, in Sweden the density of active beaver colonies (Hartman 1994) or occupied lodges (Lavsund 1979a, b) has been estimated based on questionnaire surveys sent to moose-hunting unit leaders and forest owners. As in Finland, the information provided is based on observations made while hunting both moose and small game, and while engaged in other outdoor activity as well. In Norway, Punsvik (1987) sent questionnaires to moose-hunting team leaders asking them to estimate the number of occupied lodges on their respective hunting units, after consultation with team members and landowners. Counts of occupied lodges can be employed either as an index of beaver density or multiplied by an estimate of mean colony size to obtain a population estimate.

Two basic problems must be confronted when estimating population size; observability and sampling (Lancia et al. 1994). Most methods of surveying do not result in counts of all individuals present on the area in question. Instead, the probability of observing all individuals will usually be less than one. When counting occupied beaver lodges an additional problem must be dealt with. It is essential to be able to distinguish between those lodges that are presently in use and those no longer occupied, as beaver territories, and the lodges on them, may be alternately occupied and abandoned. For well-established populations, usually 25-75% of the visible lodges or previously used sites will be occupied at any one time (Dennington & Johnson 1974, Slough & Sadleir 1977, Slough & Jessup 1984, Parker et al. 2001). This creates a large potential for error, particularly in classifying unoccupied lodges as occupied, which would result in over-counts. For this reason, hunters are normally asked to record only occupied lodges seen (Lavsund 1979a, b, Punsvik 1987, S. Härkönen, pers. comm.) and instructed on how to discriminate them from unoccupied. Thus the observability of occupied beaver lodges will be affected by two types of error; not observing all occupied lodges present (negative error) and wrongly classifying unoccupied lodges as occupied (positive error).

Studies have presented lodge number or density apparently without correction for bias (Lavsund, 1979a,b, Punsvik 1987, Hartman 1994, Härkönen 1999), even though bias was suspected (Punsvik 1987, Härkönen 1999, Härkönen pers. comm.). By bias is meant the difference between the expected value of a population estimate and the true population size (Lancia et al. 1994). Lavsund (1979a, b) however, measured the error between densities obtained from questionnaire surveys and densities derived from direct ground counts of occupied lodges on 7 sample sections of a larger study area. He subjectively concluded that error was negligible and that the questionnaire survey method he employed appeared to be a reliable measure of occupied lodge density. However, Lavsund's (1979a, b) samples were not selected randomly, and therefore do not provide a reliable basis for statistical tests of error. Consequently, neither the bias nor the precision (the variance of a population estimate repeated many times (Lancia et al. 1994)) associated with questionnaire survey counts of occupied lodges appears to have been adequately tested.

In Norway, new beaver management laws were introduced in 1997 requiring that township harvest quotas be based on some estimate of beaver population size, though the method to be used and the precision required were not specified. As moose hunting occurs on most forested areas in Norway, the use of moose hunting teams to count occupied beaver lodges has been suggested by regional wildlife managers as a potential method for obtaining necessary beaver population estimates at the township level (T. Punsvik & J. Aas, pers. comm.). The goal of this study was 1) to compare moose-hunter team counts of occupied lodges with total counts obtained using standard ground survey methods within a single township, 2) to identify the sources of error between the two methods and 3) to evaluate the potential of this moose-hunter census method as a future beaver management tool.

METHODS

Study area

The study was conducted in Bø Township (59°29'N, 09°13'E; 266 km^2) in Telemark County, southeast Norway during autumn 1995. The mountainous terrain is 77% forested, 9% cultivated, 9% above tree line, 3% urban areas and 2% water. It is interspersed with many small to medium-sized streams and small lakes typical of Norwegian beaver habitat. Following local extirpation, beaver first became reestablished in the township about 70 years ago (Olstad 1937) and have since reoccupied most suitable habitats there (H. Parker & F. Rosell, unpubl.).

