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Game monitoring systems supporting the development of sustainable hunting tourism in Northern Europe: A review of current practises

Scott Newey
Fredrik Dahl
Sami Kurki
(eds.)

Reports 66

University of Helsinki
Ruralia Institute
Reports 66

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2010

Publisher University of Helsinki
Ruralia Institute
www.helsinki.fi/ruralia

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ISBN 978-952-10-6473-9 (pdf)
ISSN 1796-0630 (pdf)

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Introduction

Recreational, or sport hunting, has a strong tradition in many areas of Europe, United States and Canada (Willebrand 2009; Gordon, Hester & Festa-Bianchet 2004). Hunting tourism has been identified as an important but currently under developed source of regional development in Northern Europe (Fraser of Allander Institute 2010; Matilainen & Keskinarkaus 2010; Willebrand 2009; Macmillan & Phillip 2008; PACEC 2006). The perceived lack of social acceptance, combined with inadequate knowledge on the economic potential and ecological sustainability have slowed the development of hunting tourism in many areas of Northern Europe (Matilainen & Keskinarkaus 2010; Willebrand 2009). Key to the future of hunting and hunting tourism is the development and adoption of transparent, cost-effective, and robust methods for monitoring population dynamics, population trends, and the level of harvest (Matilainen & Keskinarkaus 2010).

While in principle there may be little difference between recreational and commercial hunting (used here to include hunting tourism) in practice commercial hunting where market dynamics, limitations of harvest control, and potential conflict over short- and long- term objectives may influence harvest levels might be expected to lead to over exploitation of certain age-sex categories or the whole population (Milner, Nilsen & Andreassen 2007; Mysterud, Tryjanowski & Panek 2006; Gordon, Hester & Festa-Bianchet 2004; Jackson et al. 2001; Taylor & Dunstone 1996; Ludwig, Hilborn & Walters 1993). The risk of over exploitation is likely to be exasperated under an open access model where resources are shared with no clear rights of ownership or responsibility (Costello, Gaines & Lynham 2008; Sinclair, Fryxell & Caughley 2006; Scheffer, Brock & Westley 2000; Ludwig, Hilborn & Walters 1993 ; Rosenberg et al. 1993). Under a monopolistic system, where the resource user has control over resource use and management decisions, however, theory suggests that a resource user ought to behave conservatively and remove modest harvest to maximise long-term return (Sinclair, Fryxell & Caughley 2006; Rosenberg et al. 1993).

Monitoring of exploited populations and the level of harvest is critical for economic, ecological and social sustainability yet represents one of the most challenging areas of ecology and embraces issues of governance, population ecology, and harvesting. While there is a comprehensive literature on the population survey and census techniques, there appears to be less information available on the process of how population and harvesting data are gathered and used in the decision making process of how hunting is regulated. There is a growing awareness and literature on the role and importance of stakeholder involvement in establishing trust and legitimacy in decision making processes and natural resource governance. Population and harvest monitoring, decision making processes and stakeholder involvement were all identified as important for the sustainable development of hunting tourism in northern Europe (e.g. Matilainen & Keskinarkaus 2010). Furthermore, robust information on population status is important to hunting tourism operators for business planning and quality assurance.

In the present report, based on the North Hunt project, we assess the efficacy of existing game monitoring programmes and the management decision making processes to support the development of hunting tourism in northern Europe. First, we present five case studies, representing socio-economically important game species, selected from partner countries and assess the social and ecological 'sustainability' of each case study. Second, we present the preliminary results of a two years field experiment investigating the use of expert opinion based population assessment as a potential low cost method of monitor trends of game populations at the local, management unit, level. Finally, we discuss the challenges of monitoring and management processes of game populations in order to support the development of hunting tourism sector in Northern Europe.

Evaluation of case studies

Sustainable harvest

Populations of wild animals are often exploited for subsistence, recreation or commerce. Our ability to sustain exploited populations is often inadequate due to limitations in our understanding of critical biological processes, poor demographic data (even for well studied species), and poor decision-making frameworks (Milner-Gulland & Akcakaya 2001; Sutherland 2001; Bawa & Menon 1997; Ludwig, Hilborn & Walters 1993; Rosenberg et al. 1993). Sustainable utilisation of natural resources and populations is recognised in the Convention on Biological Diversity (CBD) as a central tenet underpinning human well being, and a central goal of environmental management (United Nations 1992). One of the most challenging and urgent issues in wildlife management is developing reliable, cost-effective, and robust methods for managing harvests for long-term sustainability (Rist et al. 2010; Milner-Gulland & Akcakaya 2001; Bawa & Menon 1997; Wilson et al. 1996). Ignorance and over exploitation has led to the loss, collapse or threat of extinction for many exploited species and systems (Myers & Worm 2003; Hudson & Dobson 2001; Sutherland 2001; Jackson et al. 2001) indeed some have suggested the over-exploitation of natural resources is inevitable (Ludwig, Hilborn & Walters 1993; but see Rosenberg et al. 1993).

