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**Beaver Management in Norway - A Review
of Recent Literature and Current
Problems**

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Preface

In 2011 we were informed by Johan Danielsen of the Norwegian Directorate for Nature Management that new by-laws governing the management of beaver in Norway were soon to be developed. In that connection there was need for a review of the recent scientific literature including beaver harvest data and previously unpublished research results of relevance for this modernization process.

In this report we review these sources, as well as the historical development of beaver management in Norway, since many of today's management practices are better understood in light of their historical origin. We have also taken the liberty to include a section that summarizes our own analysis of current problems involved in beaver management. Finally, we make recommendations for the improvement of present management practices based on twenty years of experience conducting research on beaver ecology and management and working with landowners, beaver managers, hunters and trappers.

We have chosen to write this report in English in order to make it available to an increasing number of wildlife managers in Europe and Asia presently in the initial stages of developing modern management plans for beaver in their respective countries. Because Norway is one of the few countries in Eurasia where the beaver was never extirpated, its experience managing them encompasses almost 170 years, a know-how we feel should be made available to others. The report also includes an extended summary in Norwegian.

Bø, 19 June, 2012

Howard Parker

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Extended summary

Beginning with the total protection of the beaver (*Castor fiber*) in Norway in 1845, beaver management has undergone numerous changes as population development, resource exploitation goals and management objectives have evolved. Presently, new beaver management by-laws are being developed. This report briefly summarizes the historical development of beaver management in Norway, reviews the recent literature of particular relevance for the development new by-laws and makes recommendations for the future improvement of beaver management.

The main goals of beaver management are to maintain populations throughout their natural range at densities sufficient to enhance biodiversity, produce a harvestable surplus and reduce beaver-human conflicts. In addition, beaver management should optimize recreational opportunities for the public and economic opportunities for landowners, e.g. through the lease of beaver hunting. These often opposing objectives sometimes lead to conflict.

The beaver has been an important source of fur, food, and castoreum (as medicine) for the inhabitants of Fennoscandia (Norway, Sweden and Finland) and northwest Russia for millennia. While beaver were completely extirpated from Sweden, Finland and northwest Russia in the late 19th century, a remnant population of 100-200 beaver survived in southeast Norway. Following alternating periods of protection and exploitation the population grew slowly. In 1932 the effective leg-hold trap was forbidden in Norway. Live-trapping and hunting with firearms in autumn were still allowed but proved ineffective for controlling populations. With damage complaints increasing, in 1981 the open season was extended to early May. Spring hunting, i.e. with firearms, improved hunting efficiency and has gradually become the main harvest form. Thus the consumptive value of beaver has transformed from commercial furbearer to recreational game species. This same transition to spring hunting has also developed in neighboring Sweden and Finland.

Norwegian beaver management is better understood in light of two basic fundamentals of Norwegian wildlife management. 1) All wildlife is publicly owned, and therefore wildlife management should seek to maximize the public's enjoyment and utilization of wildlife. 2) The hunting privilege belongs to the landowner. Once public authorities have determined when, where and how much game can be harvested, landowners can either hunt themselves or lease the hunting rights to others. In the later case, wildlife becomes a source of income to landowners while providing hunting opportunities for the general public.

Most of the details of practical beaver management may be found in the "Wildlife Act", its accompanying by-law for beaver management (by-law FOR 2002-03-22 nr 314: *Forskrift om forvaltning av hjortevilt og bever*), and the by-laws defining the open seasons for hunting and trapping (by-law FOR-2012-03-01 nr 190: *Forskrift om jakt- og fangsttider samt sankning av egg og dun for jaktseongene fra og med 1. april 2012 til og med 31. mars 2017*) and the hunting and trapping methods allowed (by-law FOR 2002-03-22 nr 313: *Forskrift om utøvelse av jakt, felling of fangst*). These laws outline when, where and how beaver can be trapped and hunted, the organizing of landowners into beaver management units, and how hunting quotas are determined and distributed among landowners. With the exception of an acute need for control of damage and alien species,

trapping and hunting are not allowed during the breeding season, though what constitutes the breeding season is not clearly defined in the “Wildlife Act”. This lack of clarity has recently been the cause of some debate concerning when the breeding season for beaver actually starts, and therefore when spring beaver hunting should cease.

Harvesting to conserve, manipulate and exploit beaver populations is a central element of Norwegian beaver management. Quota regulation of the harvest has been continually employed since 1855, at which time landowners were also granted the exclusive right to hunt beaver. At present, municipal wildlife managers first decide whether the local beaver population can be harvested based on population information gathered from e.g. landowners, hunters, or autumn counts of occupied lodges. A harvest quota for the entire township is then established and divided among landowners according to how much beaver habitat they own. The amount of beaver habitat on a particular area or estate can be measured in two different ways; either as the *area* of “beaver habitat” or the *length* of “beaver-utilized shoreline”. Beaver habitat includes all habitat normally used by beaver; i.e. forest, bog and agricultural landscapes below tree line, usually excluding urban areas, larger lakes and steep mountain hillsides. “Beaver-utilized shoreline” is the length of shoreline in rotational use by beaver, since shoreline habitat presently in use and later abandoned, will normally be reoccupied again at some future time.

In order to distribute the municipal quota among landowners, the *minimum area* necessary to receive one beaver permit is determined by dividing the total area of beaver habitat in the municipality by the municipal quota. Alternatively, the *minimum shoreline length* necessary is determined by dividing the total length of beaver-utilized shoreline by the municipal quota. Municipal managers may choose between the two alternatives, though the length of beaver-utilized shoreline on an estate is the best predictor of colony density when the area involved is relatively small (Fig. 1). Reliable data on the length of beaver-utilized shoreline in a municipality, however, is more difficult to obtain than the area of beaver habitat.

To receive their portion of the municipal quota, landowners must first organize *beaver management units*. Because Norwegian estates average small (≈ 50 hectares), landowners must usually group together in order to attain the minimum area necessary to receive a quota of at least one beaver. Typically, the minimum area required to receive one beaver would be 300-500 hectares. Thus beaver management units almost always entail many landowners, creating challenges with respect to e.g. landowner cooperation and organization. Once organized and approved by the municipal authorities, each beaver management area is allotted its portion of the total municipal quota based on the relative amount of beaver habitat or beaver-utilized shoreline it encompasses. Management areas too small to meet the required minimum area or minimum shoreline length do not receive a quota, which serves to motivate landowners to merge into larger units. Management units for cervids (moose *Alces alces*, red deer *Cervus elaphus* and roe deer *Capreolus capreolus*) in most instances also function well as management units for beaver, though usually not in farmland. This is because most management units for cervids do not involve farmland, though farmland is usually good habitat for beaver.

The present national distribution of beaver (Fig. 2) extends from mid-Norway south through the eastern and southern counties. As of 2003, Troms and Finnmark no longer have beaver, despite several releases of new animals in recent decades. The national population size is thought to be about 70,000 individuals and still growing. On a scale of

about 200-500 km², newly established populations appear to peak after 35-40 years, followed by an abrupt fall (phase 1, Fig. 3). This pattern closely mimics the Riney-Caughley model for introduced ungulates. Populations are thought to eventually enter a more stable carrying-capacity phase (phase 2, Fig. 3). Over-browsing is thought to be the main cause of the initial abrupt decline (Fig. 3). Though information is limited, colony density seems to vary considerably between landscape types, being greatest along low-gradient rivers and in farmland, and least in alpine regions (Table 1). A suggested mean colony density for all landscapes combined (excluding alpine) once populations have stabilized is 0.25 colonies per km², or one colony per 4 km².

A central goal of the “Wildlife Act”, the “Nature Diversity Act”, and of Norwegian forest owners is the conservation of biodiversity at the genetic, species, landscape and ecosystem levels. As an ecosystem engineer, beaver physically change the landscape primarily through dam-building and tree-felling, significantly modifying the geomorphology, hydrology, ecological succession and species composition of the landscape. Locally however, species biodiversity may temporarily decline. Modern clear-cut forestry, though detrimental to many wildlife species, may actually benefit beaver by stimulating the shoreline growth of broadleaf species favored by them.

Municipal wildlife managers are required to arrive at a municipal beaver quota, which requires information on population size. Since sites occupied by beaver are highly visible in autumn, information is usually gathered then. Population size is usually expressed as number of colonies rather than number of beaver, as the number of beaver in each colony is difficult to determine. When an estimate of the actual number of animals in the population is necessary, a mean colony size of 4 is usually employed for the Eurasian beaver. Five methods used to estimate population size on a municipal scale are briefly described in this report.

Reliable harvest information is important for population management. The national beaver harvest figures for 1984-85 – 2010-11 (Fig. 4) reveal an unexpected pattern consisting of an initial 3-fold increase the first 5 years, followed by a gradual 3-fold decline and leveling-out. During this same period, the range of the beaver throughout Norway has slowly expanded and presumably the population size as well. Therefore a gradual increase in the national harvest would also be expected, but for some reason the data indicate a decline. From 1985 - 2000 the harvest estimation methods employed changed several times, suggesting dissatisfaction with them. We suspect that these changes in methodology may lie behind the unexpected abrupt rise and fall observed.

From 2001- 2011, however, the same sampling methodology has been employed, suggesting that the decline shown for the last 10 years may better reflect the true harvest size and trend. Since most of the national harvest has occurred in only 4 of the 11 counties where beaver are hunted (Fig. 5), the key to the trend seems to lie with these 4. The harvest data for each individual county (Fig. 6) shows significant harvest declines in 5, no change in 4, and significant increases in 2. The 5 counties showing declines, i.e. Vest-Agder, Aust-Agder, Telemark, Hedmark and Vestfold, are the counties with the oldest populations, all having had beaver for at least 50 years. We therefore suspect that populations in these 5 had entered phase 2 and stabilized (Fig. 3) before the decline in harvest numbers occurred (Fig. 6). Thus the observed harvest decline in these 5 counties does not seem to reflect the actual population trends in them. Neither is there reason to

believe that a prolonged over-exploitation has been occurring in these counties that could explain the decline.

Rather, based on contact with hunters and municipal wildlife managers, we suspect that falling hunter effort, due to difficulty in finding a place to hunt, is the main cause of the harvest decline. Though the total number of hunters in Norway has increased slowly during the past 10 years, mean age is increasing and recruitment of new hunters into the population has begun to decline. In our experience, beaver hunters tend to be younger than average because beaver hunting is less expensive than other forms. This ageing of the hunter population, together with a declining recruitment of younger hunters, may be having some effect on hunter effort, though hardly sufficient to explain the near 50% decline in the harvest since 1994.

New beaver management by-laws were established in 1997 and 2002, and though new laws are intended to improve existing laws, this may not always happen. In particular, the extra effort required to organize many small landowners into beaver management units in farmland, i.e. outside of management units for cervids, seems to discourage many landowners from organizing. Without management units no quotas are issued and the harvest suffers.

Spring hunting is the dominating harvest form in Fennoscandia. Beaver, however, cannot be sexed or reliably aged under spring hunting conditions, so hunters normally shoot the first animal seen. The sex-ratio of spring-shot animals does not deviate significantly from 50:50 in any age class. However adults, and in particular pregnant females, are more likely to be the first individuals shot from colonies. Most pregnant females shot in late April have visible fetuses, an experience many hunters are uncomfortable with, and a situation that challenges the general management principle of not hunting during the reproductive season. The best way to limit the takeoff of pregnant females is to shoot the quota from as few colonies as possible, as each colony usually contains only one. Hunting predominantly in damage colonies will help accomplish this goal, plus reduce damage.

Many factors including e.g. habitat quality, reproductive rates, and selection for sex and age groups affect the sustainable harvest rate. Results from recent field experiments suggest that the level of sustainability for spring-shot Eurasian beaver is around 10-20%, a figure lower than that suggested for trapped populations. Once the colony number for a municipality has been determined, we suggest that the initial annual quota be set at one beaver per colony. At a harvest success of about 50%, which in our experience is seldom attained, and an average of 4 animals per colony, this would lead to a take-off of around 10-15%. Future quota size can be adjusted when necessary. If unwanted over-harvesting should occur, populations are likely to rebound quickly (Fig. 9). Since recreation rather than economic gain is the prime motivation for hunting beaver, hunting effort will likely fall as populations decline, thereby counteracting any tendency to over-harvest.

Limiting damage caused by beaver is a central management goal. Initially, all beaver dams and lodges are protected by the "Nature Diversity Act" and removing them requires permission from municipal authorities. In general, there is a direct relationship between the number of colonies and reports of damage. Methods to limit both colony number and damage include 1) avoiding the commonly experienced population "over-shoot" (phase 1, Fig. 3) by starting to harvest early in the initial population growth phase (Fig. 8); 2) by concentrating the harvest effort to sites where damage is often reported (Fig. 8) and 3)

implementing non-lethal control methods to limit damage where this is practical. Municipal beaver management plans should include maps that show hunters where damage is often a problem.

Central problems facing Norwegian beaver management and their potential solutions include the following. 1) Many landowners perceive the beaver to be a problem species with little positive economic value. Increased tolerance will likely develop with increased knowledge of the beaver's ecological role and potential economic value through more education at all age levels. The Norwegian Federation of Forester's recent course on ways to increase biodiversity in managed forests, including the beaver's role, is a good example of this.

2) Many non-hunters and hunters alike object to the shooting of females in the late stages of pregnancy. Most sexually mature female cervids (moose and deer) are also pregnant when shot, a practice hunters rarely object to since most are killed early in pregnancy before fetuses are visible. If female beaver were shot from new-born young this would certainly violate accepted animal welfare practice, but this has never been documented within the present hunting season limits. In the absence of spring hunting, few animals would be harvested and beaver management would essentially be reduced to damage control. Hunters must accept that pregnant individuals can be shot and try to avoid this based on methods outlined here.

3) An invasion of Norway and Sweden by the North American beaver from Finland (Fig. 10) is almost guaranteed if appropriate action to hinder this is not taken within the next few years. The imminent question is whether coexistence or the competitive exclusion of one species by the other will ultimately result, with the possible regional extirpation or eventual extinction of the Eurasian beaver. The spread of this alien throughout Eurasia can still be prevented if the will to do so exists.

4) In our experience, the main problem facing today's beaver harvest management derives from the lack of interest that landowners, and to some degree municipal wildlife managers, have for this species. Few landowners hunt beaver themselves and few are willing to organize the lease of beaver hunting when its market value is so low. In addition, numerous small landowners must often cooperate to form beaver management units, a process many find difficult. When beaver management units are not formed, quotas do not get issued and many beaver hunters have no place to hunt. In contrast, beaver hunting functions well when organized by single, large landowners, either private or public.

Landowners are a key element in the harvest management process and somehow must be motivated to take this responsibility more seriously. Together with municipal wildlife managers they need to take greater responsibility for creating hunting opportunities for non-landowners and for recruiting young hunters into an ageing hunter population. Making beaver hunting more accessible is one way to do this.

Keywords: alien species, animal welfare, beaver, *Castor fiber*, *Castor canadensis*, census, Fennoscandia, harvest regulation, hunting, invasive, Norway, population, quota regulation, trapping, wildlife management

Utvidet sammendrag

Den eurasiatiske beveren (*Castor fiber*) ble for første gang total fredet i Norge i 1845. Siden har beverforvaltningen gjennomgått mange forandringer etter hvert som bestanden har økt og forvaltningsmålene har endret seg. Nye forskrifter om beverforvaltning er for tiden under utvikling. Denne rapporten oppsummerer 1) den historiske utviklingen av beverforvaltning i Norge, 2) gjør rede for den forvaltningsrelevante litteraturen av nyere dato og 3) tilrår flere forandringer som trolig vil forbedre dagens beverforvaltning i Norge.

Hovedmålene med beverforvaltningen er å 1) opprettholde bestander i deres naturlige utbredelsesområde med tettheter som er tilstrekkelig for bevaring av biodiversiteten, 2) produsere et høstbart overskudd og 3) redusere konflikter mellom bever og mennesker. I tillegg skal beverforvaltningen optimalisere rekreasjonsmuligheter for allmennheten og økonomisk utbytte for grunneiere gjennom f.eks. utleie av beverjakt. Disse, ofte motstridende målene, leder noen ganger til konflikter.

Beveren har vært en viktig ressurs som pels- og matvilt og for castoreum (som medisin) for innbyggerne i Fennoskandia (Norge, Sverige og Finland) og nordvest Russland i årtusener. Beveren ble utryddet i Sverige, Finland og nordvest Russland på slutten av 1800-tallet, men en bestand på 100-200 overlevde i sørøst Norge. Bestanden vokste sakte etter vekslende perioder med fredning og høsting. I 1932 ble bruken av de effektive fotsaksfellene forbudt i Norge. Levendefangst og jakt med skytevåpen var fortsatt lov om høsten, men var ikke effektive nok til å kontrollere bestandsveksten. Som et forsøk på å begrense skadeomfanget ble jakttiden i 1981 forlenget gjennom vinteren og våren til tidlig i mai. Vårjakten med våpen viste seg å være både effektiv og populær, og har siden overtatt som den mest populære høstingsformen. Dermed har beverens "konsum" verdi utviklet seg hovedsakelig fra verdifullt pelsvilt til et jaktvilt med kjøttet som hovedprodukt. Den samme overgangen til vårjakt har funnet sted også i våre naboland Sverige og Finland.

Norsk beverforvaltning kan ses i lyset av to grunnleggende prinsipper i norsk viltforvaltning. 1) Viltet eies av alle og ingen, og viltforvaltning bør derfor søke å maksimere allmennhetens glede og utnyttelse av viltet. 2) Jaktretten tilhører imidlertid grunneieren. Når den offentlige viltforvaltningen har bestemt når, hvor og hvor mange dyr som kan høstes, kan grunneiere enten jakte selv eller overføre jaktretten til andre. I det siste tilfelle kan viltet bli en inntektskilde til grunneiere, samtidig som det gir jakt muligheter for allmennheten.