The total census

During autumn, beaver at temperate and northern latitudes usually prepare for winter by building or repairing lodges and dams, and caching food under water near the lodge (Wilsson 1961, Novak 1987). The presence of a winter cache is considered the best single confirmation of an active colony (Bergerud & Miller 1977) and one cache per colony is usual (Hay 1958, Wilsson 1961, Swenson & Knapp 1980). An autumn census of active colonies is usually conducted during or shortly following the

period of cache construction between leaf-fall and freeze-up (Hay 1958, Dezhkin & Safonov 1966).

Between 16 October and 5 December 1995, all lakes and streams indicated on a standard 1/50,000 map (M711 series) of Bø Township were surveyed on foot or by canoe. All lodges with caches either finished or under construction were defined as occupied. Likewise, newly built or repaired lodges at sites with considerable tree felling and/or dam-building activity, but where caches were not found were also defined as occupied, as winter caches are not always present or visible at active sites (Scharlemann 1953, Semyonoff 1957, Hill 1982). Lodges within 200m distance of each other showing sign of use or repair were considered to belong to the same colony, as beaver families may repair and use more than one lodge within the territory during autumn and winter (Hay 1958, Valeur 1965, Lavsund 1979, Geiersberger 1986).

Mapping the temporal progression of cache construction

In order to map the temporal progression of cache construction and other sign of autumn activity, a random selection of 19 previously occupied colonies in the township (Johnsen & Kaasa 1991) was monitored between 18 September and 8 November. Each site was visited weekly and a record kept of the date on which cache building, lodge building or repairs, extensive tree felling and increased use of drag trails was first observed. Sign of each of these activities is observable by hunters, and often at considerable distances.

The hunter census

Moose hunting in Norway, Sweden and Finland is traditionally conducted by teams of hunters, with each team hunting exclusively on a pre-designated area or moose-hunting unit. Moose hunting units encompass mainly forested and bog landscapes primarily below tree line, often excluding cultivated land. Most moose hunters reside locally and many own the land they hunt on. Consequently, most are well acquainted with the area they hunt.

At an information meeting 4 days prior to the start of the moose hunt, all hunting teams in the township were informed of project objectives and instructed on how to differentiate between occupied and unoccupied lodges using fresh sign of dam and lodge building, recently felled trees, heavily used drag trails and winter cache construction. Team members normally congregate at the end of each days hunt to report to the team leader on moose observed that day as part of a national moose survey. At this time, leaders were also asked to record on a form, and on a map of the hunting unit (1/50,000), the number and location of occupied lodges seen by team members that day, along with the type of fresh sign observed. Mapping reduced the possibility of double counting near hunting unit borders. The cumulative proportion of each hunting unit actually hunted on by team members was also marked off on the map after each days hunt. All hunters were instructed to hunt in a normal fashion, i.e. to only passively observe beaver lodges while hunting and not to actively search for them. Most moose hunting was conducted as drives whereby hunters systematically move through an area while attempting to push moose past posted team members. Consequently, most of the areas actually hunted on were well covered.

Landscape classification

The township was divided into four landscape classes: 1) *Forest* - comprising primarily forested land dominated by spruce *Picea abies* and pine *Pinus sylvestris* with lesser amounts of birch *Betula spp.*, aspen *Populus tremula*, willow *Salix spp.*, and alder *Alnus incana*; 2) *Cultivated* - crop land planted primarily with grass, cereal grains or vegetables, but interspersed with streams and lakes often with forested borders (primarily willow, birch and alder); 3) *Urban* – urbanized areas dominated by buildings but interspersed with forest-bordered waterways and 4) *Alpine* - above tree line.

Statistics

All mean values are shown with standard deviations (SD).

RESULTS

The total census

The total census of the township revealed 155 lodges of which 62 (40%) were occupied. Forty-three (69%) of these were found on moose-hunting units and 19 (31%) outside (Table 1). Four (21%) of these 19 were located in forest, 13 (68%) in cultivated landscapes and 2 (11%) in urban areas. Colony density was similar within and outside the moose-hunting units. Forty-nine percent of the 62 active colonies were located on streams (≤ 5 m wide), 10% on rivers (> 5 m wide), 38% on lakes or tarns and 3% on ditches or springs.