In theory achieving sustainable harvests is simple: Harvest the population at the same rate at which it can increase. Hence a population increasing at 20% a year can be sustainably harvested at 20% per year, with the effect that the population is held to an induced rate of increase of zero. Most harvesting of wildlife for recreational hunting has however largely been managed on a trial and error basis due to lack of information about the system. Arguably this strategy has been successful when habitats and population densities are in balance, intrinsic rates of increase are high, population growth is strongly density-dependant, and the population size is kept at a level synonymous with the maximum sustainable yield (Sinclair, Fryxell & Caughley 2006). These conditions describe what often happens in traditional recreational/extensive game management systems, and have generally been resilient where harvesting pressure has remained low, habitats have remained intact, and/or when game resources are privately owned.

The rational and need to monitor

Monitoring environmental parameters and populations is central to sustainable management of natural resources. Monitoring exploited populations, particular those that are commercially exploited where there is a potentially greater, or perceived greater, risk, of over exploitation is an increasingly important task in wildlife management (Rist et al. 2010; Milner-Gulland & Akcakaya 2001; Bawa & Menon 1997). Monitoring programmes need clear objectives and must be rigorously designed to collect meaningful and useful data if they are to reliably inform conservation science or management (Legg & Nagy 2006; Nichols & Williams 2006).

The EU has a commitment to nature conservation and sustainable management of resources. This commitment is embodied in the EU Birds Directive (1979), the EU Habitats Directive (1992), and the Natura 2000 network of protected areas under these Directives. The EU developed its own European Community Biodiversity Strategy in 1998, which is intended to be complementary to biodiversity strategies developed in individual member states following the Convention on Biological Diversity. In 2001 EU Heads of State and Government reaffirmed their commitment at the Gothenburg Summit by pledging

themselves to "halt the decline of biodiversity by 2012". This commitment complements the agreement by world leaders in 2002 at the World Summit for Sustainable Development (WSSD) to "the achievement by 2010 of a significant reduction in the current rate of biodiversity loss at the global, regional and national level". Implicit in many of these pieces of legislation is the obligation for member states to carryout monitoring of species to assess baseline conservation status and to monitor population trends. A detailed presentation or review of legislation is beyond the scope of this review, and is summarised in Table 1.

Monitoring of resource status and use alone may not be sufficient to ensure sustainable use if data and management decisions are not considered legitimate by all stakeholders (Rist et al. 2010; Dietz, Ostrom & Stern 2003; Bawa & Menon 1997). Monitoring of resources and their use needs to be integrated with knowledge of the socioeconomic factors driving use and the objectives of stakeholders (Michaels 2009; Armitage 2005; Dietz, Ostrom & Stern 2003; Bawa & Menon 1997). There is growing appreciation that the stakeholder involvement can extend in to all areas of decision making and management process and so called 'co-management' has been proposed and successfully implemented in a number of wildlife management cases (see Fortmann 2008 and Gunderson, Holling & Light 1995 and case studies therein).

In fisheries management where there is a strong tradition of management and a theoretical, empirical and monitoring framework underpinning fisheries management stakeholder engagement and the inclusion of socioeconomic drivers and uncertainty are well established and formalised in to the Management Strategy Evaluation concept (Sainsbury, Punt & Smith 2000; Butterworth & Punt 1999). However, cross-seeding of these principles in to other natural resource management arenas has been slow {Milner-Gulland, 2010 3289 /id}.

Conceptual Management Model, Criteria and Evaluation

Population assessment and monitoring underpin many ecological studies and the management of natural populations, and there is a wealth of literature on the subject (Borchers, Buckland & Zucchini 2002; Southwood & Henderson 2000; Krebs 1999; Wilson et al. 1996; Sutherland 1996). Reference material on population assessment asserts that the methods must be tailored to the aims, question, species and habitat under study which leads to a huge number of combinations and tactical detail (Nichols & Williams 2006; Legg & Nagy 2006; Krebs 1999; Wilson et al. 1996). In this review we do not intend to provide an overview of specific survey, census, or analytical methods, rather we intend to take a step back from the tactical details and develop a conceptual model of the monitoring process; how information is collected, assimilated and assessed, and how the monitoring data are used to in making management decisions. We will focus on terrestrial game birds and mammals that are legally hunted in Northern Europe, though the over arching principles should apply to monitoring programmes of many kinds.