Mesteparten av detaljene i praktisk beverforvaltning finnes i "Lov om jakt og fangst av vilt" (Viltloven), og tilhørende forskrift for beverforvaltning (forskrift FOR 2002-03-22 nr. 314: *Forskrift om Forvaltning av hjortevilt og bever*), samt forskrift om jakt og fangsttider (forskrift FOR-2012-03-01-190: *Forskrift om jakt- og fangsttider samt sanking av egg og dun for jakt sesongene fra og med 1. april 2012 til og med 31. mars 2017*). Disse lovene beskriver når, hvor og hvordan beverbstanden kan beskattes, hvordan grunneierne organiseres i bevervald samt hvordan jaktkvotene fastsettes og fordeles mellom grunneiere. Med unntak av et akutt behov for kontroll av skade forårsaket av vilt, eller spredning av fremmede viltarter, er alt vilt fredet i yngletiden. Begrepet *yngletid* er imidlertid ikke klart definert i Viltloven. Denne uklarheten har nylig

vært årsak til debatt om når yngletiden for bever faktisk starter, og derfor når vårjakten på bever bør opphøre.

Høsting for å bevare, regulere og utnytte beverbestander er et sentralt element i norsk beverforvaltning. Kvoteregulering av fangsten har pågått kontinuerlig siden 1855, da grunneiere for første gang ble tildelt jaktretten på bever. Under den nåværende forskriften bestemmer forvalterne i kommunen først om den lokale beverbestanden kan høstes basert på bestandsinformasjon innsamlet fra f.eks. grunneiere, jegere, eller en høsttelling av bebodde hytter. En fangstkvote for hele kommunen blir så fastsatt og delt mellom grunneiere i henhold til hvor mye beverhabitat de eier. Omfanget av beverhabitat på et bestemt område kan måles på to forskjellige måter, enten som arealet av "beverhabitat" (*tellende areal*) eller lengden på "bever-utnyttet strandlinje" (*tellende vannlengde*). *Tellende areal* omfatter alle habitater som vanligvis brukes av beveren, dvs. skog, myr og kulturlandskap under tregrensen, som oftest uten urbane strøk, større innsjøer og stupbratte lier. *Tellende vannlengde* er lengden på strandlinjen beveren enten har brukt tidligere, basert på gamle spor i terrenget, eller som er i bruk nå basert på ferske spor.

Ved fordeling av den kommunale beverkvoten blant grunneierne blir nødvendig *minsteareal* for å felle én bever først bestemt ved å dividere det tellende arealet i kommunen på den vedtatte kommunale kvoten. Alternativt blir *minste vannlengde* bestemt ved å dividere tellende vannlengde på den kommunale kvoten. Forvalterne i kommunene kan velge mellom de to alternativene, men tellende vannlengde for en eiendom er den beste estimatoren for kolonitetthet når områdene er relativt små (Figur 1). Pålitelige data for tellende vannlengde i en kommune er imidlertid mer arbeidskrevende å skaffe enn tellende areal.

For å få sin del av den kommunale kvoten, må grunneierne første organisere bevervald. Fordi norske eiendommer i gjennomsnitt er små (≈ 50 hektar), må grunneiere vanligvis organisere seg i fellesvald for å oppnå minimum ett minsteareal, dvs. det arealet som er nødvendig for å få tildelt minst en bever. Vanligvis vil minstearealet i en kommune tilsvare 300-500 hektar. Derfor vil et "gjennomsnitts" bevervald omfatte 6-10 grunneiere, men ofte mange flere, noe som skaper utfordringer mht. samarbeid og organisering. Vald godkjent av kommunen blir automatisk tildelt sin andel av den kommunale kvoten hvert år. Vald som ikke omfatter enten ett minsteareal eller én minste vannlengde får ingen kvote. Dette skal motivere grunneiere til å organisere seg i større enheter.

For tiden er hovedutbredelsen av bever (Figur 2) konsentrert til sør-, sørøst- og midt-Norge. Siden 2003 har Troms og Finnmark vært uten bever, til tross for flere utsettelser av dyr de siste tiårene. Den norske bestanden antas å være på ca. 70 000 individer og vokser fortsatt. På en landskapsskala på ca. 200-500 km² når nyetablerte bestander en topp etter 35-40 år, etterfulgt av et brått fall, trolig pga. overbeiting (fase 1, Figur 3). Dette vekstmønsteret er veldig likt Riney-Caughley modellen for innførte hovdyr. Deretter vil de fleste bestander trolig gå over i en mer stabil fase med veksling rundt områdets bæreevne (fase 2, Figur 3). Kolonitettheten synes å være størst langs lav-gradient elver og i jordbruksområder, og minst i alpine områder (Tabell 1). Når bestanden har stabilisert seg vil gjennomsnittlig kolonitetthet for alle landskapstyper (unntatt alpine) på stor landskapsskala ligge på ca. 0,25 kolonier per km², eller en koloni per 4 km² (Tabell 1), basert på dagens begrensede opplysninger.

Et sentralt mål for "Viltloven", "Naturmangfoldloven", og for norske skogeiere er bevaring av biologisk mangfold på alle nivå, fra genetisk til økosystem. Som

økosystemingeniør endrer beveren landskapet fysisk, først og fremst gjennom dambygging og tre-hogst. Dette fører til vesentlige endringer i landskapets geomorfologi, hydrologi, artssammensetning og den økologiske suksesjonen. Lokalt kan imidlertid det biologiske mangfoldet avta kortvarig. Moderne bestandsskogbruk, som er ødeleggende for noen viltarter, kan faktisk være en fordel for beveren siden veksten av løvtrær, som den foretrekker, øker vesentlig etter hogst.

Kommunale viltforvaltere skal etablere en kommunal beverkvote, noe som krever informasjon om bestandsstørrelsen. Siden okkuperte beverlokaliteter er svært synlige om høsten, samles vanligvis informasjonen da. Bestandsstørrelse er vanligvis uttrykt som antall kolonier, og ikke antall bever, siden antall bever i hver koloni er vanskelig å bestemme. Når et estimat av det faktiske antall dyr i bestanden er nødvendig, benyttes vanligvis en gjennomsnittlig kolonistørrelse på 4 for den eurasiatiske beveren. I denne rapporten beskriver vi fem metoder for å anslå beverbestanden på kommunalt nivå.

Pålitelige fangsttall er viktig for forvaltning av bestander. Den nasjonale fangststatistikken for bever fra 1984 til i dag viser et uventet mønster bestående av en innledende 3-dobling de første 5 årene etterfulgt av en gradvis 3-ganger halvering, og så en stabilisering (Figur 4). I løpet av denne perioden har utbredelsen av bever i Norge økt, og mest sannsynlig bestandsstørrelsen også. Derfor vil en gradvis økning i den landsomfattende fangsten også være forventet, men av uvis årsak viser resultatene det motsatte. Fra 1985 - 2000 forandret metodene for fangstregistrering seg flere ganger, noe som tyder på misnøye med metodene. Dette skiftet i metodebruk kan muligens være årsaken til de uventede fangsttallene mellom 1984 og 2000. Fra 2001- 2011 har kun én metode for fangstregistrering blitt brukt, og derfor er statistikken for denne perioden sannsynligvis mer troverdig hva gjelder både nedgangstrenden og størrelsen på fangsten. Siden det meste av den landsomfattende fangsten stammer fra bare 4 av 11 fylker (Figur 5) ligger forklaringen til trenden hovedsakelig her. De fylkesvise fangsttallene (Figur 6) viser en vesentlig nedgang i fangsten i 5, ingen forandring i 4 og en vesentlig økning i 2 av fylkene. De 5 fylkene som viser en nedgang, dvs. Vest-Agder, Aust-Agder, Telemark, Hedmark og Vestfold er fylker med de eldste bestandene, og alle har hatt bever i minst 50 år. Vi tror derfor at bestandene her har vært stabil nokså lenge (dvs. nådd fase 2 i Figur 3), og at nedgangen i fangsten ikke gjenspeiler en nedgang i bestanden, men heller en nedgang i jaktinnsats. Både egen erfaring fra Telemark fylke samt kontakt med jegere og viltforvaltere andre steder tyder på dette. Mens antall jegere i Norge har økt sakte de siste 10 årene har gjennomsnittsalderen også økt, og rekrutteringen av yngre jegere begynt å avta. Etter vår erfaring er beverjegere yngre enn gjennomsnittet for alle jegere, trolig fordi beverjakt koster forholdsvis lite, og ofte er gratis. Denne økningen i jegernes alder i kombinasjon med fallende rekruttering av yngre jegere kan ha påvirket jaktinnsatsen, selv om dette alene neppe kan forklare nesten 50 % nedgang i fangsten siden 1994.

Nye beverforvaltningsforskrifter ble etablert i 1997 og 2002, og selv om nye lover er ment å forbedre eksisterende lover, skjer ikke dette alltid. Når hjorteviltvald også fungerer som bevervald, fungerer dagens forskrifter som oftest bra. Men når mange små grunneiere må danne egne "bevervald", f.eks. i kulturlandskapet som vanligvis ikke inngår i hjorteviltvaldene, nekter mange grunneiere å være med. For de fleste av dem er ikke beveren verd innsatsen rent økonomisk. Uten godkjente vald blir det ingen kvotetildeling og fangsten minker.

Jakt om våren er den dominerende høstingsformen i Fennoskandia. Men siden jegerne ikke klarer å kjønnsbestemme beveren under jakt, og sjelden aldersbestemmer den, skyter de vanligvis det første dyret de ser. Nyere studier har vist at kjønnsfordelingen blant vårskutte bever ikke avviker vesentlig fra 50:50. Derimot er voksne dyr, og spesielt drektige hunner, mer utsatt for å bli det første dyret skutt i en koloni enn dyr tilhørende andre grupper. Mange jegere er lite glad for å skyte drektige bevere, særlig når de er høygravide i slutten av april. Vårjakt på bever utfordrer derfor det generelle forvaltningsprinsippet at man ikke skal jakte i yngletiden. Den beste måten å begrense uttaket av drektige hunner på er å jakte i så få kolonier som mulig, siden en koloni vanligvis bare inneholder én reproduserende hunn. Å konsentrere jaktinnsatsen til hovedsakelig skadepolonier vil både minke uttaket av drektige hunner og begrense skade.

Mange faktorer påvirker størrelsen på et bærekraftig bestandsuttak som f.eks. reproduksjonsrate og seleksjon for bestemte kjønns- og aldersgrupper. Nyere forskning på den eurasiatiske beveren har antydnet at et uttak på rundt 10-20 % vil være bærekraftig når uttaket skjer med skytevåpen om våren, et lavere tall enn ved fellefangst vinterstid for begge beverarter (*C. fiber* og den nordamerikanske beveren *C. canadensis*). Som en tommelfingerregel foreslår vi at den årlige kvote i en kommune blir satt til ett dyr per koloni, når antall kolonier for en kommune har blitt bestemt. Ved en fellingsuksess på 50 % av tildelt kvote og et gjennomsnitt på 4 dyr per koloni vil dette føre til et uttak på 10-15 %. Etter vår erfaring blir fellingsuksess sjelden større enn 50 % av det tildelte. Dersom for hard fangst over flere år skulle redusere bestanden mer enn ønsket vil bestanden sannsynligvis ta seg raskt opp igjen (Figur 9). Siden rekreasjon og ikke økonomisk gevinst er den viktigste motivasjonen for beverjakt vil sannsynligvis jaktinnsatsen minke med minkende bestand, og derfor motvirke en tendens til overbeskatning.

Å begrense skade forårsaket av bever er et sentralt forvaltningsmål. Alle beverdammer og -hytter er i utgangspunkt beskyttet av "Naturmangfoldloven", og fjerning av dem krever tillatelse fra myndighetene i kommunen. Som oftest er det en direkte sammenheng mellom antall kolonier og rapportert skade. Derfor vil begrensning av antall kolonier i en kommune ofte være en målsetning. Metoder for å begrense antall kolonier og skade inkluderer 1) å unngå den innledende bestandstopp som er vanlig for bever (fase 1, Figur 3) ved å åpne for jakt og fangst tidlig i bestandsvekstfasen (Figur 8); 2) å holde koloniantallet under bæreevnen, delvis ved å konsentrere høstingsinnsatsen til steder hvor skade ofte skjer (Figur 8); og 3) bruk av ikke-dødelige kontrollmetoder for å begrense skaden hvor dette er praktisk. Forvaltningsplanen for en kommune bør inkludere kart som viser jegerne hvor skade ofte er et problem.

Sentrale problemer for den norske beverforvaltningen og deres potensielle løsninger inkluderer følgende. 1) Mange grunneiere oppfatter beveren kun som et problemskapende skadedyr uten positiv økonomisk verdi. Økende toleranse vil trolig utvikle seg med økende kunnskap om beverens økologiske og potensielle økonomiske verdier gjennom bedre opplysning og informasjon. Et godt eksempel på dette er kurs som Norges skogeierforbund nylige tilbød skogeiere om hvordan biologisk mangfold kan opprettholdes under dagens skogbruk. Mange jegere, kanskje især utenlandske, er mer enn villig til å betale for godt tilrettelagt beverjakt. Tydeligvis er mange grunneiere ikke klare over dette.

2) Mange jegere og ikke-jegere misliker at høygravide bever blir skutt under vårjakt. De fleste kjønnsmodne hunnene av hjortedyr er også drektige når de blir skutt om høsten, en praksis jegere sjelden protesterer mot siden de fleste skytes tidlig i drektighetstiden før fostrene er synlige. Hvis mødrene skytes fra nyfødte beverunger vil dette helt klart bryte med akseptert dyrevelferd, men dette har aldri blitt dokumentert innenfor dagens gjeldende jakttider. Uten jakt om våren ville beverforvaltningen i all hovedsak blitt redusert til skadekontroll. Beverjegerne må akseptere at drektige individer *kan* bli skutt, og heller ta i bruk metoder for å begrense problemet.

3) En invasjon av den nordamerikanske beveren til Norge og Sverige fra Finland (Figur 10) vil trolig skje om få år om ikke tiltak settes i gang for å hindre dette. Det overhengende spørsmålet er om de to beverartene vil klare å eksistere sammen, eller om den ene tilslutt vil utkonkurrerer den andre. Det er en viss fare for at den eurasiatiske beveren kan forsvinne regionalt, og i verste fall over hele kontinentet etter mange år. En utryddelse av den nordamerikanske arten fra Europa og Asia er fortsatt mulig hvis viljen til å gjennomføre det eksisterer.

4) Etter vår erfaring er hovedproblemet med dagens beverforvaltning manglende interesse blant mange grunneiere og kommunale viltforvaltere for forvaltningen av denne arten. Få grunneiere jakter bever selv, og få er villig til å organisere utleie av beverjakt når markedsverdien tilsynelatende er så lav. I tillegg må mange små grunneiere som oftest samarbeide for å danne et bevervald, en prosess mange ikke ser seg tjent med. Når vald ikke etableres blir ikke kvoter tildelt og mange beverjegere går glipp av et sted å jakte. Beverjakt fungerer imidlertid bra når forvaltningsansvaret tilhører store grunneiere, enten de er private eller offentlige.

Grunneierengasjement er et nøkkelement i all vellykket viltforvaltning. Hva angår beverforvaltning må grunneieren på en eller annen måte bli mer motivert til å ta dette ansvaret mer seriøst. Sammen med viltforvaltere i kommunen bør de føle et større ansvar for tilrettelegging av beverjakt for allmennheten, og for å rekruttere yngre jegere inn i en aldrende jegerstand. Å gjøre beverjakta mer tilgjengelig er en måte å gjøre dette på.

1. Introduction

Following its near extirpation in the latter half of the 19th century (Collett 1897), the Eurasian beaver *Castor fiber* has since become reestablished in much of southeastern and mid-Norway and is gradually expanding to the west and north (Rosell and Parker 2011). From the first total protection of beaver in 1845 to the present, beaver management in Norway has undergone numerous changes as both populations and management objectives have evolved. Rosell and Parker (1995) reviewed the beaver literature in connection with the then ongoing modernization of Norwegian beaver management. The present report is primarily a review of the literature published since then that we consider of relevance for the new revision of beaver management by-laws now in progress. In Norway, where the beaver was never extirpated, science-based management involving harvest regulation has been employed for more than 150 years. Consequently, the experience gained here should be of interest to managers in Europe and Asia in the early stages of establishing modern beaver management practices (Parker and Rosell 2003).

Our goal here is to 1) briefly review the historical, ecological, cultural, social and economic roots of Norwegian beaver management; 2) describe present key elements of Norwegian beaver management; 3) review the recent literature, beaver harvest records and previously unpublished data of potential importance for the ongoing modernization of Norwegian beaver management; 4) discuss strengths and weaknesses of current beaver management practices based on the authors' personal experience and 5) propose potential solutions to these problems. While the main emphasis here is on management of the Eurasian beaver, numerous references are made to management of the more thoroughly studied and ecologically similar North American beaver *C. canadensis*.

2. Main goals of the “Wildlife Act” and “Nature Diversity Act”

According to the “Wildlife Act” (*Lov om jakt og fangst av vilt*) last revised in 2010, its accompanying by-law for beaver management (*Forskrift om forvaltning av hjortevilt og bever* FOR 2002-03-22 nr 314) and the “Nature Diversity Act” (*Lov om forvaltning av naturens mangfold*, 2009) last revised in 2010, the main goals of beaver management are to maintain populations throughout their natural range at densities sufficient to maintain biodiversity, produce a harvestable surplus and reduce beaver-human conflicts. In addition, beaver management should optimize recreational opportunities for the public and economic opportunities for landowners, e.g. through the lease of beaver hunting.

3. Beaver management in Norway – a brief history

The beaver has been an important resource for the inhabitants of Fennoscandia (Norway, Sweden and Finland) and northwest Russia for millennia judging from the high incidence of beaver skeletal remains and rock-carvings of beaver at stone-age sites in this region (Forsten and Lahti 1976, Danilov et al. 2011). In 1750 beaver were found throughout most of Norway. By 1850 they were nearly extirpated, with only a few hundred animals remaining in the southeastern counties of Telemark and Agder (Collett 1897, Rosell and Parker 2011). A detailed account of how and why this rapid demise and near extirpation occurred has never been reported. Neither has the history of beaver exploitation in Norway prior to 1750. In contrast, the fur-trade histories of Russia (Fisher 1943, Martin 1986), England (Veale 1966), and in particular North America (Ray 1987) are relatively well known.

Prior to the beaver's near extirpation from Fennoscandia in the 18th and 19th centuries, this region had presumably been an important source of beaver pelts and castoreum for the rest of Europe for at least 1-2 millennia (Forsten and Lahti 1976, Rosell and Parker 1995, Danilov et al. 2011). Following establishment of the fur trade between North America and Europe in the 16th century, the European import of beaver pelts from North America increased rapidly and was substantial for the period 1750-1840 (Ray 1987). This was a major reason for the near extinction of beaver on that continent, and presumably the beaver population in Fennoscandia succumbed to these same international economic forces and uncontrolled exploitation. However, it is unclear why the main decline in Norway reportedly occurred then and not earlier, given the regions close proximity to central European markets where the demand for fur had presumably been high at least since the early middle ages (Fisher 1943, Veale 1966, Martin 1986, Ray 1987, Rosell and Parker 1995). As an example, in adjacent northwest Russia the beaver population was considerably reduced already by the 17th century (Danilov et al. 2011).