The hunter census

Twelve of the 13 hunting teams in the township agreed to participate in the study. The corresponding 12 moose-hunting units encompassed 171.4 km^2 or 68.3% of the 250.8 km^2 area below tree line within the township (Table 1). The hunting unit belonging to the one team that did not participate covered 8.8 km^2 and contained one active beaver colony. Hunting teams averaged 10.8 ± 5.0 participants and each team hunted an average of 8.8 ±

3.6 days during the season (Table 2). Only 2 of the 12 teams reported that their entire hunting unit area had been covered during the hunt. The 12 hunting teams actually hunted on 108.7 km^2 (63.4%) of the total 171.4 km^2 comprising the total hunting unit area. Six of the 12 hunting teams under-counted, 2 over-counted and 4 counted correctly (Table 3).

Hunters found 15 occupied lodges on the area they actually hunted on while the total census here showed 30, i.e. an initial observation probability of 0.50. However, an additional 8 unoccupied lodges here were erroneously classified as occupied. Hunters therefore reported finding 23 (77%) of the 30 occupied lodges within the area actually hunted on (Table 4). The total census located 42 occupied lodges on the 12 moose-hunting units and 61 within the entire township. Thus hunting team counts resulted in considerable negative error at all 3 spatial levels (Table 4).

Table 1. The distribution of occupied beaver lodges located within and outside of moose hunting units in Bø Township, Telemark County, Norway, autumn 1995, based on a total ground census of all lakes and streams within the township.

	Landscape class	Number of occupied lodges	Area (km^2)	Colony density
Within moose-hunting units	Forest	43	180.2	0.24
Outside moose-hunting units	Forest	4	36.6	0.11
	Cultivated	13	26.0	0.50
	Urban	2	8.0	0.25
	Tota	19	70.6	-
	Mean			0.27[a]
Total		62	250.8	-
Mean				0.25

[a] 19/70.6 = 0.27

Table 2. The number of hunters participating in the hunt, the number of days hunted by each moose-hunting team, the total area of each moose hunting unit and the area of each unit actually hunted on in Bø Township, Norway, autumn 1995. Means are shown with standard deviations.

Moose-hunting team	Number of: hunters	days hunted	Area (km^2) of hunting unit	Area and proportion of the unit actually hunted on	
1	5	15	15.1	9.5	(59.7%)
2	7	9	9.9	6.3	(63.5%)
3	4	4	7.9	7.2	(90.7%)
4	8	9	18.1	18.1	(100%)
5	12	15	18.3	8.0	(43.8%)
6	18	4	24.0	8.4	(35.0%)
7	8	5	10.1	7.8	(77.2%)
8	12	7	17.8	7.1	(39.9%)
9	16	8	9.7	4.5	(46.5%)
10	9	10	15.0	9.8	(65.3%)
11	20	10	16.2	12.7	(78.5%)
12	11	10	9.4	9.4	(100%)
Sum	130	106	171.4[a]	108.7[a]	
Mean ±SD	10.8 ± 5.0	8.8 ± 3.6	14.3 ± 4.9	9.1 ± 3.5	(63.4%± 22.9)

[a] Sums shown differ slightly from actual column sums due to rounding off errors.

Table 3. The number of occupied beaver lodges found during a total ground census and the number reported found by 12 teams of moose hunters on 108.7 km^2 actually hunted on in Bø Township, Norway, autumn 1995.

Moose-hunting team	Number of occupied lodges: found during total census	reported found by moose hunters	Error**
1	3	2	-1
2	4	3	-1
3*	0	1	+1
4	5	0	-5
5	4	1	-3
6*	0	0	0
7	2	0	-2
8	5	10	+5
9	3	2	-1
10	3	3	0
11	1	1	0
12*	0	0	0
Sum	30	23	-7
Mean ± SD			1.6 ± 1.8

* Though no occupied lodges were present, teams could erroneously classify unoccupied lodges as occupied.
** Error can be positive when unoccupied lodges erroneously are classified as occupied.