Clearly the development of hunting tourism is ultimately an economic venture, but is underpinned by ecological and social sustainability (Matilainen & Keskinarkaus 2010). In essence ecological sustainability concerns the risk of over harvesting leading to local or regional declines in the population or species extirpation. The risk of over exploitation can be reduced or managed given; (i) a good understanding of the species ecology, (ii) access to historical data on species distribution and abundance, (iii) robust long-term population monitoring programmes, (iv) monitoring of hunter effort and harvest, and (v) control of harvest.

We identify three key stages (Table 2) that cover what we consider to be the main stages in the game monitoring processes. In the following case studies we describe what data is collected, by whom, how data collection is funded and who has access to the data. We next consider how and who collates and analyses the data, and finally we describe the decision making process in particular who is involved, how data and stake holder views are incorporated in to the process, and how management decisions are disseminated.

Social sustainability is dependant on the relationships between stake holders, not only those involved in hunting but the wider social and business community at the local, regional and national scales. For the purposes of this study we concentrate on factors influencing the local and regional social sustainability and consider the following criteria:

1. Stake holder representation and participation
2. Transparency of data and decision making process
3. Accountability/independence/quality assurance
4. Conflict resolution mechanisms are important in promoting trust and respect among stake holders and ultimately faith in the final decision process.

Case Studies

Ptarmigan Lagopus muta in Iceland

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Introduction and Background

The ptarmigan *Lagopus muta* is one of the most popular game species in Iceland. Bag statistics from the year 2009 show that 85 000 ptarmigan were hunted. Ptarmigan population abundance fluctuates and changes can occur rapidly. It is estimated that fluctuations occur on average every 10 years. It is estimated that the population fluctuates from around 2-4 million birds at peak population density to less than a million at the lowest point (Magnússon 2006). Ptarmigan hunting was suspended in 2003 when population estimates suggested that the population had decreased significantly, but since then the population has increased. Although there are no quotas on the number of ptarmigan that can be killed, hunters are requested to limit the number killed to their own needs. Over the past five years, the government has shortened the ptarmigan hunting season; in 2005, the season was 45 days and in 2009 the season was 18 days. Here we describe the current process to monitor the ptarmigan population, monitor hunting pressure and how data are used to inform management decisions, the process is summarised in Table 3.

Regional & National Monitoring

The Icelandic Institute of Natural History (IINH) has a role to monitor the game and wildlife populations. Since 1952 the IINH has counted birds in the winter and spring, first in eleven areas, but during the last years the number of areas has increased and in 2009 forty-four areas were monitored. The purpose of this counting is to collect information on over winter population abundance and distribution. The IINH has monitored the ptarmigan population since the early 1960's. The objective of monitoring the ptarmigan population is to provide reliable consultancy on population status and provide an assessment of how many ptarmigan can be harvested in the coming season. Monitoring the ptarmigan population consists of five main projects: (i) estimating population abundance in spring (April to May), (ii) estimation age structure of the population (adult:juvenile ratio), (iii) measurements of condition (e.g body mass and parasites), (iv) marking individuals (ringing and radio-transmitters) and (v) bag statistics. These data are used to determine population fluctuations and assess population abundance (Nielsen 2007). The monitoring involves gathering data variables (population index) of variations between years. The changes are analyzed in order to provide reliable consultancy on the condition of the population and how the hunting should be conducted. The population index is estimated in the spring by counting male birds close to nesting and the distribution of the population is estimated late-summer by counting chicks (Nielsen 1993). The IINH uses distance sampling to estimate the abundance of birds in specified areas (Nielsen 2007). The IINH is funded by the government but for the ptarmigan research the IINH also receives funding from revenue generated through the sale of Hunting Cards that all hunters must purchase annually in order to hunt.

Harvest/Game bag monitoring

In Iceland there is a hunting card system where hunters are required to purchase an annual hunting card to be allowed to hunt. The hunting card is issued by the Wildlife Management Division of The Environment Agency of Iceland. To be eligible to obtain a hunting card, hunters must attend training seminars

and pass a hunting test. There are no limitations on the number of issued hunting cards and the card, currently, costs 3 500 Ikr.

Annual bag records are collected by Wildlife Management Division (WMD) of The Environment Agency of Iceland and this information has proved to be very reliable. All hunters have to submit a bag report for all species hunted, where they were hunted and how many days they spent hunting in order to renewing their hunting card (the hunting card is valid for one year). It is estimated that about 90% of hunters in Iceland return annual statistics which provide good estimates of bag numbers (Beck 2010). In the bag report the hunters can report in which area they hunted (6 zones), what species and number of hunting days. The WMD uses these data to estimate hunting pressure on game species.