3.1 From commercial trapping to recreational hunting

While a remnant population of 100-200 beaver remained in southeast Norway at mid-19th century (Collett 1897) they were completely extirpated from neighboring Sweden in the early 1870's (Hartman 2011), from Finland in 1868 (Lahti and Helminen 1974) and from northwest Russia in the late 19th century (Danilov et al. 2011). In 1845 the beaver was totally protected for the first time in Norway, initially for a period of 10 years (Rosell and Parker 1995). Following several shorter periods of protection and exploitation (Rosell and Parker 1995) it was totally protected again in 1899 with the enactment of the country's first modern wildlife act (*Jaktloven av 1899*). At that time the population had again been reduced to approximately 100 animals (Collett 1897).

With the population now increasing, autumn trapping and hunting were again allowed in 1918. In 1932, apparently for animal welfare reasons, the use of the leg-hold trap for the capture of all wildlife was forbidden in Norway, leaving live-trapping and hunting with

firearms as the only legal harvest methods (Myrberget 1967b). As the use of live-traps proved cumbersome, hunting soon took over as the prime harvest method. However, hunting during autumn also proved relatively inefficient as beaver were most active during the long autumn nights when shooting light was insufficient. In addition, most hunters were occupied with hunting other game then.

In 1972, following development of the quick-killing Conibear trap, dead-trapping was again permitted (Rosell and Parker 1995). In the wake of a now rapidly expanding population and increasing damage complaints, in 1981 the open season was extended through winter to 30 April in southeastern Norway and 15 May further north. This extension of the open season into the long daylight hours of the northern spring, together with the development of optically improved telescopic sights, significantly increased the efficiency of hunting as a harvest form for beaver and therefore its popularity. Though no nation-wide data exist, we suspect that over 90% of the present harvest consists of animals shot in spring, mainly during the last 2-3 weeks of the season (Parker and Rosell 2001). This same trend in harvest method from trapping to spring hunting has also developed in Sweden and Finland (Hartman 1999, Parker and Rosell 2003).

Other factors apparently affecting the transition from trapping to hunting include 1) a gradual decline in trapping interest among Norwegians in general; 2) the fur industry's present lack of interest in beaver pelts from Fennoscandia and 3) the increased interest in recreational hunting of beaver in spring, a time when few other animals can be hunted in Norway. Consequently, the consumptive value of beaver in Fennoscandia has gradually transformed from commercial furbearer to recreational game species, hunted primarily for its meat and the hunting experience. However, trappers (when available) are often called upon to remove nuisance colonies, as trapping is usually more time-efficient than hunting.

3.2 Development of a quota system to regulate harvest

Prior to its total protection in 1845 beaver could, in principle, be hunted or trapped by anyone, anywhere, and at any time (Olstad 1957). With the reopening of the harvest season 10 years later, the right to hunt beaver now belonged to the landowner who could trap or hunt them throughout the year, though now with an annual quota of one beaver per estate (Olstad 1957, Myrberget 1967a). Owners of larger estates, however, could apply for larger quotas (Myrberget 1967b). This was apparently the first instance of a quota-regulated beaver harvest in Norway. In 1863 a new law limited the open season from 1 August to 31 October.

In 1929, those districts with substantial populations adopted an improved system whereby the quota allotted to each landowner was based on the area of beaver habitat each estate encompassed; one beaver for those with ≤ 100 hectares, 2 for estates with 100-300 hectares, and 3 for those with > 300 hectares (Myrberget 1967b). This same area-based quota allotment system, in modified form, still exists under the present "Wildlife Act" and accompanying by-law FOR 2002-03-22 nr 314: "*Forskrift om forvaltning av hjortevilt og bever*". Presently, beaver habitat includes all habitat normally used by beaver; in essence all forest, bog and agricultural landscapes below tree line, usually

excluding urban areas, larger lakes and steep mountain hillsides. Alternatively, the length of shoreline in rotational use by beaver may provide the basis for quota allotment, since shoreline habitat presently in use and later abandoned, will normally be reoccupied again following forest regrowth (Fryxell 2001).

4. Some key elements of Norwegian beaver management

Norwegian beaver management is better understood in light of two basic fundamentals of Norwegian wildlife management. 1) All wildlife is publicly owned, and therefore wildlife management should seek to maximize the public's enjoyment and utilization of wildlife. 2) The hunting privilege, however, belongs to the landowner. Once public wildlife management authorities have determined when, where and how much game can be harvested, landowners can either harvest their allocated quota themselves or lease the hunting rights to others. In the later case, the wildlife resource becomes a source of income to landowners, while providing hunting opportunities for the general public (Parker and Rosell 2003). The multiple and often opposing objectives of enhancing biodiversity, minimizing beaver-human conflicts, creating recreational opportunities for the public and economic opportunities for landowners sometimes lead to conflict.

Most of the details of practical beaver management may be found in the "Wildlife Act", its accompanying by-law for beaver management (by-law FOR 2002-03-22 nr 314: *Forskrift om forvaltning av hjortevilt og bever*), and the by-laws defining the open seasons for hunting and trapping (by-law FOR-2012-03-01 nr 190: *Forskrift om jakt- og fangsttider samt sanking av egg og dun for jaktseongene fra og med 1. april 2012 til og med 31. mars 2017*) and the hunting and trapping methods allowed (by-law FOR 2002-03-22 nr 313: *Forskrift om utøvelse av jakt, felling of fangst*). These laws outline when and where beaver can be harvested, the organizing of landowners into beaver management units, how hunting quotas are determined and distributed among landowners, and how beaver damage is to be dealt with. With the exception of an acute need for control of damage and alien species, trapping and hunting of all wildlife is not allowed during the breeding season. For most species this period extends from late spring to early autumn, though what constitutes the breeding season is not clearly defined in the "Wildlife Act". This lack of clarity has recently been the cause of some debate concerning when the breeding season for beaver actually starts, and therefore when spring beaver hunting should cease (Frafjord 1991, Solheim 1991, Parker and Rosell 2001).

4.1 Establishment and distribution of harvest quotas

Municipal wildlife managers in each township decide whether the stage of development of the local beaver population warrants the opening of hunting and trapping. Information about population size and damage is gathered from various sources including landowners, moose hunters (Hartman 1994, Härkönen 1999, Parker et al. 2002a) or estimates based on

autumn counts of occupied lodges (Novak 1987). Based on this information, an initial harvest quota for the entire township is then established.

In order to distribute the municipal quota among landowners the *area* of “beaver habitat”, or alternatively the *length* of “beaver-utilized shoreline” in rotational use by beaver in the municipality, is first calculated. The *minimum area* required for landowners to receive one beaver permit is then determined by dividing the total area of beaver habitat by the municipal quota. Alternatively, a *minimum shoreline length* is determined by dividing the total length of beaver-utilized shoreline by the municipal quota. Municipal wildlife managers may choose between the two alternatives, though the length of beaver-utilized shoreline on management units has been found to be a better predictor of colony density than the area of beaver habitat (Fig. 1) (Steifetten, Uren, Parker & Rosell unpublished), particularly in townships where management units tend to be small. This is because beaver occupy landscapes in a linear fashion along shorelines, rarely felling trees more than 50 m from the water’s edge (Parker et al. 2001a). In contrast, large sections of “beaver habitat” often contain no beaver. Reliable information on the length of beaver-utilized shoreline in a municipality, however, usually requires the collection of considerable field data and is therefore more difficult to obtain than the area of beaver habitat, which can usually be obtained from existing maps.

Landowners, either alone or organized in landowner associations, then establish beaver management units that must be approved by municipal wildlife managers. Beaver management units typically consist of conglomerates of many landowners as Norwegian estates average small (≈ 50 forested hectares) (Nedkvitne et al. 1990), while a typical quota issue would be one beaver pr. 300-500 hectares of beaver habitat. Thus beaver management units almost always entail many landowners, creating challenges with respect to e.g. landowner organization and cooperation.

Each beaver management area within the township is then allotted its portion of the total municipal quota based on the relative amount of beaver habitat or beaver-utilized shoreline it encompasses. Management areas too small to meet the required minimum area or minimum shoreline length do not receive a quota, which serves to motivate landowners to merge into larger units. Once beaver management areas are approved by the municipal wildlife manager, they automatically receive their quota each year. Municipal quotas may be adjusted annually by municipal wildlife managers in response to e.g. changes in population size, damage complaints, or other management objectives. At the end of each hunting season, a management unit administrator is required to report the number of beaver harvested on each beaver management unit to municipal authorities.

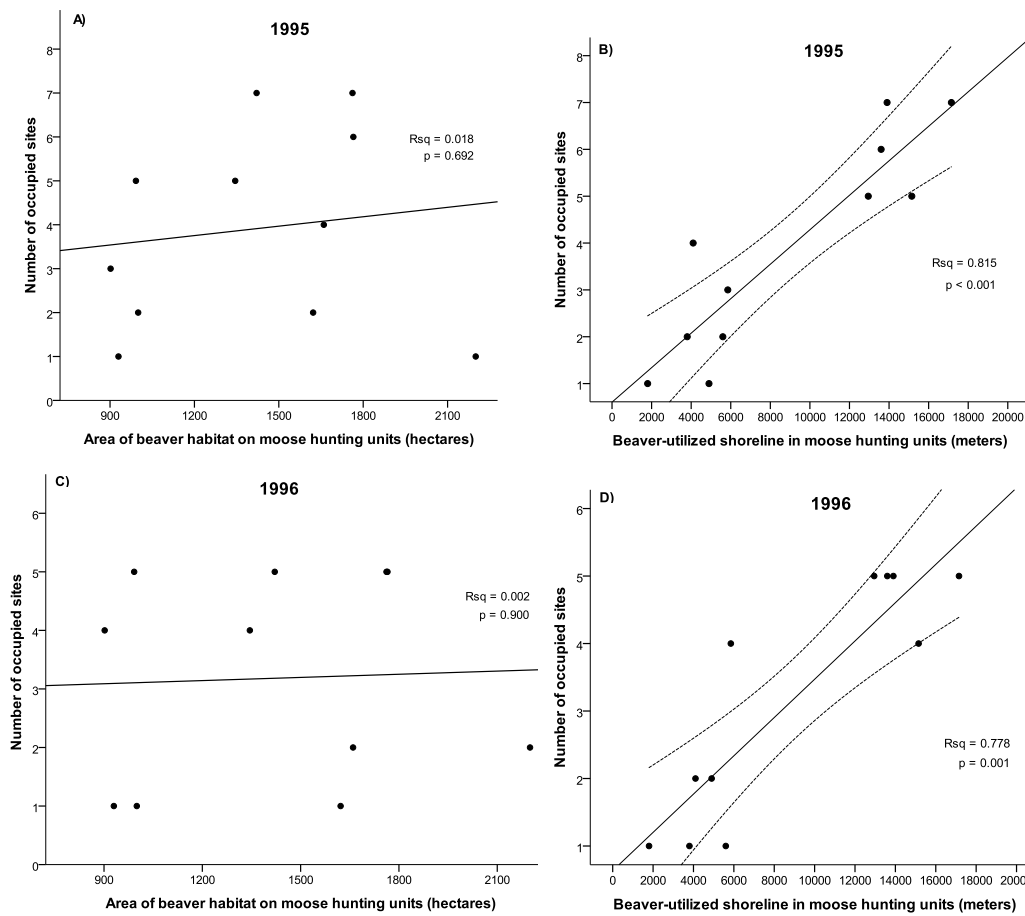


Figure 1. Regression of the number of beaver-occupied (*Castor fiber*) sites on the area of beaver habitat (A and C) or the length of beaver-utilized shoreline (B and D) present on 11 moose hunting units in October 1995 and 1996, Bø Township, Telemark County, Norway. “Beaver habitat” here is defined as the combined area of forest, bog and small lakes. “Beaver-utilized shoreline” is defined as all shoreline in rotational use by beaver based on the presence of scent-marks, tree-felling, dams and lodges.

5. Population size, development and density

5.1 National scale

The main population distribution of beaver (Fig. 2) extends from mid-Norway south through the eastern and southern counties (Rosell and Parker 2011). Until 2003, beaver were present at several localities in the two most northerly counties of Troms and Finnmark following releases in recent decades, but new information has revealed them now to be absent here (Parker 2005). Though no statistically reliable estimate of the present Norwegian population size exists, Parker and Rosell (2003) suggested 70,000, compared to estimates of 50,000 in 1998 (Nolet and Rosell 1998) and 5000 in 1965 (Hartman 1999). Since beaver were originally found throughout most of the country, the complete repopulation of Norway will likely require decades more.

5.2 Regional and municipal scales

Following a long absence, the beaver has returned to Fennoscandian landscapes nearly devoid of its main predator the wolf (*Canis lupus*), and until recently with little browsing competition from cervids (moose *Alces alces*, red deer *Cervus elaphus* and roe deer *Capreolus capreolus*) (Hjeljord 2008). This, coupled with low to moderate harvest pressure in Norway and Sweden (Hartman 1999), has apparently lead to near optimal population growth in most regions. Hartman (1994) studied beaver population growth in boreal forest in south-central Sweden on a landscape scale of up to several hundred km² and found that colony density initially irrupted, peaked after 25-34 years, and subsequently declined. The entire growth and decline pattern closely mimicked the Riney-Caughley model of population growth for introduced ungulates. Limited experience from both Norway (Parker et al. 2001a, Bergan 2003) and North America (Johnston and Naiman 1990, Fryxell 2001) suggest a similar pattern of population development.

The difference in colony density between population lows and peaks may be substantial, depending on the landscape scale involved (Hartman 1994, Fryxell 2001, Bergan 2003), with decreasing difference as the landscape area increases. The landscape scale of particular interest here is that of Norwegian municipalities, as this is the scale at which most beaver populations are managed. This typically varies between 200 –1000 km². The over-browsing by beaver of deciduous trees and bushes for food and building material, followed by territory abandonment, seems to be the prime cause of the initial population decline. Population re-growth then seems to experience a time-lag due to the ensuing regeneration time for deciduous food sources (Hartman 1994, Fryxell 2001, Parker et al. 2001a, Hyvonen and Nummi 2008). Based on limited published accounts (Hartman 1994, Parker et al. 2001a, Bergan 2003) and anecdotal observations, we suggest that the typical temporal pattern of abundance for a beaver population following introduction, and for its deciduous food resources at a landscape scale typical for Norwegian municipalities, is similar to that illustrated in Fig. 3. We would caution, however, that no long term data describing this temporal relationship for the Eurasian

beaver are known to exist. Therefore, how populations of Eurasian beaver will fluctuate in the aftermath of an initial population peak and decline and at different landscape scales is presently unknown. However, the combined effects of living in an unstable environment including e.g. flooding, varying ice conditions, competition for food from cervids, the effects of modern forestry, varying rates of predation and human exploitation, and global warming suggest that maintaining population stability at the municipal level will prove difficult (Sinclair et al. 2006).

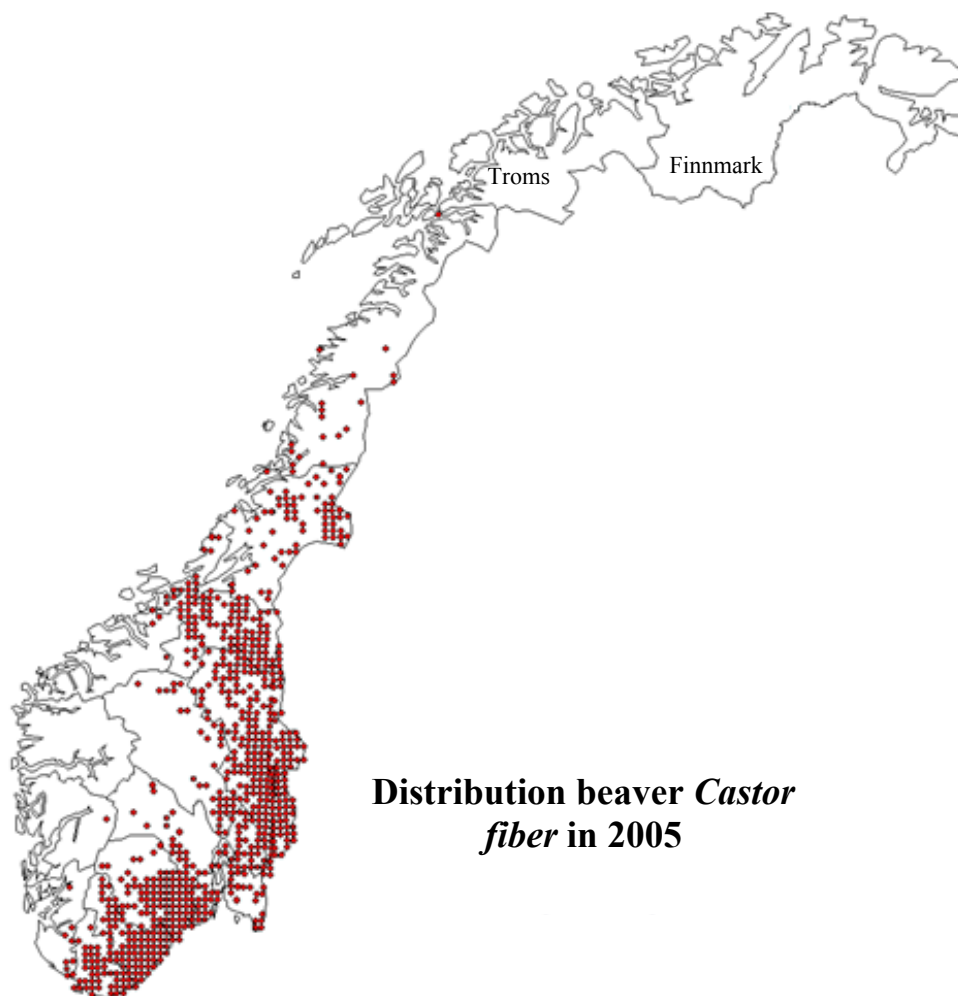


Figure 2. The distribution of beaver (*Castor fiber*) in Norway in 2005. The country was divided into 10 km² quadrates and each point refers to a quadrate where either beaver, or their lodges or dams, have been observed (Rosell and Parker 2011). The data were collected by the Norwegian Zoological Society (Norsk Zoologisk Forening, Prosjekt Pattedyratlas) based on information from numerous sources including municipal wildlife managers, landowners, hunters, and society members.