Estimation by extrapolation

Hunters actually hunted on 108.7 km^2 (45%) of the 242.0 km^2 of beaver habitat encompassing the 12 moose-hunting units and reported finding 23 occupied lodges. As the density of occupied lodges was similar within hunting units and on beaver habitat outside hunting units (Table 1) we extrapolated this figure to obtain an estimate for the entire township of 51 occupied lodges, or 82% of the actual number present.

Sign of beaver activity observed by moose hunters

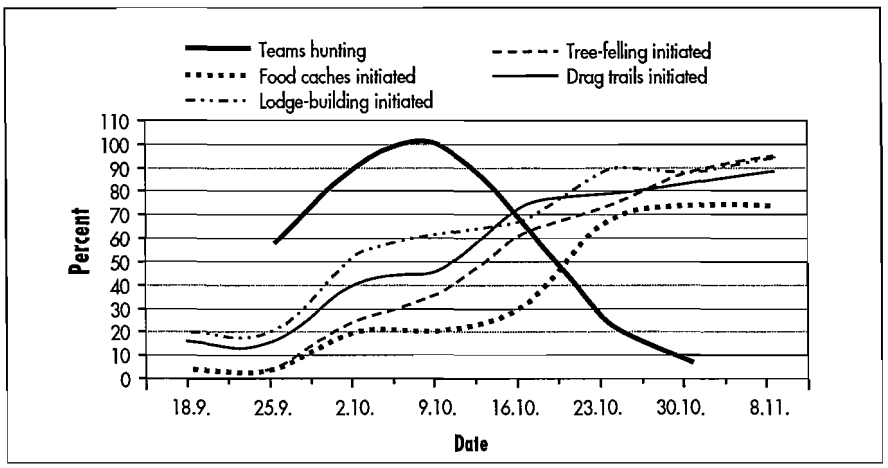
At the 23 sites hunters reported as occupied, recent tree-felling was observed at 22 (96%), fresh use of drag trails at 17 (74%), lodge-building or repairs at 4 (17%) and cache-building, which is normally considered to be the best sign of an active colony, at only one (4%). The township had a split hunting season start. Seven of the teams could begin on 25 September and 5 on 5 October. Figure 1 shows the distribution of the combined hunting team effort throughout the hunting season (25 September - 30 October), together with the development of different forms of beaver winter preparation behavior at 19 randomly chosen occupied colonies within the township. The bulk of the hunting effort

Table 4. A comparison of the number of occupied beaver lodges reported found by hunters while hunting moose and during a total census in Bø Township, Norway, autumn 1995.

	Number of occupied lodges found on: area actually hunted on by moose hunters (108.7 km^2)	total moose-hunting area (171.4 km^2)	total township below tree line (242.0 km^2)
During total census	30	42	61[a]
Reported found by moose hunters	23	23	23
Difference (% error)	-7 (-23%)	-19 (-45%)	-38 (-62%)

[a] The total census of the township actually revealed 62 occupied colonies (Table 1). However, 1 of these was on the moose-hunting unit that did not participate in the study.

Figure 1
The proportion of moose-hunting teams hunting in Bø Township, Telemark County, Norway and the temporal development of 4 forms of beaver winter preparation behaviour at 19 randomly chosen colonies within the township. Seven of the hunting teams could begin hunting on 25 September and 5 on 5 October.



peaked at 7 October. At this time fewer than half of the colonies were showing sign of winter preparation activity, with the exception of lodge building. Most teams had finished hunting when winter preparation activity peaked. In particular, cache building was the latest form of behavior to develop.

DISCUSSION

Moose hunters observed only 50% of the occupied lodges within the areas actually hunted on. The habitat beaver occupy and the type of lodge built may affect the probability of an occupied lodge being observed. Gustavsen (1996) indicated that e.g. island-type stick and mud lodges (Novak 1987) located on impoundments were more likely to be observed by hunters than bank dens tunneled on streams. Many occupied lodges, however, seem to have been missed because the peak in the hunting effort occurred before many colonies had become actively engaged in winter preparation. Had the main hunting effort occurred in late October or early November, most colonies would have been actively engaged in winter preparations. Additionally, with the autumn leaf-fall nearly over, visibility would have been better then.