Management decisions and interpretation

The INH and WMD send recommendations, to the Ministry for the Environment, based on the population size and hunting pressure. The recommendations are on how many ptarmigan can be hunted and length of the hunting season. The Ministry for the Environment then issues the season and recommendations on how many ptarmigan can be shot. There is no quota on the ptarmigan only recommendations to hunters to only hunt what they need for Christmas.

Red grouse Lagopus lagopus scoticus in Scotland

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Introduction and Background

In the UK, including Scotland, hunting and shooting rights belong to the landowner. This is significant because even today following compulsory purchase of land by the Government for forestry and conservation purposes 85% of Scotland is privately owned (Wightman 1996). There are estimated to be 450 privately owned and financed estates (Smith 2009). Private landownership has a number of perceived benefits. It allows independent support through investment, management, utilisation and enjoyment of land and game without extensive reference to other bodies. Secondly, there may be economic returns to be made from capital appreciation, agriculture, forestry, and in the future renewable and carbon trading. Thirdly the purchase and management cost of the land confers an element of social status on the owner. Finally it allows a focus on particular land management techniques that support two forms of hunting which have become synonymous with Scotland; deer stalking and driven grouse shooting. The high densities of game required by these forms of hunting mean that a large harvest can be taken. An increasing desire by land owners to recover costs as well as enjoy the sport has meant that deer, hares and grouse have become an important source of revenue for UK sporting estates (Tapper 1992). Management for shooting is the primary management strategy for 20% of Scotland's land cover (Scottish Government 2009). In all it influences 44 million ha of land and is estimated to be worth £230 million a year to the national economy (PACEC 2006).

The red grouse *Lagopus lagopus scoticus* is a common and economically important game bird in Scotland which is tied to heather moorland in the UK (Hudson 1992; Warren 2002). The grouse shooting season across the UK is open from 12 August (the 'Glorious Twelfth') and closes on 10 December. As in

other parts of Europe, a proportion of red grouse are harvested during 'walked up' or 'rough shoots', sometimes over dogs, where a line of 3-8 hunters walk over an area of moorland and attempt to shoot animals as they flush and take flight. However in 2009 in Scotland 85% of red grouse in the UK were harvested during driven grouse shooting (Dunlop & Smith 2010). Driven shooting of red grouse is a sporting tradition unique to the UK that involves a line of people, acting as 'beaters'. Beaters walk across an area (typically 150 ha in size and known as a 'drive') moorland in autumn to flush into flight coveys of red grouse over a line of butts (small low-walled shelters), from which hunters (typically 8-10), usually referred to as 'guns', attempt to shoot the driven grouse as they fly over and past. Driven shooting is typically thought to require at least 60 grouse per 100ha of moorland in order to 'show' the birds properly to the guns.

Bags typically reflect density and hunting type with properties that drive birds shooting an average of 280 birds per year (range: 128-799) and other hunting types 50 birds per year (range: 33-124) in 2009. The unique nature of driven grouse shooting gives a clear market position and means that the fee structure can be set to recover the costs of managing to produce the high densities of grouse required. In 2009 it cost those participating an average of €72 per bird to shoot driven grouse and €41 per bird to shoot grouse in other ways. These returns meant 41% of shooting properties recovered their annual management costs (on average €64,338) in 2009. This is cumulatively important for Scotland; management solely for red grouse contributed £27million to the Scottish economy and supported 1 072 full time equivalent jobs in 2009 (Dunlop & Smith 2010). Here we review the monitoring and decision making process commonly found on private estates managed for red grouse sport shooting in Scotland (Table 3).

Data gathering

Local level monitoring of grouse numbers

Given the economic importance of red grouse, shooting a sustainable harvesting plan is clearly important. Many managers take the view that grouse are a crop and before shooting starts an assessment of the potential harvest is necessary (Hudson & Newborn 1995). Typically each year grouse moor managers plan a harvesting regime based on estimates of density and breeding success (Evans et al. 2007). These counts, a management cost for private landowners, are justified as not only providing a guide to the harvest but also as an indicators as to potential reasons for poor breeding.

Traditionally, density and breeding success are estimated from direct counts between 12 July and 12 August, depending on grouse hatch date and when mature young of the year can fly strongly and reform into a covey. Two forms of counting are used, block counts and transect (or 'Wilson-Fawcett') counts. Both forms of counts are laid out in relation to a line of shooting butts so as to provide an estimate of abundance and productivity for the drive which will put birds over the guns.