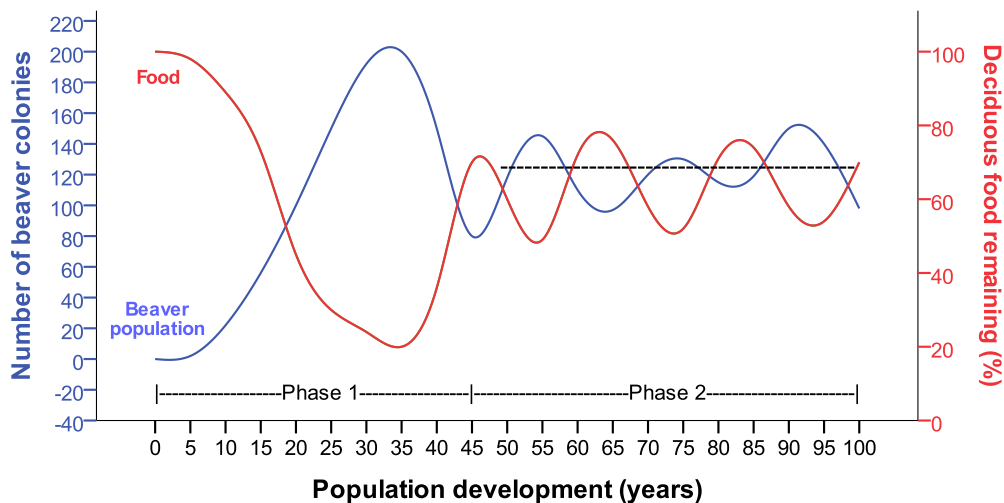


Figure 3. A graphic presentation of the predicted relationship between a developing population of beaver (*Castor fiber*) and its prime winter food source of deciduous trees and bushes. Assumptions for the model are an area of 500 km² of typical beaver habitat in Fennoscandian boreal forest with a peak in colony density occurring at 0.40 colonies/km² after 35 years, and a mean colony density of 0.25/km² (the dotted line) following population recovery. Harvest pressure is light or non-existent. The basic shape of the curve for colony number in “phase 1” is relatively well founded in field studies. The shape in “phase 2” is based on limited anecdotal observation.

5.3 Population densities in different landscapes

As with all wildlife, beaver population density varies considerably in time, space, and with habitat quality (Novak 1987). Whereas precise counts of the number of beaver in individual colonies are difficult to obtain (Rosell et al. 2006), counting the number of colonies or occupied sites in autumn involves little error when done by trained personnel. Therefore beaver population density is usually expressed as counts of colonies rather than counts of individuals. Densities may be expressed either as colonies/km² of beaver habitat or colonies/km shoreline. In the absence of local census data, which can be expensive to obtain, municipal managers may instead employ published data on mean colony density obtained from similar landscapes, and from populations at similar stages of growth, when establishing quotas. In Table 1 we present a review of both the areal and linear population density data published for Eurasian beaver in Fennoscandia. Based on this limited data set, and on landscape scales of approximately ≥ 100 km² that include all habitats supporting beaver (forest, agricultural and rivers, but excluding alpine areas), mean density was 0.24 colonies/km². Though data are presently limited, Norwegian agricultural landscapes appear to contain higher than average beaver densities (Eikeland 2004) while densities in alpine habitat near tree line appear to be much lower (Mossing 2005).

6. Managing for biodiversity

The ongoing return of the beaver to former habitats throughout Eurasia is a major conservation success story (Nolet and Rosell 1998). A central goal of the “Wildlife Act”, “Nature Diversity Act” and of Norwegian forest owners and managers as well (Hytönen 1995, Solbraa 1996, Anononous 1999) is the conservation of biodiversity at the genetic, species, landscape and ecosystem levels. As an ecosystem engineer, beaver physically change the landscape primarily through dam-building, significantly modifying its geomorphology, hydrology and biotic properties (Rosell and Parker 1996, Collen and Gibson 2001, Rosell et al. 2005). Likewise, beaver foraging has considerable impact on the ecological succession, species composition and structure of plant communities (Rosell and Parker 1996, Rosell et al. 2005). Both dam-building and foraging lead to increases in species richness at the landscape scale by increasing habitat heterogeneity (Wright et al. 2002). Locally, however, species biodiversity may temporarily decline following extensive foraging (Jones et al. 1997, Fryxell 2001).

The strength of the beavers’ impact varies with geographical location, relief and type of habitat impounded (Rosell et al. 2005). Whereas dam-building in flat landscapes can impound large areas (Johnston and Naiman 1990, Härkönen 1999, Hood and Bayley 2008) the proportion impounded in mountainous Nordic landscapes is considerably less (Lavsund 1987, Parker et al. 2001a). As most of Norway is mountainous, impoundments here tend to be small, e.g. Parker et al. (2001a) reported that only 0.2% of 3469 hectares of forest in Telemark County, Norway, had been impounded at the time of peak density. To date, most studies of the ecological influence of beaver on biodiversity have been conducted in North America, though the number of studies involving both species of beaver in Eurasian ecosystems is increasing (Rosell et al. 2005) including e.g. their influence on populations of fish (Hägglund and Sjöberg 1999, Parker and Rønning 2007), insectivorous bats (Ciechanowski et al. 2011, Nummi et al. 2011), amphibians (Dalbeck et al. 2007, Bashinskiy 2008) and waterfowl (Nummi 1989;1992, Nummi and Poysa 1997, Nummi and Hahtola 2008), but see also chapters 13-20 in Sjöberg and Ball (2011). Future research will continue to unravel the role of the beaver in Eurasian ecosystems.

6.1 How does modern forestry affect beaver populations?

Much has been written about how beaver affect forestry in the Nordic countries (see review in Parker et al. 2001), but how does intensive forest management affect beaver density and production? Beaver favor pre-thinning and thinning-age stands containing a large proportion of young to middle-aged broad-leaf species, in particular aspen (*Populus tremula*) and birch (*Betula pubescens* and *B. verrucosa*) (Härkönen 1999, Fryxell 2001, Parker et al. 2001a). Following clear-cutting in Nordic forests, the initial new growth is dominated by many of the broad-leaf species favored by beaver (Solbraa 1996). This suggests that as long as broadleaves in the younger age-class stands adjacent to shoreline are not excessively thinned or killed with defoliant, modern clear-cut forestry may actually increase beaver density, compared to the selective cutting of older trees or even natural regeneration cycles.

7. Population estimation

Beginning in 1997, and according to current beaver management by-laws, municipal wildlife managers are required to arrive at a municipal beaver quota once the decision to initiate harvesting has been made. How this quota is to be arrived at, however, is not specified by law. The quota is then divided among beaver management units according to the relative amount of beaver habitat or length of beaver-utilized shoreline found on each.

Numerous methods for estimating and monitoring beaver population size have been developed (see reviews in Novak 1987 and Rosell and Parker 1995). Among mammals, beaver are unusual in that the location of occupied territories is easy to detect in late autumn from the presence of e.g. fresh scent marks, newly felled trees, food caches, and lodges and dams in use (Novak 1987, Rosell and Parker 1995). The number of animals in a colony, however, is difficult to determine (Rosell et al. 2006). Therefore, population size is usually expressed as number of colonies (sometimes referred to as occupied colonies or occupied sites). When an estimate of the actual number of animals in the population is desired, a mean colony size of 4 is often employed for the Eurasian beaver (Parker et al. 2002b, Rosell et al. 2006).

Because sign of previous beaver activity remains visible for many years, and since previously and presently occupied sites can usually be discriminated, it is possible during a census to map both presently and previously occupied sites. In populations that have stabilized after 35-50 years of occupation, i.e. phase 2 in Fig. 3, beaver will have found and occupied at least once almost all suitable sites. Following extensive foraging, sites are abandoned for a varying number of years. Once preferred food species have grown back in sufficient quantity, a new period of colonization will eventually occur. Thus a source-sink dynamics pattern of site occupation and abandonment becomes established, with rotation times varying depending on e.g. habitat quality and harvest levels (Fryxell 2001). In these populations, and at a landscape scale including most types of beaver habitat (e.g. $> \approx 100 \text{ km}^2$), the proportion of sites occupied (site occupation rate) at any time tends to vary between 0.33 and 0.50 (Table 1). Thus, on average, $\frac{1}{3}$ to $\frac{1}{2}$ of the potential beaver habitat within a larger area will be in use at any time.

7.1 Methods to determine colony number

The following first 3 methods are the most commonly used to determine the number of colonies or occupied sites in Norwegian municipalities. Methods 4 and 5 have yet to be tested and therefore are of potential interest only.

1) **Total census:** A total census of all habitats suspected to contain beaver can be conducted on foot or by boat or canoe, usually in October after the construction of winter food caches has started (Rosell and Parker 1995, Parker et al. 2002b). Though a total count of colonies may be costly, key information on the number of previously occupied sites and location of beaver-utilized shoreline can be gathered simultaneously. For municipalities with beaver populations in phase 2 (Fig. 3), and when more precise population information is needed, this method is to be recommended. The method is technically straightforward, can be executed by personnel or volunteers with little training, and can be financed through the municipal wildlife management fund available

to each township. As most beaver habitat in Norway lies near some kind of road, most is easily reached for censusing (Parker 2000, Uren et al. 2000). The census can also be conducted over several years if necessary, and for most management purposes would normally need to be conducted only once. By incorporating beaver habitat and colony location data plus localities prone to beaver damage into the Geographical Information System (GIS) database of each township, a continual information update can be easily maintained (Parker 2000, Uren et al. 2000). Total census data also aids landowners in planning and organizing beaver management units, and municipal managers in distributing quotas to management units based on the length on beaver-utilized shoreline in each.

2) **Moose-hunter counts:** During each hunting season throughout most of Fennoscandia, moose hunters record data on the sex, age and number of moose seen during the hunt, as well as hunter effort (Solberg and Saether 1999). Lav Sund (1979) and Hartman (1994) conducted questionnaire surveys of moose-hunting team leaders to estimate autumn beaver colony density in Sweden and found the method to be precise enough when conducted on a relatively large landscape scale. Härkönen (1999) reported that the method, together with information from other sources, has been used in Finland for many years. Parker et al. (2002a) however, tested the method against a total count in Bø Township (266 km²) and found that teams, for numerous reasons, under-counted occupied lodges by 62%. They suggested that the method might function best as an index of population change, rather than an estimate of density. It is possible that information reported by beaver hunters on e.g. the number, weight class and sex of animals shot, number of occupied sites observed, number of days hunted and area hunted in, plus the number seen, could form the basis for a reliable index of population size and trend as outlined by Parker (2000) and similar to the system employed by moose hunters (“*Sett elg*”) on moose populations (Solberg and Saether 1999).

3) **Diverse information:** Miscellaneous information on colony number and location gathered from hunters, landowners and local inhabitants is probably the most common source of information employed by municipal wildlife managers. It appears to fill the need in many municipalities, particularly where hunting pressure is low and the need for precise population information is less critical.

4) **Stratified random sampling:** Another method, still under development (Parker et al. 1998), involves the use of stratified random sampling to sample the number of occupied sites in autumn. The beaver population on the area in question, e.g. a municipality, must have entered phase 2 (Fig. 3) with most potential colony sites having been occupied at least once. On a standard 1/50,000 scale map of the area, each km² quadrat is divided into four equal sections, resulting in a map grid of 0.25 km² quadrats. Those quadrats containing a previously or presently occupied lodge are categorized as “beaver habitat” based on a previously conducted total ground census of the area. Future sampling is limited only to those quadrats defined as beaver habitat. Using Bø Township as an example, 846 quadrats contained water (i.e. were potential beaver habitat), but only 158 (19%) were categorized as beaver habitat. Seventy-nine percent of the beaver habitat quadrats were situated within 200 m of some kind of road, and therefore easily accessible for future censusing. The method is best suited for areas >500 km² in size and in landscapes readily accessible by roads, i.e. criteria that describe many Norwegian municipalities. Regular use of the method within a selection of municipalities in each county would provide basic information on long-term beaver population

fluctuation at the landscape scale. In our estimation, few municipalities would need the precision provided by the method to effectively manage their beaver populations.

Table 1. Areal density of occupied beaver (*Castor fiber*) colonies in different landscapes and linear density along low gradient rivers in Norway and Sweden. Hunting pressure at all sites varied from nothing to light, with seemingly little effect on colony density. Densities were measured after a minimum population occupation time of 35 years, after which most populations, at the landscape scales presented here, appear to stabilize following initial peaks (Hartman 1994). Values in parentheses represent the landscape areas (km²) and river lengths (km) involved in each study. The “Total” column shows density values for combinations of landscapes.

Reference	Landscape Category					Census form ^f	Percent site occupation ^g	Approximate Population Age (years) ^h
	Forest (F) ^a (colonies/km ²)	Agricultural (Ag) ^b (colonies/km ²)	Alpine (Al) ^c (colonies/km ²)	River (R) ^d (colonies/km)	Total ^e (colonies/km ²) (landscapes)			
Campbell et al. 2005				0.50 (22 km)		Total count	100	70
Parker & Rønning 2007				0.40 (65 km)	0.32 (105 km ²) (F,Ag,R)	Total count		47
Hartman 1994					0.22 (10,580 km ²) (F,Ag,R)	Moose hunting teams		34
Hartman 1994					0.17 (3385 km ²) (F,Ag,R)	Moose hunting teams		25
Eikeland 2004		0.43 (30 km ²)				Total count	59	40

Bergan 2003	0.24 (128 km ²)					Total count		80
Parker et al. 2002b	0.22 (217 km ²)	0.50 (26 km ²)			0.25 (251 km ²) (F,Ag,R)	Total count	40	80
Mossing 2005			0.04 (165 km ²)			Total count	28	60
Mean values:	0.23	0.47		0.45	0.24 (N = 4)			

^a Primarily boreal forest < 600 m above sea level including smaller lakes and all streams.

^b Primarily farmland. Most water sources have a forested edge.

^c Primarily sub-alpine birch (*Betula pubescens*) forest or shrub willow (*Salix. spp.*) heathland 880-975 m above sea level.

^d "River" refers to low gradient, meandering streams normally 20-80 m wide. Beaver territories encompassed both sides. Therefore, territory length is measured midstream. Due to their low gradients, most sections of these rivers would typically be included in a territory.

^e "Total" refers to the colony density when several landscape forms are combined into a single area, including rivers.

^f All censuses were performed in mid- to late-autumn after most single beaver or family units had located for the winter, usually with a food cache started. Counts were either total ground counts made on foot or with a canoe, or based on counts made by moose hunting teams using a method reported to be reliable (Lavsund 1979, Hartman 1994).

^g Proportion of previously occupied sites that were occupied at the time of each study.

^h Approximate time in years from the first established colony in the area to the date the census was conducted. Figures were rounded off to the nearest decade when exact values were not provided.

However, for research studies requiring more precise population data the method should prove useful.

5) **Use of “comparable data” on colony density:** Larger municipalities (>200 km²?) containing “typical” beaver habitat and with well established populations could base their quotas on colony densities measured in other municipalities with similar habitat. Table 1 summarizes the present published information on the colony density of Eurasian beaver in Nordic landscapes in well established populations, i.e. apparently at the phase 2 level (Fig. 3). The mean density for all landscapes combined containing beaver habitat (column “Total”), excluding alpine habitats, reveals a mean colony density of 0.24 colonies per km², or approximately 1 colony per 4 km² of beaver habitat. In the absence of other information on colony density, we suggest that this figure be employed as a reasonable approximation, i.e. the number of autumn colonies = km² of beaver habitat/4. In municipalities with light hunting pressure, even considerable population over-estimates using this method are not likely to result in significant over-harvesting.

Regardless of the method used to determine the number of colonies in a township, with the exception of a total census, any figure will only be an estimate. Furthermore, the real colony number will always be subject to annual change. The most important function of the municipal colony number is to form the basis for the distribution of the annual quota to beaver management units, based on their relative size. Unless there is reason to believe that the number of colonies in the township has changed significantly, the same municipal colony number can be used year after year. As long as municipal harvest success rates (annual bag/annual quota) tend to be low, as they seem to presently be, there is little chance that serious over-harvesting will occur. A low interest in beaver hunting also reduces the need for precise, pre-hunt population estimates. In short, even a large over-estimate of the true population size will seldom lead to over-harvesting when interest for hunting beaver is low.

8. Harvest management

After having been extirpated throughout most of Eurasia, beaver are now returning to previously occupied landscapes throughout the continent and to a human population with a new ecological awareness and precise management goals (Nolet and Rosell 1998, Halley and Rosell 2002). While beaver generally enhance biodiversity (Wright et al. 2002, Rosell et al. 2005) and help to stabilize hydrological cycles (Naiman et al. 1986, Naiman et al. 1988, Wright et al. 2002), they can also cause considerable damage (Härkönen 1999, Parker et al. 2001a). In some countries they are also an important source of fur, meat and recreation for hunters and trappers (Hartman 1999, Parker et al. 2002b), as well as income for landowners (Parker et al. 2001a). It is therefore likely that population management involving some form of harvesting will be an important part of the management schemes of many Eurasian countries in the foreseeable future (Parker and Rosell 2003).

8.1 Beaver “hunting” – currently a unique Nordic harvest model

For reasons outlined in section 3.1, most beaver in Norway are shot in spring rather than trapped in winter. This is also the common harvest pattern in Sweden and Finland (Hartman 1999), but apparently not elsewhere (Parker and Rosell 2003). Thus spring beaver hunting, at present, appears to be a unique Nordic harvest model (Parker and Rosell 2003, Parker et al. 2006). Though some spring shooting of beaver is practiced in North America, particularly in northern Canada and Alaska (Estland 2000), trapping is still the dominant harvest form both there and in the countries of the former Soviet Union (Novak 1987, Parker and Rosell 2003). We suspect that spring hunting will remain the main harvest form throughout Fennoscandia in the foreseeable future.