Negative observability was partly offset by 8 unoccupied lodges being wrongly classified as occupied. Some lodges seen by hunters in early October may, in fact, have been active then but not a month or two later during the total census as beaver families may build, use or repair several lodges during early autumn before finally selecting one for winter use (Hay 1958, Valeur 1965, Lavsund 1979a, Geiersberger 1986). Hunters reported recent tree-felling as the most common sign of activity at lodges classified as occupied. Though felled trees, particularly birch, are readily observable at a distance, it is difficult to determine if felling occurred recently, or a year or two previous, without closer inspection. Many unoccupied lodges are probably erroneously classified as occupied because hunters pass by at long distances and are unable to correctly evaluate the sign available.

In addition to observational errors, hunters reported hunting on only 63.4% of the total moose-hunting unit area. The unhunted proportion varied considerably between individual hunting units and is likely to vary considerably both at the township area scale and between years. Relatively unpredictable factors such as variability in moose density and weather conditions are also likely to influence the size of the area hunted on.

The large error (- 62%) for the entire township, in addition to the above-mentioned factors, resulted from the considerable number of occupied lodges found during the total census outside moose-hunting units, particularly in cultivated landscapes. Cultivated landscapes are important from a management standpoint, as both damage from beaver and interest for beaver hunting are often considerable there (H. Parker & F. Rosell, pers. obs.). As the basic management unit for beaver in Norway is the township, survey methods employed must produce acceptable levels of error on this spatial scale.

The results from this study involved a single township during one year. Therefore we cannot make inferences about the bias or precision expected in moose-hunter counts of occupied lodges between townships, or within townships between years. Our results, however, suggest that bias in most townships will most likely be negative due to the low observability of occupied lodges on areas actually hunted on, and because a considerable proportion of the beaver habitat within townships will never be covered by moose hunters.

If acceptable estimates of occupied lodge density could be obtained on the areas actually covered by hunters, extrapolations could be made both for the total area of moose hunting units and the remaining beaver habitat within townships. This would be a feasible solution if occupied lodge density were similar within and outside moose hunting units, as was the case in this study. Though expensive, managers could measure the error between hunter counts and ground counts within their respective townships over a number of years to obtain a measure of both the precision and bias involved. Adjustments for any bias could then be made and confidence intervals established. Extrapolation may provide the most precise and least biased estimates, providing accurate information on the area actually hunted on by teams, in fact, is obtainable.

In southeast Finland, local hunting club leaders report annually in a post hunt questionnaire on the number of individual North American beaver and number of occupied lodges they believe to be present on their hunting units (Härkönen 1999, Härkönen, pers. comm.). Based on data taken from Härkönen's (1999) Figure 2, mean colony size was 2.5 ± 0.27 during a 15-year period on 14,756 km^2. From this same study (Figure 3), we calculated mean colony density to be 0.10 colonies per km^2 in 1997 in the most densely populated sections comprising 6000 km^2. In a review of 51 studies of North American beaver in Europe and North America, Rosell & Parker (1995) found a mean colony size of 5.2 ± 1.4 (range 2.4 – 5.5) while colony density for established populations in North America ranges between 0.15- 4.6 colonies per km^2 (Novak1987). Though the population on Härkönen's (1999) study area is both hunted and still increasing, his figures for both colony size and density are considerably lower than might be expected for a 60-year-old population of North American beaver in what has been described as very good beaver habitat (Härkönen 1999). This suggests a possible negative bias in his survey method.

In order to map population expansion and density, Lavsund (1979a, b) sent an autumn questionnaire to 490 moose-hunting team leaders and large forest owners in Jämtland and Värmland Counties, Sweden, requesting information on the number of