8.2 Why has the beaver harvest in Norway apparently declined nationally and in most regions?

Game harvest data provide important information for managers, but often do not reflect changes in population size (Sutherland 2001). The Norwegian national beaver harvest, beginning in 1984-85 (Fig. 4), reveals an unexpected pattern involving an initial 3-fold increase during the first five years, followed by an abrupt decline and gradual leveling-out. Since the beaver population has been slowly expanding in Norway, along with the number of municipalities allowing beaver hunting and trapping, a gradual increase in the total harvest would normally have been expected. Are these figures a reliable measure of the harvest, and if so, what kind of useful management information do they reveal?

8.2.1 Harvest monitoring methods employed have changed often

Methods for recording the national beaver harvest have varied considerably during the past few decades (Statistisk Sentralbureau 2012). From 1985 to 1993 the harvest estimates of all game killed were based on questionnaires sent to a random sample of 4% of all registered hunters (not all registered hunters actually hunt each year). From 1994 to the present, however, all registered hunters having actually bought a national license during the past hunting season were requested to report the number of game animals they had shot or trapped, in essence an attempt at a total harvest count. Not all hunters however responded, and in order to measure response error, from 1995 to 2000 those hunters not responding were sampled again. We do not know if or how this additional sample information was used to adjust the estimate. From 2001 to the present this additional sampling ceased. In its place, hunters not reporting the previous season's bag

were instead “fined” by having to pay an additional fee for the next years hunting license.

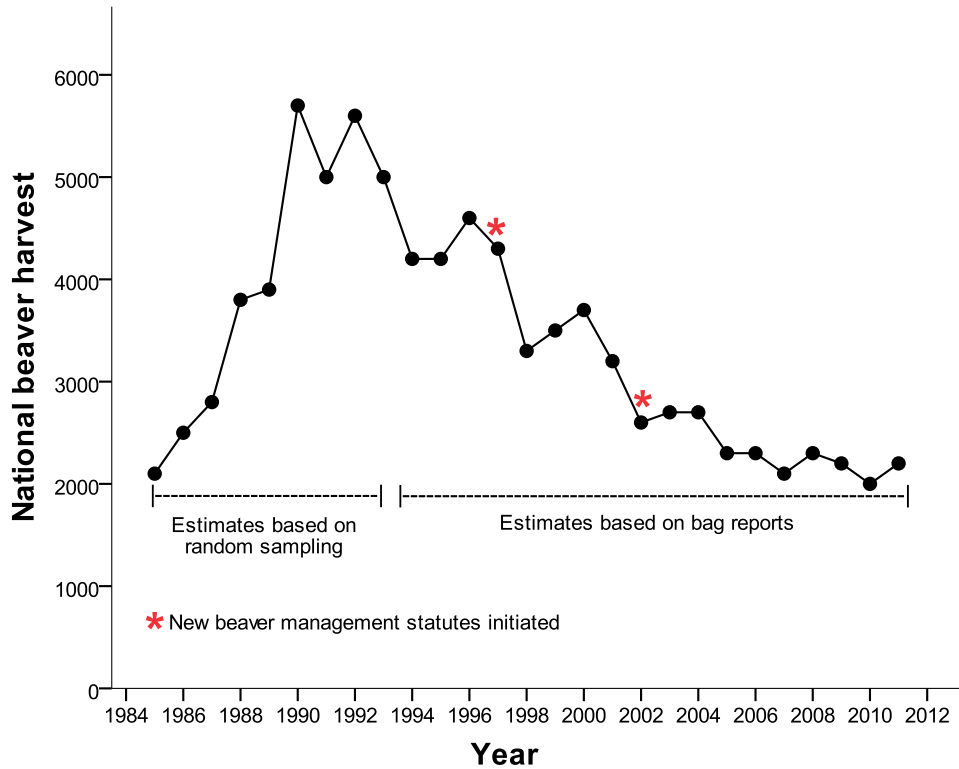


Figure 4. The annual Norwegian beaver (*Castor fiber*) harvest for seasons 1984/85 - 2010/11. As the open season for beaver extends from autumn to spring, the yearly designations in the figure refer to the year in which the hunting season ended (i.e. 1984/85 = 1985). From 1985 to 1993 estimates of all game bagged were based on questionnaires sent to a random sample of 4% of all registered hunters. From 1994 to the present, estimates are based on bag reports that all registered hunters actually buying a national license during the past hunting season were requested to submit. From 1995 to 2000, those hunters not responding were sampled again in order to obtain a measure of response error. Beginning in 2001, this additional sampling scheme was terminated and replaced with a system whereby hunters not reporting the previous season’s bag were “fined” by having to pay an additional fee for the next years hunting license. New beaver management by-laws were initiated in 1997 and 2002.

We have no means of evaluating how these numerous changes in methodology may have affected the annual bag figures, though they suggest dissatisfaction with the methods used and can be expected to increase the degree of error involved in the data set. In particular we suspect that the 46% harvest increase from 1989 to 1990 (Fig.4), followed by an abrupt fall, to be erroneous. It was based on a 4 % random sample of all hunters of which few actually hunted beaver, and of which many did not reply. Likewise, the abrupt fall from 1990-1994 seems strange, particularly since no known change in methodology occurred during this period. There is reason to believe that harvest figures from 2001 to

the present, which also show little annual variation, are the most reliable to date since no method changes were made and hunters were indirectly rewarded (i.e. not required to pay an additional hunting license fee) when submitting the requested bag data. Consequently, it seems likely that the data from 2001-2011 (Fig. 4) are a good portrayal of the true legal harvest, a trend which shows a leveling-off tendency. Unfortunately, data on hunter effort are not available.

8.2.2 Could the beaver population actually be falling in some counties?

The county-wise national harvest from 1994 to the present (Fig. 5) shows that 72% of the bag in 2011 originated from only 4 of 11 counties. Thus the national harvest trend is strongly influenced by these 4. The harvest size and trend in each individual county (Fig. 6), again from 1994 when hunters began reporting bag results themselves, shows significant harvest declines in 5 counties, no significant change in 4, and significant increases in 2. The 5 counties showing declines, i.e. Vest-Agder, Aust-Agder, Telemark, Hedmark and Vestfold, are the counties with the oldest populations, all having had beaver for at least 50 years. We therefore suspect that most suitable beaver habitats in these counties, with the possible exception of sub-alpine regions, have experienced the expected initial population peak and decline illustrated by phase 1 in Fig. 3. Consequently, these populations most likely entered the more stable post-peak stage of population development decades ago, and are presently fluctuating around a more stable mean as illustrated by phase 2 in Fig. 3. All five counties, and in particular Telemark and Hedmark, for some reason show a flattening out trend during the last 5 years.

Assuming that the harvest data from 1994 are reasonably accurate, we suspect that one of the three following scenarios best explains the observed harvest decline in these 5 counties.

- 1) Populations are, in fact, still experiencing the initial phase 1 decline and the harvest reflects this.
- 2) Populations have entered the more stable phase 2 but are being over-exploited, so both populations and the harvest are therefore declining.
- 3) Populations are either relatively stable or even increasing but hunting effort for some reason has declined, either because the number of beaver hunters has declined or because access to beaver hunting has become more difficult; or both.

Unfortunately we have very little data to either support or refute these potential scenarios. However, we have no reason to believe that a prolonged over-exploitation has been

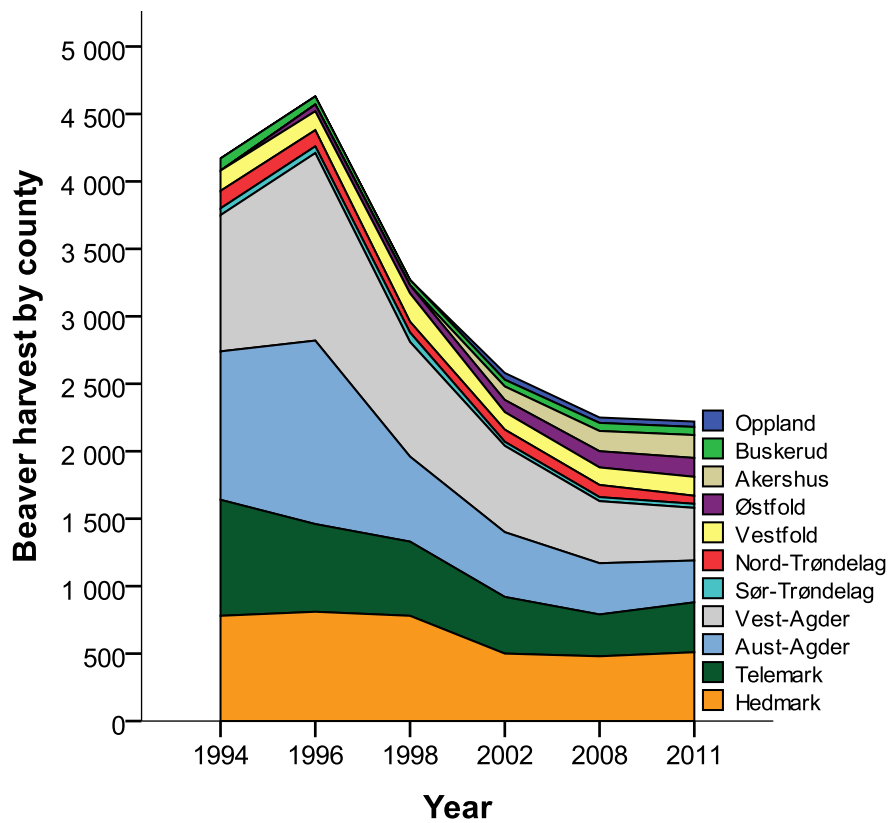


Figure 5. The annual beaver (*Castor fiber*) harvest by county for Norway for hunting seasons 1993/1994 - 2010/2011.

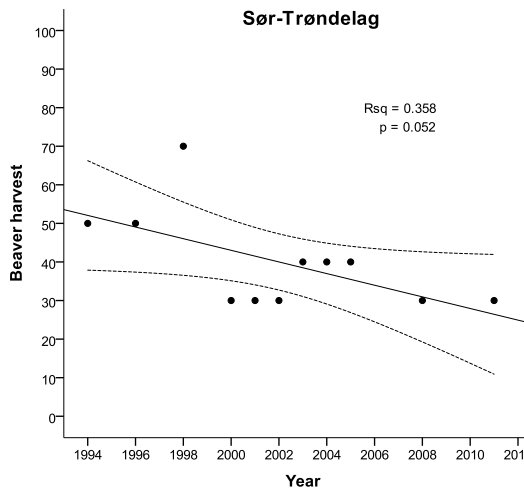
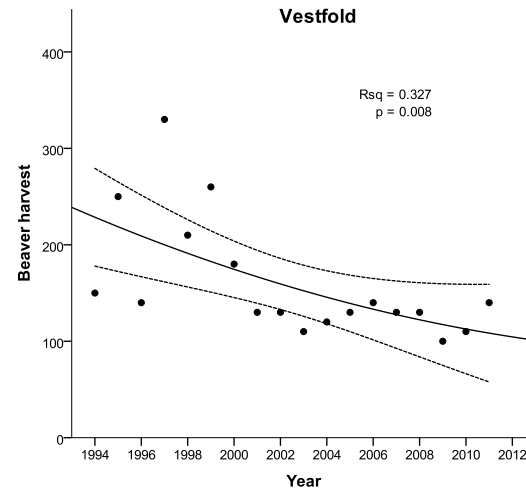
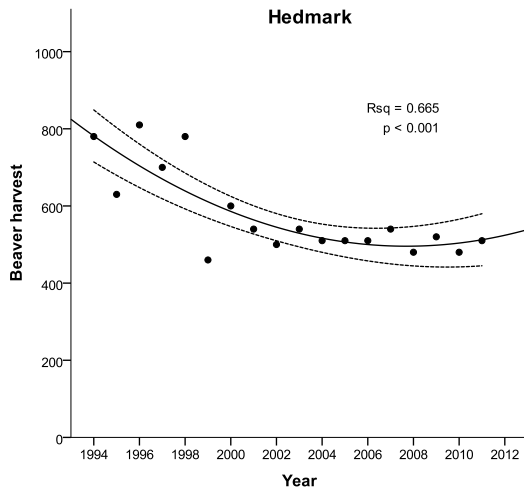
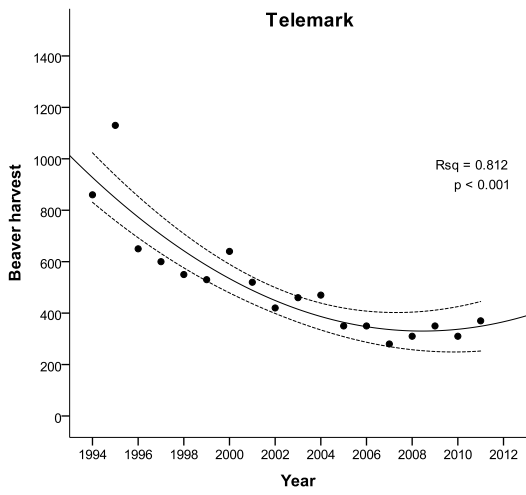
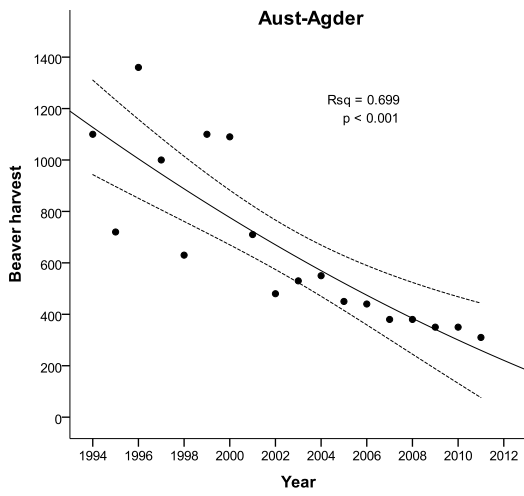
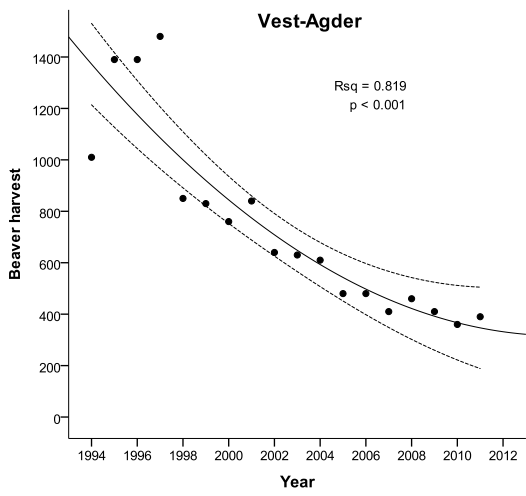
occurring in these counties. On the contrary, based on contact with hunters and municipal wildlife managers, we suspect that hunter effort has indeed been falling and that scenario 3 best explains the harvest fall in these 5 counties.

8.2.3 Might late spring thaws be influencing the harvest decline?

Most beaver are shot during the last two weeks of the season in late April (Parker and Rosell 2001). In years with late spring thaw, fewer beaver emerge from their lodges before the season closes, meaning that fewer are exposed to hunters. Therefore, the beaver harvest may be particularly sensitive to the mean temperature in April. If those counties with the largest harvests have experienced many late spring thaws since 1994, this might help explain the observed decline.

To investigate this possibility, we first pooled the annual harvest data in the 3 neighboring counties of Vest-Agder, Aust-Agder and Telemark for the period 1994-2010.

We then regressed this harvest data, as well as the monthly mean temperature in April, on year (Fig. 7). As the temperature in April showed a significant increase during this period, rather than the opposite, the time of spring thaw can hardly have contributed to the observed harvest decline. We suspect that increasing April temperatures, as predicted by current climate models for Norway (Hanssen-Bauer et al. 2003), will in fact gradually improve spring hunting conditions.



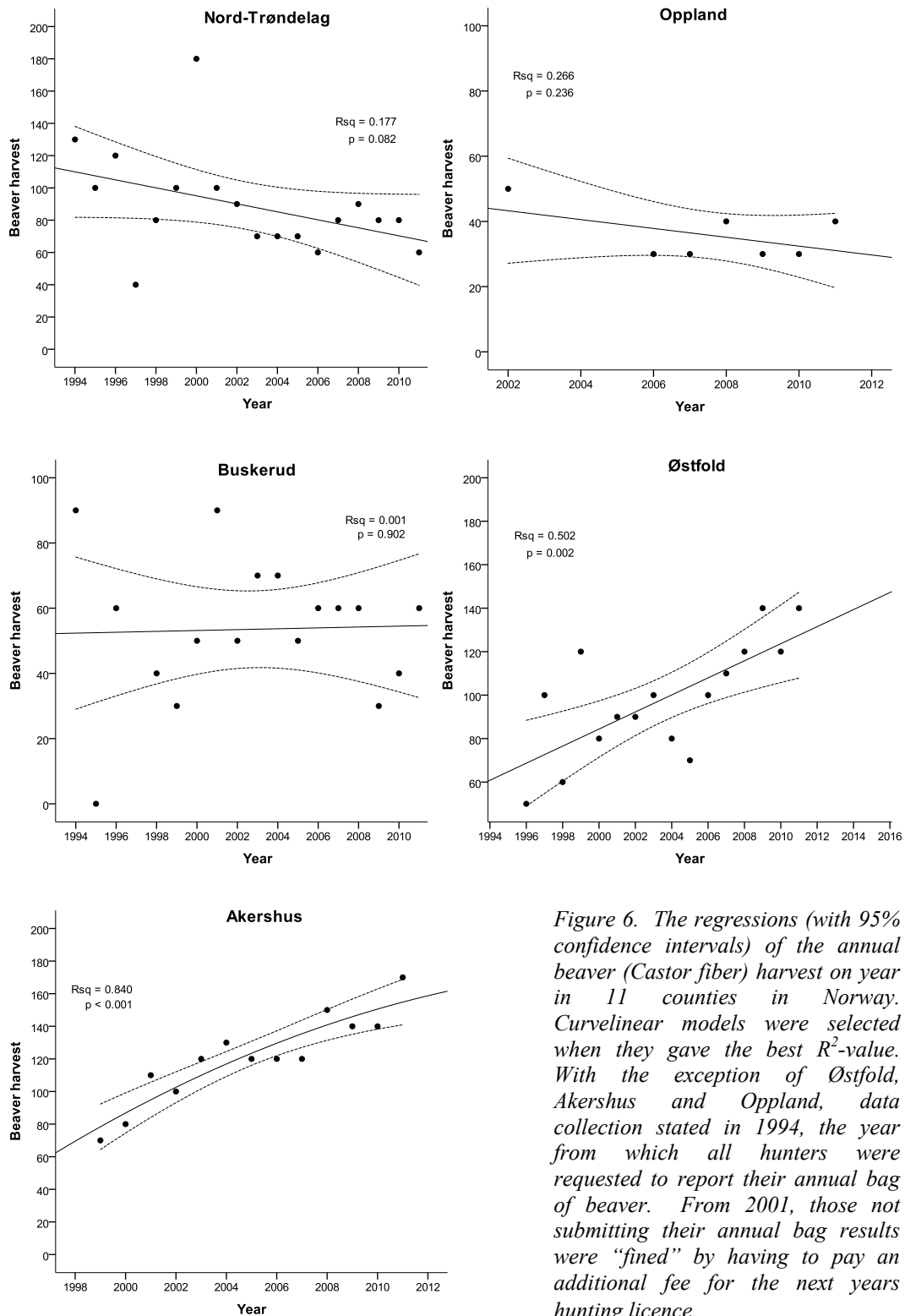


Figure 6. The regressions (with 95% confidence intervals) of the annual beaver (*Castor fiber*) harvest on year in 11 counties in Norway. Curvilinear models were selected when they gave the best R^2 -value. With the exception of Østfold, Akershus and Oppland, data collection stated in 1994, the year from which all hunters were requested to report their annual bag of beaver. From 2001, those not submitting their annual bag results were “fined” by having to pay an additional fee for the next years hunting licence.

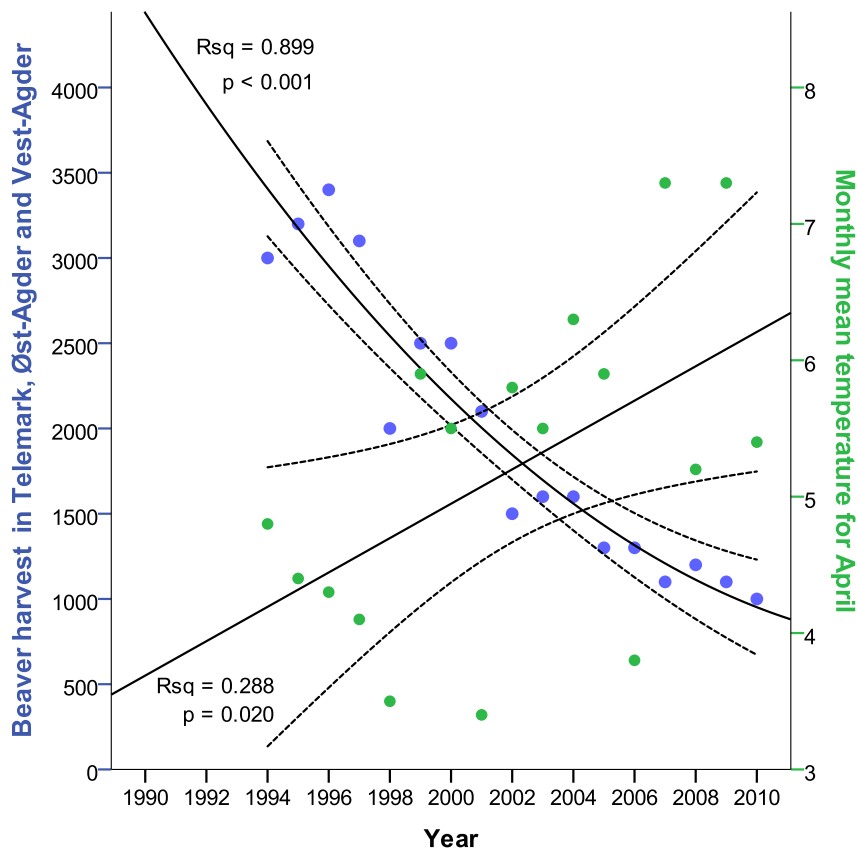


Figure 7. Regression of the beaver (*Castor fiber*) harvest in three neighboring counties in southeast Norway on harvest year, together with the regression of the monthly mean temperature in April for the same counties and same period. Most beaver in Norway are shot during April.

Why four counties have shown stable harvest levels and two counties increasing trends (Fig. 6) is difficult to say, though all six have more recently opened for beaver hunting than the five showing declines. If the hunting effort is concentrated to areas where the beaver population is still rapidly increasing, which is to be expected, this could explain the increasing harvest. Indeed, the relatively small county of Akershus which lies in the midst of Norway's major population center near the capitol of Oslo houses more active hunters than any other Norwegian county, and has a presumably growing beaver population. Thus the harvest here may, in fact, be tracking the population increase.

8.2.4 Has hunter effort been declining?

Though the total number of hunters in Norway has increased slowly during the past 10 years, mean age is also increasing and the recruitment of new hunters into the population

has begun to decline (Statistisk Sentralbureau 2012). In our experience, beaver hunters tend to be younger than average, possibly because beaver hunting is less expensive and often free, and therefore more affordable for younger hunters than most other hunting. This ageing of the hunter population, together with a declining recruitment of younger hunters, may be having a greater effect on hunter effort among beaver hunters than those hunting other species. However, this alone seems hardly sufficient to explain the near 50% decline in the harvest since 1994.

New beaver management by-laws were established in 1997 and 2002, and though new laws are intended to improve existing laws, this may not always happen. When cervid management units can also function as beaver management units, the current beaver management by-law usually functions well. However, in those townships containing considerable beaver-rich farmland, the current by-law functions poorly because farmland in most townships is not classified as cervid habitat. In these townships, many small landowners are therefore forced to organize special beaver management units in farmland in order to receive a beaver quota there. This requires an extra organizational effort many are not willing to make, simply because the economic returns involved are usually small. Without management units no quotas are issued and the harvest suffers.

8.3 At what population stage should harvesting start?

After more than a century of beaver population growth approximately half of the country is still uninhabited (Fig. 2). Therefore many municipalities with newly established beaver populations will be faced with having to decide when harvesting should begin. Many appear to delay much longer than necessary, i.e. until populations are near or even past the initial phase 1 peak (Fig. 3) before opening for harvest, apparently for fear of over-harvesting. This usually results in considerable over-browsing of preferred broadleaf species (Hartman 1994, Fryxell 2001) and widespread reports of damage, followed by steep population declines. If harvesting is first initiated near the peak, the abrupt population fall that inevitably results often gets wrongly blamed on over-exploitation.

8.3.1 Can the initial population peak and decline be avoided?

A goal of modern beaver management is to minimize damage complaints. This may, in part, be accomplished by limiting both the number and location of occupied sites. As populations increase, so will the number of occupied sites. Therefore avoiding the initial peak, as well as maintaining colony number below carrying capacity should also limit reports of damage. To accomplish this, limited hunting and trapping should begin early in the population growth phase, before the maximum growth rate is reached. This allows time for a local group of beaver hunters and trappers to become established and gain experience. As the population grows the harvest effort can increase, concentrated in particular to locations experiencing serious damage. Here an attempt to remove all colony members should be made. If the takeoff is maintained near the maximum rate of

increase, the initial peak and its associated negative aspects can be avoided, while simultaneously sustaining a high harvest (Fig. 8). Subsequence maintenance of a population level somewhat below carrying capacity should increase net recruitment and therefore the potential harvest (Sutherland 2001, Sinclair et al. 2006), create more hunting opportunities, and reduce damage claims. Colonies with the greatest biodiversity and non-consumptive recreational potential can either be harvested lightly, or not at all.



Figure 8. The anticipated population curves for an unharvested (or lightly harvested) beaver (*Castor fiber*) population and a more optimally harvested population where hunting and trapping begin early and takeoff is approximately balanced with net population growth at a relatively low colony density. The management goal is to avoid an initial “over-shoot” peak with extensive over-browsing and to maintain the population at a lower, more productive and hopefully more stable population level.

However, achieving this is no easy task and to date we know of no municipality or large estate that has managed to avoid the initial peak and subsequent decline. We suspect, however, that most municipal beaver populations in Norway could sustain considerably higher harvest levels through a better planned harvest management. At present, beaver population management in Norway is considerably less refined than for e.g. moose (Jerstad et al. 2003).

8.4 Beaver population management through hunting

After having been nearly trapped and hunted to extinction, beaver are returning to former landscapes considerably altered by humans. Though still valued for their pelt and as food, beaver increasingly are being appreciated for their ecological role as a keystone species (Nolet and Rosell 1998, Rosell et al. 2005). This has created an array of new

management challenges involving the species' ecological importance, economic value and animal welfare status. Amidst all the conflict, however, trapping and hunting continue to be key management tools for population regulation in many countries, and are likely remain so for many years to come. For reasons outlined in section 3.1, the main harvest form for beaver in Norway, Sweden and Finland has recently changed from economically motivated fur-trapping to recreational hunting.

8.4.1 Do hunters exploit the population randomly?

The selective nature of different harvest forms and how they influence the reproductive potential, genetic structure and life history development of wild populations has been a topic of increasing interest among wildlife and fisheries managers (Sinclair et al. 2006). The harvesting of game species is often directed at a particular sex or age group, typically to select for trophy individuals or to control reproduction (Sinclair et al. 2006). For species showing sexual dimorphism, or where juveniles can readily be distinguished from adults, hunters can easily select individuals according to sex and age. Beaver however, cannot be sexed or reliably aged under spring hunting conditions, so hunters normally shoot the first animal seen (Parker et al. 2001c, Parker et al. 2002b). Parker et al. (2002b) investigated the sex, age and reproductive status of spring-shot beaver and found that the sex ratio did not deviate significantly from a 50:50 distribution in any age group. Adults however, and in particular pregnant females, were more likely to be the first individuals shot from colonies. Why pregnant females are more susceptible to being shot first is still uncertain, though the nutritional demands of late pregnancy may lead them more often to shore in search of high quality nutrition than other beaver, thereby exposing them more often to hunters (Parker et al. 2002b). If pregnant females also tend to emerge first from the lodge they will tend to be shot first, since most hunters usually shoot the first beaver they see. However, Parker et al. (2001b) did not find evidence for this.

8.4.2 Is it possible to avoid shooting pregnant females?

Female beaver shot in late April are often in the advanced stages of pregnancy, a situation that many hunters and non-hunters alike are not comfortable with (Frafjord 1991, Solheim 1991, Parker and Rosell 2001). Hunting in spring also challenges the general management principle of not harvesting game populations during the reproductive season. Can the shooting of pregnant females be avoided? Most hunting occurs in the evening and most animals are shot at the water's edge while scent-marking or foraging (Parker et al. 2002b). Parker et al. (2001b) investigated whether pregnant females were more susceptible to being shot early or late in the spring season, at a particular time of day, or at a particular distance from the lodge (hunters often post near the lodge) to evaluate these criteria as a basis for selective shooting. They also examined the potential for using body size to selectively harvest age groups.

Neither period of the season nor the time of day beaver were shot were reliable grounds for selection. However, pregnant females were shot significantly further away from the lodge than juveniles and averaged 2.6 times heavier. Thus hunting nearer the lodge and attempting to shoot smaller individuals may reduce the takeoff of pregnant females. Likewise, hunting in the morning may reduce the takeoff of pregnant females since they

tend to retire earlier to the lodge at dawn than adult males (Parker et al. 2011). However, the most effective way to limit the shooting of pregnant females may be to concentrate the takeoff to as few colonies as possible, as each colony usually contains only one. If, in contrast, the management goal is to reduce recruitment and population density, hunting in as many colonies as possible should be an effective method (Parker et al. 2002b, Parker et al. 2011).

8.4.3 What are sustainable harvest levels?

To date, most experience with sustainable yield harvesting of beaver is from winter-trapped populations in North America (Novak 1987). In Norway, Sweden and Finland, however, spring shooting is the main harvest form (Hartman 1999, Parker et al. 2002b, Parker and Rosell 2003). Novak (1987) reviewed the literature on harvest rates for both the Eurasian and North American beavers, emphasizing that sustainable rates are dependent upon a number of factors including e.g. habitat quality, reproductive rates, and selection for sex and age groups. Parker et al. (2002b) investigated the sex and age composition of a spring-hunted beaver population in southeast Norway. They removed an estimated 24% of the population from 242 km² from mid-March to mid-May through normal hunting over three years, a takeoff rate they expected would be sustainable based on published data from trapped populations (Novak 1987). To their surprise, the number of colonies declined by 46% during the study (Fig. 9), while the proportion of juveniles in the bag declined from 26 to 3%. Adults, and in particular pregnant females were more susceptible to being shot than other sex and age groups, suggesting that a takeoff of about 25% through spring hunting may be unsustainable in the long run. The authors suggested that the level of sustainability is likely between 10-20% dependent upon habitat quality, how colonies are harvested and the population net reproduction rate (Parker et al. 2002b). This figure is lower than most values suggested for trapped populations of both species (Novak 1987).

Though the question of what constitutes sustainable harvest levels of spring-hunted Eurasian beaver needs further testing, to date we have no evidence to indicate that prolonged over-harvesting is occurring in Norway at the municipal level. Indeed, the 24% harvest rate by spring hunting reported by Parker et al. (2002b) required an unusually large hunter effort (Parker and Rosell, unpublished). Since recreation rather than economic gain is the prime motivation for hunting beaver, it appears that hunting effort tends to fall as populations decline, an apparent demonstration of “the law of diminishing returns” (Leopold 1933).

8.4.4 Setting municipal quotas

Once the colony number for a township has been determined, we suggest that the annual quota be determined by issuing one beaver per colony. With a 100% harvest success and an average of 4 animals per colony this would amount to a takeoff of about 25%, which appears to be unsustainable when spring hunting is the main exploitation form. However, since a harvest success in excess of 50% seems to be rare, this model should lead to a harvest rate of about 10-15%, a level that Parker et al. (2002b) believed to be sustainable. Therefore, until experience proves otherwise, we suggest that one animal per colony be

issued as a beginning quota. This quota can be maintained until new information on colony number suggests that an adjustment should be made.

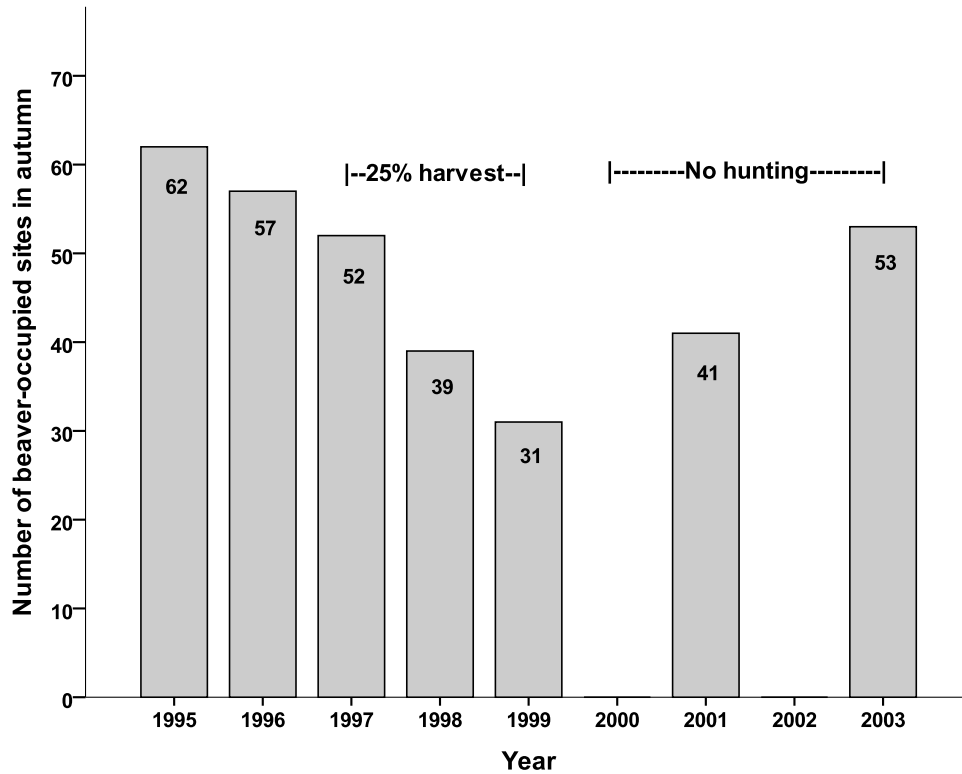


Figure 9. Change in the number of beaver-occupied (*Castor fiber*) sites in autumn on 242 km² in Bø Township, Telemark County, Norway following an annual mean harvest rate of 24% (range 22-26%) over 3 years. Beaver were shot during normal hunting from mid-March to mid-May. After a 4-year period of no hunting, the number of occupied sites in autumn had returned to 93% of the pre-harvest (1996) level (Parker et al. 2002b).

9. Beaver damage management

Initially, all beaver dams and lodges are protected by the “Nature Diversity Act”. In cases where beaver cause “considerable” damage to property, crops, fruit trees or forest, landowners can apply to municipal wildlife authorities for permission to remove dams and lodges, and to trap or shoot damage individuals outside the normal hunting season. Municipal wildlife authorities decide what constitutes considerable damage, though the landowner’s own evaluation often weighs heavily. Animals trapped or shot either become municipal property or are given to the landowner and subtracted from his hunting quota.

Once permission has been granted, landowners themselves are responsible for removing dams, lodges and nuisance beaver from their own property and must cover the costs involved. However, local trappers or hunters are often willing to remove nuisance animals free of charge in exchange for the carcass. Trapping is usually more efficient than shooting for removing nuisance beaver in acute situations (Hammerson 1994). No governmental or private compensation for damage caused by beaver is paid to landowners. Thus the cost of beaver management to government agencies in Norway is negligible.

A major goal of Norwegian beaver management has been to transform the status of beaver from nuisance animal to keystone species and valuable game resource. This goal can partly be accomplished by concentrating the hunting effort to nuisance colonies and by holding colony density below carrying capacity through trapping and hunting to minimize damage. Landowners, however, must first be motivated to organize beaver management units large enough to receive a harvest quota. If landowners do not wish to hunt beaver themselves, which is often the case, the hunting can then be leased to others, thus providing income to landowners that will partly or wholly compensate for damage sustained (Parker et al. 2001a). Ironically, many hunters are unable to obtain beaver hunting, despite damage complaints, simply because landowners are not well enough organized to receive quotas. Municipal beaver management plans should include maps that show hunters where damage is often a problem (Parker 2000) and landowners should direct hunters to these sites when necessary.