occupied beaver colonies they believed to be present on the forest areas they owned or hunted on. He received answers from 340 and compared the results from the questionnaire survey against ground counts of occupied colonies on 7 sample areas comprising 12.4% of a 16,796 km^2 study area. His subjective conclusion was that the questionnaire survey appeared to be a reliable method for determining the number of occupied colonies at this spatial scale. Though Lavsund's results are difficult to evaluate due to e.g. non-random sampling, they do suggest small bias between survey questionnaires and ground counts. The strength of his study lies in a large number of estimates, covering thousands of km^2, of a parameter (occupied lodges) whose observability can be either positive or negative, which will tend to nullify bias. In addition, hunting team leaders base their estimate of occupied lodge number not only on what is observed during moose hunting, but also on additional information gained while hunting small game and while engaged in various other activities on hunting units throughout the year (G. Hartman, pers. comm.). This differs considerably from the method we employed. In our study, hunters were first instructed on how to differentiate between occupied and unoccupied lodges and then asked to report daily on occupied lodges seen only while hunting moose. We used this method in an attempt to maximize hunter observation accuracy. Whereas our method will predictably produce a strong negative bias, there is evidence that Lavsund's may not. His method is also less time consuming for hunters to conduct than ours. On large townships covering hundreds of km^2, and with many hunting teams participating, Lavsund's method may result in acceptably accurate estimates of the number of occupied lodges present, and therefore warrants further testing. Mean township area in Norway is 744 ± 894 km^2 (range 6-9704 km^2) suggesting that Lavsund's method may function well, at least for the larger townships encompassing many moose-hunting teams.

It seems likely that some degree of positive correlation will exist between true occupied lodge density and hunting team counts. The question is rather what levels of bias and precision are involved and how these are affected by e.g. spatial scale, lodge density and changing proportion of lodge occupancy. The proportion of occupied lodges will probably be greater in expanding than stable or declining populations. It is also questionable whether participants in annual questionnaire surveys are capable of reporting on the present years lodge number independent of experience and results from the previous year. Thus far, none of the different methods employing moose-hunting teams to survey occupied beaver lodges has been properly tested for bias and precision.

Moose-hunting team observations may be more useful as an index for recording trends in beaver population density than in estimating the number of occupied lodges. For instance, hunting team leaders could be asked to simply evaluate populations as either increasing, stable or decreasing. This form of evaluation would be less affected by the proportion of hunting units covered each year, and if conducted on a large enough spatial scale, e.g. townships or larger, should provide an index of population change sufficient for the adjustment of beaver quotas under most circumstances. A test of the method's accuracy would be desirable before implementation at the national level.

As the popularity of beaver hunting increases and beaver are hunted over increasingly larger areas, beaver hunters themselves may be a more motivated and reliable source of information on beaver population trends than moose-hunting teams. In Bø Township in 1995, only 5 (5%) of the 106 moose hunters also trapped or hunted beaver, suggesting a low level of motivation among the participants in our study. Dividing townships into beaver management units as suggested by Parker (2000) should provide both the motivation and the organizational basis for conducting acceptable beaver surveys.

Management implications

Survey methods employing moose hunters to count occupied beaver lodges should be used with caution, if not previously tested for bias and precision. Our results suggest that negative bias can be expected. As obtaining a sufficient measure of these errors may be prohibitively expensive, we would strongly urge managers to consider whether estimates of occupied lodge number are indeed essential for managing their populations. Harvest quotas could be adjusted based on indexes of beaver population change. In Norway, this information could be collected annually by hunting team leaders simultaneously with information on moose populations (Hågenrud et al. 1987, Jaren 1992). Leaders could record whether the beaver population on their hunting units appeared to be stable, increasing, decreasing or absent. As moose hunting units cover most beaver habitat in the majority of townships, trends should provide a representative index of population change on this spatial scale. As beaver hunting becomes more popular and better organized, beaver hunters themselves could assume the task of data collection.

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SAMMENDRAG

Feilkilder forbundet med elgjegertellinger av bebodde bever *Castor fiber* hytter i Norge