Damage from flooding and tree-felling in Norway is minor (Parker et al. 2001a) compared to that experienced in parts of North America (Arner and Dubose 1982, Wigley and Garner 1987) and Finland (Härkönen 1999). This is primarily because dams built in mountainous landscapes usually result in small impoundments and because birch *Betula pubescens*, aspen *Populus tremula* and willow *Salix spp.*, the dominating species felled by beaver in Norway, normally have less commercial value than conifers. Thus the negative economic effects of beaver damage in Norway may be easier to compensate for through the lease of hunting rights than would be possible in countries experiencing more extensive damage.

The relative economic loss that beaver inflict on forest owners is also dependent upon property size. Parker et al. (2001a) demonstrated that in typical Norwegian

landscapes, large forest owners, in the long run, would be likely to lose only about 0.1% of their conifer production from flooding by beaver. For a forest owner, this is a negligible loss compared to the combined losses from e.g. insect damage, windfall, moose grazing and disease. Owners of small forest properties however, of which there are many in Norway, may occasionally experience considerable beaver damage if a dam is built or many trees are felled on their small property. In Norway, forest properties are relatively small averaging only about 50 hectares for those > 2.5 hectares (Nedkvitne et al. 1990). Thus Norwegian wildlife managers deal with relatively many complaints, in part because there are many small landowners. Beaver activity occurring in agricultural, urban and suburban landscapes can be particularly damaging and solutions to conflicts controversial (De Almeida 1987, Conover 2002). In Norway, reports of nuisance beaver in these landscapes are relatively few as only a small proportion of the country is cultivated (4%) or residential (1%).

9.1 Does beaver hunting limit population density?

Although there may be no direct one-to-one relationship between an increasing wildlife population and the severity of a specific wildlife problem, human-wildlife conflicts usually tend to increase with increasing population density (Conover 2002). An implicit goal of Norwegian beaver management is damage reduction through population control, but is spring hunting an effective method for accomplishing this?

Though precise data are lacking, our experience suggests that present mortality rates from hunting and trapping in most Norwegian townships are insufficient to significantly reduce the density of individual beaver or colonies at this scale. The national legal beaver harvest for the years 2005 – 2011 averaged approximately 2200 individuals (Fig. 4). Assuming a population size of approximately 70,000 (Parker and Rosell 2003) gives an annual harvest of 3%, which presumably would have little effect on population growth and density at the national scale. On a county scale, the recent falling harvest trend in those counties with the largest beaver populations (Fig. 6) also suggests that the current hunting takeoff is relatively low, and most likely of little limiting effect. Presently, the main deterrent to beaver damage appears to be site-specific control of nuisance individuals or colonies. In our experience, landowners often report that colonies established on tributaries to larger rivers frequently cause damage. These colonies are usually established by juveniles and concentrating the hunting effort here would lessen the take-off of established adults on main rivers. A lower harvest of adults would also boost the productivity of the population, in situations where that is a management goal.

There is, however, evidence that spring hunting can effectively reduce population density. Parker et al. (2002b) shot 24% of the estimated spring population of beaver during 3 years and experienced a 47% fall in the number of occupied colonies (Fig. 9). One reason for this dramatic decline was the apparent susceptibility of adults, and particularly pregnant females, to being shot first in colonies. Following 4 years of no hunting, the population rebounded quickly (Fig. 9). In southwest Finland, hunting

mainly in spring has apparently slowed the expected rate of increase of both North American and Eurasian beaver over many years (Ermala 1997, Lahti 1997, Ermala 2001). In Sweden, however, the modest take-off from spring hunting seems to have had no additive effect on natural mortality (Hartman 1999).

In general, lethal methods are usually more effective at suppressing populations if conducted after they have passed through a mortality bottleneck (Conover 2002). Spring hunting, because it occurs just prior to reproduction and tends to select for adults (Ermala 1997, Lahti 1997, Parker et al. 2001b) has particular potential for controlling population density.

9.2 Non-lethal damage control

Aside from the removal of dams and lodges in acute cases of flooding and the use of protective sheathing around tree trunks to prevent felling, non-lethal methods to alleviate or prevent beaver damage are seldom employed in Norway (Rosell and Parker 1995, Parker and Rosell 2003). In some instances however, non-lethal control methods may prove less costly for landowners in the long run than lethal methods, while simultaneously enhancing biodiversity. Non-lethal methods presently used in beaver management or undergoing development include e.g. live capture and relocation, water level control, chemical repellants and protective sheathing to inhibit tree felling, habitat alteration, and fertility control (Hammerson 1994, Nolet and Rosell 1998, Müller-Schwarze and Sun 2003, Halley and Bevanger 2005). Though non-lethal control methods do not involve killing animals directly, they may cause suffering and are often expensive (Conover 2002).

In some instances, non-lethal control may be the only practical solution in e.g. urban areas where hunting and dead-trapping would be unsafe. Halley and Bevanger (2005) reviewed the non-lethal methods most suitable for use in Norwegian landscapes. Though it remains to be seen whether Eurasian beaver can be adequately managed on large temporal and spatial scales using only non-lethal control methods (Parker and Rosell 2003), their future application in Norwegian beaver management deserves increased attention.

10. Problems facing Norwegian beaver management

10.1 Landowner acceptance of the beaver

Whereas conservationists, hunters and the general public have embraced the return of the beaver, Norwegian farmers and forest owners have been less willing to accept it as a legitimate member of the ecosystem, a process termed reconciliation ecology (Busher and Dzieciolowski 1999). Many landowners perceive the beaver only as a problem species, due mainly to its limited economic value. In contrast, high densities of moose and red deer that often inflict considerable damage to crops and forest (Hjeljord 2008), also provide considerable income and therefore are generally accepted by landowners.

Part of the acceptance problem derives from a lack of knowledge. Increased tolerance will likely develop with increased knowledge of the beaver's ecological importance and potential economic value through more education at all age levels (Nielsen and Knuth 2001). An example of the latter is the course recently offered to Norwegian forest owners by the Norwegian Federation of Foresters on ways to increase biodiversity in managed forests, including the beaver's role (Aanderaa et al. 1996). A management problem that could be lessened through more education is the common practice among landowners of illegally removing the dams and lodges of nuisance beaver without permission. In our experience, many landowners are not aware that permission is actually required, suggesting that better information to the public would reduce this practice. Increased knowledge should lead to greater tolerance for minor damage.

10.2 Spring hunting – an animal welfare challenge

Another management problem involves recent resistance among animal welfare advocates, and sometimes hunters as well, to hunting in late spring when many adult females are shot in the late stages of pregnancy (Parker et al. 2001b, Parker & Rosell 2002). In Norway, the hunting of all wildlife is prohibited during the breeding season after young are born. This prompted Solheim (1991) and Frafjord (1991) to question whether female beaver were being shot from new-born young in late April and early May. Considerable experience from both Norway (Parker & Rosell 2001) and Sweden (Mørner 1990), however, has shown that post-partum females are not shot then. Parker & Rosell (2001) demonstrated that this was primarily because few births occur before hunting stops in early May. In addition, females are seldom seen outside the lodge during the first 1-2 weeks following parturition (Frank Rosell, personal observation.). As spring hunting is most effective during the last 2-3 weeks of the season, it seems likely that this practice will continue in the near future. However, if the present trend towards earlier springs predicted by climate models (Hanssen-Bauer

et al. 2003) and exemplified in Fig. 7 continues, the mean parturition date for beaver may gradually occur earlier. If so, the closing date for the season may need to be adjusted to avoid shooting females with new-born young.

10.3 Non-consumptive beaver management

As beaver have gradually returned to former habitats, their popularity among wildlife observers has increased. During the “white nights” of mid-summer at northern latitudes, beaver and their constructions are highly observable for tourists and others while paddling through beaver habitat on “beaver safaris”. Though beaver not exposed to hunting may be less wary and therefore easier to observe, in our experience both spring hunting and observing beaver during the off-season in the same areas are compatible. Wildlife safaris that include observing beaver are a potential source of income for local entrepreneurs, thereby increasing the acceptance of beaver locally. Landowners wishing to conserve beaver and their habitats unaffected by hunting should acquaint themselves with the non-lethal management methods reviewed by Halley and Bevanger (2005).

10.4 Is the beaver hunting effort declining?

Though studies directly addressing the problem are lacking, this appears to be the case. As outlined above, increased hunter age and a gradual decline in the recruitment of young hunters (Statistisk Sentralbureau 2012) may be contributing factors. However, we believe the main problem involves hunter access. If, for some reason, landowners do not establish beaver management units they receive no quota. Likewise, if they do not apply for their portion of the quota, despite having an approved beaver management unit, they receive no quota. In some instances units receive a quota that never gets used, neither by landowners nor others. Either way, no harvest occurs.

How often these scenarios occur is unknown, but in our experience they are not uncommon and seem to have increased in recent years, which may have contributed to the recent harvest decline (Figures 4, 5 and 6). Thus successful beaver harvest management, to a large degree, seems to rely on landowner commitment. The right to hunt is theirs, but when they do not wish to hunt beaver themselves and profit little by leasing to others, they are not motivated to perform their vital role in the management process. This leads to limited access opportunity for those non-landowners who want to hunt beaver. Younger hunters in particular, who often find access to hunting particularly difficult (Andersen and Kaltenborn 2007) may be easily discouraged from hunting beaver when access is so complicated.

10.5 Landowner organization – a challenge

The way in which landowners are organized appears to affect their involvement in the beaver management process. Here we briefly analyze how this appears to function.

10.5.1 Owners of large, private estates

Large, private landowners in Norway are well-organized, professional resource managers that strive to make a profit through effective land management. Their goal is to both limit beaver damage and profit from them. Due to their large size they receive considerable annual quotas for moose, red deer, roe deer and beaver and can normally employ the same management units for all four species. They often lease beaver hunting together with the use of a cabin, thereby increasing their profit. The management of beaver by this category of landowner seems to function well for both landowners and hunters.

10.5.2 Large tracts of publically-owned land

As with large private estates, large tracts of municipal or state-owned public land are usually well organized with respect to beaver management.

10.5.3 Moose-hunting units composed of many small landowners

Almost all forested land in Norway is part of an organized cervid management unit that receives an annual quota for moose, red deer and roe deer. In most cases, these units are conglomerates of many small landowners. This organizational form usually functions well for moose and deer hunting because many landowners hunt these species themselves, or can lease the hunting to others for a reasonable profit. In most cases these cervid-hunting units are also large enough to receive a beaver quota, and therefore can function as beaver management units as well. However, since few landowners are interested in hunting beaver themselves and see little potential for profiting from its sale, many apparently never apply for the beaver quotas they are entitled to. Alternatively, they apply for and receive a quota, but end up neither hunting themselves, nor allowing others to do so. The profits involved in leasing beaver hunting apparently are not worth the considerable organizational effort often required. The end result is that few beaver are felled. Therefore many potential beaver hunters appear to be hindered from hunting because landowners are uninterested in leasing it.

To test this idea, we searched the internet site “inatur.no” on 22 March, 2012, for beaver hunting available in Norway. This is a date on which many beaver hunters would be considering leasing a hunting area. Only 7 sources throughout the entire country advertised the sale of beaver hunting. All encompassed relatively small, private areas except for “Statskog”, the managing institution for most state-owned forest in Norway. Statskog offered beaver hunting at 38 sites throughout southern Norway, of which 18 were already sold-out just before the start of the main spring hunting season. This exemplifies 1) the lack of interest among most private landowners for leasing beaver hunting, 2) the willingness of Norway’s largest single forest manager to create beaver hunting opportunities for non-landowners and 3) a considerable interest for beaver hunting, since almost half of Statskog’s hunting areas were already leased several weeks before the start of the prime hunting period.

A particular problem that many municipalities with considerable area in farmland encounter is how to manage the often dense beaver populations in these landscapes (Eikeland 2004). Since agricultural landscapes are normally not included in cervid management units, landowners here need to create exclusive beaver management units large enough to receive at least one beaver. Again, since the cooperation of many landowners is necessary and the economic benefits for each at best small, few are motivated to create units in this type of landscape. This is unfortunate since damage complaints are often frequent on farmland, at the same time that hunters often prefer to hunt here due to easy access. This problem has been particularly difficult to resolve.

Many landowners are apparently reluctant to organize beaver management units because the economic returns are minimal, or even absent. Consequently, many beaver must be removed as nuisance animals, often outside the hunting season, in which case beaver management is reduced to damage control. Harvests are small, populations and conflicts increase, and major management goals go unattained. Thus the beaver's economic value for landowners appears to be a key driving force behind effective beaver management in Norway (Parker et al. 2001a).

10.6 Can an invasion of North American beaver be hindered?

In 1937, seven North American beaver were introduced to Finland to supplement an ongoing reintroduction of the nearly extinct Eurasian beaver there (Lahti and Helminen 1974). Many zoologists at that time recognized only one species of beaver. However, in 1973 chromosome counts acknowledged two species, and the North American beaver became an invasive alien. Since then it has spread throughout southwest and central Finland and into Karelian Russia (Fig. 10) (Parker et al. accepted). A small population also exists in northern Finland near the Swedish and Norwegian borders, where an invasion in the near future seems likely.

Recently, expanding populations of both species have converged on two fronts in Finland and northwest Russia. According to Gause's competitive exclusion principle, two species with identical niches cannot coexist indefinitely. The imminent question is whether coexistence or competitive exclusion will ultimately result, with the possible regional extirpation or eventual extinction of the Eurasian beaver. Body size is similar, though litter size of the North American beaver is slightly greater. Only minor differences in life history, ecology and behavior exist, suggesting nearly complete niche overlap. Though competitive exclusion resulting in the extinction of a native mammal by an alien congener at the continental landscape scale has been rare, the process may be difficult to detect due to potential time lags of centuries.

Thus there is a distinct risk that the North American species may eventually competitively exclude the Eurasian beaver at all landscape scales. Since no country in Eurasia obviously wants an invasion of North American beaver, and as most national conservation laws and international treaties forbid the spread of alien species, Parker

et al. (accepted) have advocated that the precautionary principle be adhered to and an attempt to eradicate the North American beaver from Eurasia be seriously considered. Successful eradication is still possible, if the will to do so exists. Parker et al. (accepted) also outline a potential eradication strategy. Without hesitation, the Norwegian and Swedish environmental authorities should convince their Finnish colleagues to implement the eradication of what appears to be a small population of North American beaver in northern Finland near the Swedish/Norwegian border. The resources required would be minimal and the costs involved could be shared by all three countries.



*Figure 10. The distribution of the Eurasian (*Castor fiber*) (light grey) and North American (*C. canadensis*) (dark grey) beavers in western Eurasia. The hatched area indicates the approximate region of population overlap near the Finnish-Russian border. A small population of North American beaver exists in northern Finland near the Swedish and Norwegian borders.*

I I. Possible solutions

I I. I Does beaver management need to be quota-based?

Quota-based management of beaver has been employed in Norway since 1855. For a species that is relatively easy to trap and hunt, exists at relatively low densities, and was nearly extirpated worldwide, quota regulation provides a secure method to regulate harvests and protect against overexploitation. In countries where the right to hunt belongs to the landowner, quotas also provide a fair method of distributing the harvest among them. Internationally, quota regulation is still one of the most commonly employed methods to control beaver harvests (Novak 1987, Novak et al. 1987, Hartman 1999). In Fennoscandia, both Norway and Finland employ quotas, but not Sweden (Hartman 1999). Since harvest regulation by quota often complicates the management process, and since beaver in some countries are successfully managed without quotas, it is reasonable to question whether quota regulation is really necessary in Norway.

There is no official regulation of small game bags in Norway, though landowners may establish quotas on their own land. Might this system work for beaver? We believe that if each landowner was allowed to harvest beaver unrestricted, or establish harvests themselves, considerable overharvesting would often occur, particularly on those many small properties where beaver are considered a nuisance. In Sweden, where hunting pressure tends to be low, quota-free beaver hunting apparently functions well (Hartman 1999). However, forest estates in Sweden average much larger than in Norway. When large landowners are involved, beaver hunting is better organized, easier to regulate, and more accessible to hunters. Large landowners tend to be more professional resource managers than the small. Based on personal experience, we doubt that eliminating quotas would lead to better beaver management in Norway.

The quota system currently used to regulate the harvest of large predators in Norway might function well for beaver. The right to hunt large predators is not exclusively the landowner's. Quotas are therefore not divided among landowners based on estate size, but are available to all hunters authorized to hunt large predators. If this system were to be established for beaver, animals shot or trapped daily would be reported to the municipal wildlife manager and the hunt stopped when the quota was reached or the open season ended. In essence, landowners would lose their exclusive right to hunt beaver, a loss many would find difficult to accept. In addition, hunter access would continue to be difficult since hunters, in most cases, would still need to contact numerous landowners in order to gain access to large enough areas to hunt on. Thus, employing this quota system is unlikely to improve beaver harvest management.

11.2 Can hunter access be improved?

In our experience, the central problem with today's beaver harvest management involves hunter access. Hunters who are not landowners often have difficulty finding a place to hunt. The establishment of beaver management units simplifies access considerably since large areas, that often involve many landowners, can be hunted on without the need to contact each landowner individually. Many hunters are unable to obtain beaver hunting, despite an abundance of beaver, when landowners remain unorganized.

A modification of the present method of defining cervid and beaver habitat might simplify the issuing of beaver quotas to landowners. As outlined above and in Table 1, agricultural landscapes are usually above average beaver habitat. However, most municipalities do not define agricultural landscapes as cervid habitat, though in reality farmland is frequently used by both beaver and cervids, particularly roe deer and red deer. If cervid management units were organized to encompass both farmland and forest, quotas for both cervids and beaver could be issued to the same management units. This would eliminate the need to establish special beaver management units in farmland, where beaver densities tend to be high (Table 1). Some municipalities are, in fact, already organized in this fashion, illustrating the model's feasibility. As most farmers are also forest owners, this model would probably not involve the organizing of that many additional landowners. With respect to cervids, farmland and forest area could be ranked differently with respect to the issuing of quotas, e.g. forest might be given double the quota per unit area as farmland.

Landowners are a key element in Norwegian wildlife management. Increasingly, they must take this responsibility more seriously with respect to beaver. They need to create beaver management units, apply for quotas, and inform hunters of where they can hunt. Public wildlife managers and landowners alike should feel a greater responsibility for recruiting young hunters into an ageing hunter population. Making beaver hunting more accessible is one way to do this.

11.3 Can the economic value of beaver be improved?

We believe that most hunters are willing to pay to hunt beaver, particularly if access is well organized and lodging made available. Reduced fees for younger hunters, which should lead to increased recruitment, might even prove to be a good investment for landowners in the long run.

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13. Literature cited

- Aanderaa, R., J. Rolstad and S. M. Søgne. 1996. Biologisk mangfold i skog. Norges Skogeierforbund og Landbruksforlaget, Oslo, Norway. (In Norwegian).
- Andersen, O. and B. P. Kaltenborn. 2007. Rekruttering til jakt. En undersøkelse om motiver for å avlegge jegerprøven, barrierer og tiltak for å øke andelen aktive jegere. NINA Rapport 221, Lillehammer. (In Norwegian with English summary).
- Anonimus. 1999. Levende Skog - standarder for et bærekraftig norsk skogbruk, med studieplan. Landbruksforlaget, Oslo. (In Norwegian).
- Arner, D. H. and J. S. Dubose. The impact of the beaver on the environment and economics in the southeastern United States. *International Congress of Game Biologists 14: 241-247.*
- Bashinskiy, I. V. 2008. The effect of beaver (*Castor fiber* Linnaeus, 1758) activity on amphibian reproduction. *Inland Water Biology 1:326-331.*
- Bergan, F. 2003. Taksering av beverbestanden i S.D. Cappelens skoger, område Nome-Drangedal, høsten 2002. Høgskolen i Telemark. (In Norwegian).
- Busher, P. E. and R. M. Dzieciolowski. 1999. Preface, pages v-vi in P. E. Busher, and R. M. Dzieciolowski, editors. *Beaver protection, Management and Utilization in Europe and North America*, Kluwer Academic/Plenum Publishers, New York, USA.
- Ciechanowski, M., W. Kubic, A. Rynkiewicz and A. Zwolicki. 2011. Reintroduction of beavers *Castor fiber* may improve habitat quality for vespertilionid bats foraging in small river valleys. *European Journal of Wildlife Research 57:737-747.*
- Collen, P. and R. J. Gibson. 2001. The general ecology of beavers (*Castor* spp.), as related to their influence on stream ecosystem and riparian habitats, and the subsequent effects on fish - a review. *Reviews in Fish Biology and Fisheries 10:439-461.*
- Collett, R. 1897. Bæveren i Norge, dens Udbredelse og Levemaade (1896). *Bergens Museums Aarbog 1:1-139.* (In Norwegian).
- Conover, M. 2002. *Resolving Human-Wildlife Conflicts - the Science of Wildlife Damage Management.* Lewis Publishers, New York.

- Dalbeck, L., B. Luscher and D. Ohlhoff. 2007. Beaver ponds as habitat of amphibian communities in a central European highland. *Amphibia-Reptilia* 28:493-501.
- Danilov, P., V. Kanshiev and F. Fyodorov. 2011. History of beavers in eastern Fennoscandia from the neolithic to the 21st century. Pages 27-38 *in* G. Sjöberg, and J. P. Ball, editors. *Restoring the European Beaver: 50 years of experience*. Pensoft Publishers, Sofia.
- De Almeida, M. H. 1987. Nuisance furbearer damage control in urban and suburban areas. Pages 996-1006 *in* M. Novak, J. A. Baker, M. E. Obbard and B. Malloch, editors. *Wild Furbearer Management and Conservation in North America*. Ontario Ministry of Natural Resources, Toronto, and Ontario Trappers Association North Bay, Canada.
- Eikeland, O. 2004. Beverens areal- og habitatbruk i et typisk kulturlandskap på Lista i Farsund kommune. Hovedoppgave, Høgskolen i Telemark, Bø i Telemark. (In Norwegian).
- Ermala, A. 1997. On beaver hunting and its influence on the beaver population in Finland. Pages 23-26 *in* K.-A. Nitsche, and K. Pachinger, editors. *Proceedings of the 1st European Beaver Symposium, Bratislava, Slovakia, 15-19 September, 1997*, Slovak Zoological Society.
- _____. 2001. The Finnish beaver status at present and means of controlling it. Pages 161-163 *in* A. Czech, and G. Schwab, editors, *The European beaver in a new millenium. Proceedings of the 2nd European Beaver Symposium, 27-30 September, 2000, Kraków, Poland*.
- Estland, W. 2000. Spring beaver hunting. *Fur Taker Magazine* 36:22-27.
- Fisher, R. H. 1943. *The Russian Fur Trade 1550 - 1700*. University of California Press, Berkeley and Los Angeles.
- Forsten, A. and S. Lahti. 1976. Postglacial occurrence of beaver (*Castor fiber* L.) in Finland. *Boreas* 5:155-161.
- Frafjord, K. 1991. Jakt i yngletida. *Fauna* 44:234.
- Fryxell, J. M. 2001. Habitat suitability and source-sink dynamics of beavers. *Journal of Animal Ecology* 70:310-316.
- Halley, D. J. and K. Bevanger. 2005. *Bever - forvaltning av en jakt-, friluft- og miljøressurs. En håndbok om moderne metoder for praktisk forvaltning av beverbestander*. NINA Rapport 21, Trondheim.
- Halley, D. J. and F. Rosell. 2002. The beaver's reconquest of Eurasia: status, population development and management of a conservation success. *Mammal Review* 32:153-178.
- Hammerson, G. A. 1994. Beaver (*Castor canadensis*) ecosystem alterations, management, and monitoring. *Natural Areas Journal* 14:44-57.
- Hanssen-Bauer, I., E. J. Forland, J. E. Haugen and O. E. Tveito. 2003. Temperature and precipitation scenarios for Norway: comparison of results from dynamical and empirical downscaling. *Climate Research* 25:15-27.
- Hartman, G. 1994. Long-term population development of a reintroduced beaver (*Castor fiber*) population in Sweden. *Conservation Biology* 8:713-717.
- _____. 1999. Beaver management and utilization in Scandinavia. Pages 1-6 *in* P. E. Busher, and R. M. Dzieciolowski, editors. *Beaver Protection, Management, and*

- Utilization in Europe and North America. Kluwer Academic/Plenum publishers, New York.
- _____. 2011. The beaver (*Castor fiber*) in Sweden. Pages 13-17 in G. Sjöberg, and J. P. Ball, editors. Restoring the European Beaver: 50 Years of Experience. Pensoft Publishers, Sofia.
- Hjeljord, O. 2008. Viltet - biologi og forvaltning. Tun Forlag, Oslo. (In Norwegian).
- Hood, G. A. and S. E. Bayley. 2008. Beaver (*Castor canadensis*) mitigate the effects of climate on the area of open water in boreal wetlands in western Canada. *Biological Conservation* 141:556-567.
- Hytönen, M. editor. 1995. Multiple-use forestry in the Nordic countries. Finnish Forest Research Institute, Vantaa, Finland.
- Hyvonen, T. and P. Nummi. 2008. Habitat dynamics of beaver *Castor canadensis* at two spatial scales. *Wildlife Biology* 14:302-308.
- Hägglund, Å. and G. Sjöberg. 1999. Effects of beaver dams on the fish fauna of forest streams. *Forest Ecology and Management* 115:259-266.
- Härkönen, S. 1999. Forest damage caused by the Canadian beaver (*Castor canadensis*) in South Savo, Finland. *Silva Fennica* 33:247-259.
- Jerstad, K., K. Solbraa and S. Knutsen. 2003. Målrettet elgforvaltning - bedre ressursutnytting. Landbruksforlaget, Oslo. (In Norwegian).
- Johnston, C. A., and R. J. Naiman. 1990. Aquatic patch creation in relation to beaver population trends. *Ecology* 71:1617-1621.
- Jones, C. G., J. H. Lawton and M. Shachak. 1997. Positive and negative effects of organisms as physical ecosystem engineers. *Ecology* 78:1946-1957.
- Lahti, S. 1997. Development, distribution, problems and prospects of Finnish beaver populations (*Castor fiber* L. and *C. canadensis* Kuhl), Pages 61-65 in K.-A. Nitsche, and K. Pachinger, editors. Proceedings of the 1st European Beaver Symposium, Bratislava, Slovakia, 15-19 September, 1997, Slovak Zoological Society.
- Lahti, S. and M. Helminen. 1974. The beaver *Castor fiber* (L.) and *Castor canadensis* (Kuhl) in Finland *Acta Theriologica* 19:177 - 189.
- Lavsund, S. 1979. Bäverinventering i Jämtlands län 1976-77. Swedish University of Agricultural Science, Department of Wildlife Ecology.
- _____. 1987. Bäverskadeproblem i Sverige, Pages 58-61 in E. Vindenes and T. Punsvik, editors. Nordisk beverseminar, Kristiansand, 27-28 August, 1986. Fylkesmannen i Vest Agder, miljøvernavdelingen, Rapport nr. 1-87.
- Leopold, A. 1933. Game Management. Charles Scribner's Sons, New York.
- Martin, J. 1986. Treasure of the Land of Darkness - The Fur Trade and its Significance for Medieval Russia. Cambridge University Press, Cambridge, UK.
- Mossing, A. 2005. Kolonitetthet, landskapspåvirkning og vinterforusjeringsatferd hos Eurasisk bever (*Castor fiber*) i et subalpint habitat på Hardangervidda. Cand. Scient. oppgave, Høgskolen i Telemark, Bø i Telemark. (In Norwegian).
- Müller-Schwarze, D. and L. Sun. 2003. The beaver - natural history of a wetlands engineer. Cornell University Press, Ithaca.
- Myrberget, S. 1967a. Beveren i Norge. *Naturen* 3:144-154. (In Norwegian).

- _____. 1967b. Den norske bestand av bever (*Castor fiber* L.). Meddelser fra Statens Viltundersøkelser Serie 2:1-40. (In Norwegian).
- Naiman, R. J., C. A. Johnston and J. C. Kelley. 1988. Alteration of North American streams by beaver. *Bioscience* 38:753-762.
- Naiman, R. J., J. M. Melillo and J. E. Hobbie. 1986. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). *Ecology* 67:1254-1269.
- Nedkvitne, K., T. H. Bjørnstad and T. Refsdal. 1990. Skogbrukslære. 4. utgave edition. Landbruksforlaget, Oslo. (In Norwegian).
- Nielsen, L. A. and B. A. Knuth. 2001. People for people: education for the human dimension. Pages 401-422 in D. J. Decker, T. L. Brown and W. F. Siemer, editors. *Human dimensions in Wildlife Management in North America*. The Wildlife Society, Bethesda, USA.
- Nolet, B. A. and F. Rosell. 1998. Comeback of the beaver *Castor fiber*: An overview of old and new conservation problems. *Biological Conservation* 83:165-173.
- Novak, M. 1987. Beaver. Pages 282-312 in M. Novak, J. A. Baker, M. E. Obbard and B. Malloch, editors. *Wild Furbearer Management and Conservation in North America*. Ontario Ministry of Natural Resources, Toronto, and Ontario Trappers Association North Bay, Canada.
- Novak, M., J. A. Baker, M. E. Obbard and B. Malloch. 1987. *Wild Furbearer Management and Conservation in North America*. Ontario Ministry of Natural Resources, Toronto, and Ontario Trappers Association North Bay, Canada.
- Nummi, P. 1989. Simulated effects of the beaver on vegetation, invertebrates and ducks. *Annales Zoologici Fennici* 26:43-52.
- _____. 1992. The importance of beaver ponds to waterfowl broods – an experiment and natural tests. *Annales Zoologici Fennici* 29:47-55.
- Nummi, P. and A. Hahtola. 2008. The beaver as an ecosystem engineer facilitates teal breeding. *Ecography* 31:519-524.
- Nummi, P., S. Kattainen, P. Ulander and A. Hahtola. 2011. Bats benefit from beavers: a facilitative link between aquatic and terrestrial food webs. *Biodiversity and Conservation* 20:851-859.
- Nummi, P. and H. Poysa. 1997. Population and community level responses in *Anas* species to patch disturbance caused by an ecosystem engineer, the beaver. *Ecography* 20:580-584.
- Olstad, O. 1957. Beveren. Pages 147-164 in B. Føyn, and J. Huus, editors. *Norges dyreliv: pattedyrene*. Cappelen forlag, Oslo. (In Norwegian).
- Parker, H. 2000. Forvaltningsplan for bever, Bø kommune, Telemark, 2000. Høgskolen i Telemark, Bø. (In Norwegian).
- _____. 2005. The state of the Eurasian beaver *Castor fiber* population in northern Norway in 2005. Department of Environmental and Health Studies, Telemark University College.
- Parker, H., A. Haugen, Ø. Kristensen, E. Myrum, R. Kolsing and F. Rosell. 2001a. Landscape use and economic value of Eurasian beaver (*Castor fiber*) on a large forest in southeast Norway. Pages 77-95 in Busher, P. and Gorshkov, Y., editors, *First Euro-American Beaver Congress, Volga-Kama National Nature Zapovednik, Kazan, Russia, 24-28 August, 1999*.

- Parker, H., P. Nummi, G. Hartman and F. Rosell. accepted. Invasive North American beaver *Castor canadensis* in Eurasia: review of potential consequences and strategy for eradication. *Wildlife Biology*.
- Parker, H. and F. Rosell. 2001. Parturition dates for Eurasian beaver *Castor fiber*: when should spring hunting cease? *Wildlife Biology* 7:237-241.
- _____. 2003. Beaver management in Norway: a model for continental Europe? *Lutra* 46:223-234.
- Parker, H., F. Rosell and F. Bergan. 2011. Kan vi unngå å skyte drektig hunnbever? *Jakt & Fiske* 140 38-41.
- Parker, H., F. Rosell and J. Danielsen. 2006. Efficacy of cartridge type and projectile design in the harvest of beaver. *Wildlife Society Bulletin* 34:127-130.
- Parker, H., F. Rosell and P. Ø. Gustavsen. 2002a. Errors associated with moose-hunter counts of occupied beaver *Castor fiber* lodges in Norway. *Fauna norvegica* 22:23-31.
- Parker, H., F. Rosell and P. C. Hagen. 1998. Feasibility of a random quadrat sampling design to monitor beaver populations in Norway (poster abstract). *In*: Reig, S., editor. Euro-American Mammal Congress, 19-24 July, 1998. Santiago de Compostela. Universidade de Santiago de Compostela, 424.
- Parker, H., Rosell, F., Hermansen, A., Sørløkk, G. & Stærk, M. 2001b. Can beaver *Castor fiber* be selectively harvested by sex and age during spring hunting? Pages 164-169 *In*: Czech, A. & Schwab, G., editors. The European beaver in a new millennium. Proceedings of the 2nd European Beaver Symposium, 27-30 Sept. 2000 Bialowieza, Poland. Carpathian Heritage Society, Krakow.
- Parker, H., F. Rosell, T. A. Hermansen, G. Sørløkk and M. Staerk. 2002b. Sex and age composition of spring-hunted Eurasian beaver in Norway. *Journal of Wildlife Management* 66:1164-1170.
- Parker, H. and O. C. Rønning. 2007. Low potential for restraint of anadromous salmonid reproduction by beaver *Castor fiber* in the Numedalslagen River catchment, Norway. *River Research and Applications* 23:752-762.
- Ray, A. J. 1987. The Fur Trade in North America: An Overview from a Historical Geographical Perspective. Pages 21-30 *in* M. Novak , J. A. Baker, M. E. Obbard and B. Malloch, editors. Wild Furbearer Management and Conservation in North America Ontario Ministry of Natural Resources, Toronto, and Ontario Trappers Association, North Bay, Canada.
- Rosell, F., O. Bozser, P. Collen and H. Parker. 2005. Ecological impact of beavers *Castor fiber* and *Castor canadensis* and their ability to modify ecosystems. *Mammal Review* 35:248-276.
- Rosell, F. and H. Parker. 1995. Forvaltning av bever: dagens tilstand og fremtidig behov. Telemark University College. (In Norwegian with English summary).
- _____. 1996. Beverens innvirkning på økosystemet - en nøkkelart vender tilbake. *Fauna* 49:192-211. (In Norwegian with English summary).
- _____. 2011. A population history of the beaver *Castor fiber fiber* in Norway. Pages 19-25 *in* G. Sjöberg and J. P. Ball, editors. Restoring the European Beaver: 50 Years of Experience. Pensoft Publishers, Sofia.

- Rosell, F., H. Parker and Ø. Steifetten. 2006. Use of dawn and dusk sight observations to determine colony size and family composition in Eurasian beaver *Castor fiber*. *Acta Theriologica* 51:107-112.
- Sinclair, A. R. E., J. M. Fryxell and G. Caughley. 2006. *Wildlife Ecology, Conservation and Management*. 2nd edition. Blackwell Publishing, Oxford.
- Sjoberg, G., and J. P. Ball, editors. 2011. *Restoring the European Beaver: 50 years of experience*. Pensoft Publishers, Sofia.
- Solberg, E. J. and B. E. Saether. 1999. Hunter observations of moose *Alces alces* as a management tool. *Wildlife Biology* 5:107-117.
- Solbraa, K. 1996. *Veien til et bærekraftig skogbruk*. Universitetsforlaget, Oslo. (In Norwegian).
- Solheim, R. 1991. Vårjakt på bever bør oppheves. *Fauna* 44:183-184. (In Norwegian).
- Statistisk Sentralbyrå (Statistics Norway). 2012. *Statistikk om jakt og fritidsfiske* (Statistics on hunting and sport fishing). Statistisk Sentralbyrå, Kongsvinger. (In Norwegian).
- Sutherland, W. J. 2001. Sustainable exploitation: a review of principles and methods. *Wildlife Biology* 7:131-140.
- Uren, G., P. C. Enger, T. H. F. Lien, E. T. Lund, T. H. Tomassen and S. Trå. 2000. GIS i beverforvaltning i Bø kommune - P114 "Prosjektarbeid i GIS" ved Høgskolen i Telemark, våren 2000. Høgskolen i Telemark, Bø.
- Veale, E. M. 1966. *The English Fur Trade in the Later Middle Ages*. Clarendon Press, Oxford.
- Wigley, T. B. and M. E. Garner. 1987. Landowner perceptions of beaver damage and control in Arkansas, Pages 34-41 *in* *Proceedings of the Eastern Wildlife Damage Control Conference*, Vol. 3.
- Wright, J. P., C. G. Jones and A. S. Flecker. 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. *Oecologia* 132:96-101.

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