I Norge, Sverige og Finland blir elgjaktlag ofte brukt til å taksere bebodde beverhytter (*Castor fiber* og *C. canadensis*) under jakten. Resultatene blir brukt for å estimere bestandstetthet og -trender, eller som grunnlag for tildeling av jaktkvoter. Tross metodens økende popularitet har feilene forbundet med den aldri blitt identifisert. I dette studiet har vi 1) sammenlignet elgjaktlagenes tellinger av bebodde hytter med totaltellinger, 2) identifisert feilkildene mellom metodene og 3) evaluert metoden som fremtidig beverforvaltningsverktøy. Studiet ble utført i Bø kommune (266 km^2), Telemark fylke, høsten 1995. Elgjegerne ble opplært i å skille bebodde fra ubebodde hytter og rapporterte daglig antall bebodde hytter sett mens de jaktet (25 september-31 oktober). En total telling av hele kommunen ble utført mellom 16 oktober og 5 desember og resultatene sammenlignet med jaktlagenes tellinger. Lagene (n = 12) undertelte bebodde hytter med henholdsvis 23%, 47% og 62% på 1) det aktuelle området som ble dekket av jegerne innenfor jaktvaldene, 2) det totale jaktvaldarealet og 3) hele kommunen. Undertellingen skjedde hovedsakslig fordi 1) sannsynligheten for å observere en bebodd hytte var i utgangspunkt bare 0.50, men økt til 0.77 siden noen ubebodde hytter ble feil klassifisert som bebodd, 2) 37% av det totale jaktvaldarealet ble ikke jaktet på og 3) 21% av de bebodde hyttene var lokalisert i dyrket landskap som ikke inngikk i elgjaktvaldene. Det meste av beverens vinterforberedelser (f. eks. trefelling, hytte- og dambygging, samling av vinterforråd) skjedde etter elgjakta, noe som gjorde det vanskelig for jegerne å skille mellom bebodde og ubebodde hytter. Målinger av metodens presisjon og avvik fra virkelig bestandsstørrelse på et arealnivå tilsvarende norske kommuner er nødvendig før metoden brukes i praktisk forvaltning. Opplysninger fra elgjegere er trolig bedre egnet til beregning av indekser av bestandsendringer (f. eks. økende, minkende, stabil) enn til estimering av antall bebodde hytter.

REFERENCES

Bergerud, A.T. & Miller, D.R. 1977. Population dynamics of Newfoundland beaver. - Canadian Journal of Zoology 55: 1480-1492.

Dennington, M. & Johnson, B. 1974. Studies of beaver habitat in the Mackenzie Valley and Northern Yukon. - Report 74-39: 1-172, Canadian Wildlife Service, Department of the Environment, Ottawa, Ontario, Canada.

Dezhkin, V.V. & Safonov, V.G. 1966. Biology and economical usefulness of beaver. - Economika Publishing House, Moscow, USSR: 1-92.

Geiersberger, I. 1986. Der Lebensraumdes Biebers (Castor fiber L.) in Bayern. - Säugetierkundliche Mitteilungen 33: 125-170. (In German)

Gustavsen, P.Ø. 1996. Effektiviteten av elgjaktlag for taksering av beverbestanden i Bø kommune, høsten 1995. - Hovedoppgave, Høgskolen i Telemark, Bø i Telemark, Norge. (In Norwegian)

Hågenrud, H., Morow, K., Nygren, K. & Stålfelt, F. 1987. Management of moose in Nordic countries. – Swedish Wildlife Research Supplement 1: 635-642.

Hartman, G. 1994. Long-term population development of a reintroduced beaver (*Castor fiber*) population in Sweden. - Conservation Biology 8: 713-717.

Härkönen, S. 1999. Management of the North American beaver (Castor canadensis) on the South-Savo Game Management District, Finland (1983-1997). - Pp. 7-14 in Busher, P.E. & Dzieciolowski, R.M. (eds.); Beaver Protection, Management and Utilization in Europe and North America. Kluwer Academic, Plenum Publishers, New York.

Hay, K.G. 1958. Beaver census methods in the Rocky Mountain region. - Journal of Wildlife Management 22: 395-401.

Hill, E.P. 1982. Beaver (Castor canadensis). - Pp. 256-281 in Chapman, J.A. & Feldhamer, G.A. (eds.). Wild Mammals of North America – Biology, Management and Economics. John Hopkins University Press, Baltimore and London.

Jaren, V. 1992. Monitoring Norwegian moose populations for management purposes. – Alces Supplement 1: 105-111.

Johnsen, J. & Kaasa, H.K. 1991. Beverundersøkelse i Bø kommune 1990-1991. - Hovedoppgave, Telemark Distriktshøgskole, Bø i Telemark, Norge. (In Norwegian)

Lancia, A., Nichols, J.D. & Pollock, K.H. 1994. Estimating the number of animals in wildlife populations. – Pp. 215-253 in Bookhout, T.A. (ed.). Research and management techniques for wildlife and habitats. The Wildlife Society, Bethesda, MD, USA.

Lavsund, S. 1979a. Bäverinventering i Jämtlands län 1976-77. - Swedish University of Agricultural Science, Department of Wildlife Ecology: 1-11. (In Swedish)

Lavsund, S. 1979b. Bäverinventering i Värmlands län 1976-77. - Swedish University of Agricultural Science, Department of Wildlife Ecology: 1-10. (In Swedish)

Nolet, B. & Rosell, F. 1998. Comeback of the beaver (Castor fiber): An overview of new and old conservation problems. - Biological Conservation 83: 165-173.

Novak, M. 1987. Beaver. - Pp. 283-312 in Novak, M., Baker, J.A., Obbard, M.E., & Malloch, B. (eds.). Wild Furbearer Management and Conservation in North America. Ontario Ministry of Natural Resources, Ontario, Canada.

Nygren, T. & Pesonen, M. 1993. The moose population (Alces alces L.) and methods of moose management in Finland, 1975-1989. - Finnish Game Research 48: 46-53.

Olstad, O. 1937. Beverens (Castor fiber) utbredelse i Norge. - Statens viltundersøkelser, Meddelelse nr. 8. Særtrykk av nytt magasin for naturvidenskapene 77: 217-273. (In Norwegian)

Parker, H. 2000. Forvaltningsplan for bever, Bø Kommune, Telemark, 2000. – Høgskolen i Telemark, Bø i Telemark, Norway: 1-9. (In Norwegian)

Parker, H., Haugen, A., Kristensen, Ø., Myrum, E., Kolsing, R. & Rosell, F. 2001. The value of beaver for a large forest owner in southeast Norway. – Pp. 77-95 in Busher, P. & Gorshkov, Y. (eds.). Proceedings of the First Euro-American Beaver Congress, August 24-28, 1998. Volzhsko-Kamskii Zapovednik, Tatarstan, Russia. (In English with Russian summary)

Punsvik, T. 1987. Metoder benyttet for å anslå bestandstetthet hos bever i Vest-Agder. – Pp. 20-22 in Nordisk beverseminar, Fylkesmannen i Vest-Agder, miljøvernavdelingen, Rapport nr.1-87. (In Norwegian)

Rosell, F. and Parker, H. 1995. Forvaltning av bever: dagens tilstand og fremtidig behov. (Beaver management: present practice and Norway's future needs.) -Høgskolen i Telemark, Bø i Telemark, Norway. (In Norwegian with English summary)

Scharlemann, E. 1953. Materialien zur Kenntnis und zur Erhaltung des Ukrain Bibers. - Z.F. Säugetierk 18: 146-162. (In German)

Semyonoff, B.T. 1957. Beaver biology in winter in Archangel province. - Russian Game Reports 1: 71-92.

Slough, B.G. & Jessup, R. H. 1984. Furbearer inventory, habitat assessment, and trapper utilization of the Yukon River Basin. - Yukon River Basin Study Project Report, Wildlife No. 1: 1-87, Yukon Department of Renewable Resources, Whitehorse, Yukon, Canada.

Slough, B.G. & Sadleir, R.M.F.S. 1977. A land capability classification system for beaver (Castor canadensis Kuhl). - Canadian Journal of Zoology 55: 1324-1335.

Swenson, J.E. & Knapp, S.J. 1980. Composition of beaver caches on the Tongue River in Montana. - The Prairie Naturalist 12: 33-36.

Valeur, P. 1965. Fra sørlandets fauna. Bever (Castor fiber L.). - Kristiansand Museums Årbok 1965: 4-14. (In Norwegian)

Wilsson L. 1961. Om bäverinventering. - Svensk Jakt 99(4): 164-167. (In Swedish)