Block counts are made with the aid of trained dogs carried out in July before the shootings season begins. Counts are carried out, by the game keeper or contractors, on blocks of land of approximately 100ha, using pointer dogs to locate and flush birds either side of transects roughly 170m apart (Aebischer & Baines 2008). Birds are counted, aged (young of the year and adult) and adults sexed as they flush. The aim is to flush every grouse on the block area to provide a realistic estimate of density. Transect counts are undertaken over variable of variable length, typically 4 000 – 6 000 m, with variable numbers of persons and dogs which thus affects strip width. These counts are therefore indices of abundance as, to a lesser extent, are the block counts owing to the inherent variability in field censuses. In order to

accommodate this counts by contractors are increasingly using Distance Sampling (Thomas et al. 2010) in order to produce estimates of density and indications of error.

Regional & National Abundance Censuses

There is no central record of the abundance of game in Scotland. It is likely that all of the current 140 properties managed for grouse shooting in Scotland, which utilise some 1.5m ha of land, undertake some form of assessment of grouse abundance and productivity. However, because of the pattern of private land ownership there is no co-ordinated national strategy for grouse counting in Scotland, harmonising methods or compilation of results. It is therefore not known what proportion of this managed land is censused.

The Game & Wildlife Conservation Trust has monitored grouse density and productivity on a sample of over 70 Scottish grouse moors, since 1976 (Aebischer & Baines 2008; Hudson 1992). Biannual counts carried out in spring and late summer (July-August) using pointer dogs to locate and flush grouse along 4-6 transects traversing an area of approximately 100ha. These are carried out on 20 long term study sites across Scotland. Since 2008 a sample of 15-20 blocks from the full site list are counted each year as part of a programme of recounts. These sites were not chosen to represent all forms of grouse habitat available in Scotland and under-represent low density (<10 birds per 100ha) grouse populations which may occupy up to 50% of Scotland's 3 million ha of heather moorland (Warren 2002).

Harvest/Game bag monitoring

There is no central record of the number or type of game shot in Scotland. At the local level each estate typically records the number of birds shot in the estate records, or a game book (Tapper 1992). These data are accurately recorded as they have an impact on the capital value of the property. National game bag statistics are compiled by the Game & Wildlife Conservation Trust through the National Gamebag Census (NGC). The NGC is a voluntary scheme that collects annual bag statistics on all game and some non-game species from over 600 UK estates annually (Aebischer & Baines 2008; Tapper 1992). These are some of the longest run datasets in Europe with entries for numbers of sites back as far as the early 20th Century.

Analysis and interpretation

On private estates there is typically no formal statistical analysis of count data. Counts of the number of young of the year and adults birds along with local expert knowledge on the status and health of the grouse population and the area that can be shot over are used as a guide to determine the number of days shooting, and the total bag size, that will ultimately be held, sold or let that season.

Management decisions and dissemination

Shooting is closely managed on a day by day basis by the senior land manager, the head gamekeeper who manages an effective local bag limit. Across the season, although the number of days shooting may already have been provisionally arranged, these will be cancelled if grouse stocks are considered too low. Estimates of grouse population and the eventual grouse bag are closely correlated suggesting interpretation and management of the shooting intensity are generally well co-ordinated (Cattadori et al. 2003). Grouse moors usually shoot between 30% and 50% of their stock of birds depending on density, conditions and whether the population is increasing in density (Hudson & Newborn 1995).

The number of grouse a group of guns is expected to shoot is clearly laid out in advance. A record is kept of the number of shots fired as well as the number of birds shot. This information is used if the guns feel they have not shot enough birds as a high shot to bird ratio suggests the guns are seeing many birds but not shooting them. Equally, at very high grouse densities it is important that the bag for the day is met as harvesting reduces densities helping manage grouse disease (Hudson 1992). Shooting less than the target bag may be financially penalised.

At a national level The Game & Wildlife Conservation Trust compiles and publishes trends in grouse abundance, productivity and bag data each year following the season end (GWCT 2009).

Relevance for commercial hunting

Around 65% of grouse shooting days in Scotland are commercial and seek an economic return on investment. The remainder are taken for the owner's pleasure and costs of investment are written off. Moors between 2 000 and 10 000 ha generated 75% of grouse shooting days in Scotland in 2009. Given the high levels of investment in predator, habitat and parasite control there is a strong incentive to ensure bags are maximised in the long term in order to recover costs. Sustainable harvesting is achieved through a high level of expert knowledge informed by a variable pattern of counting, and a high level of control on harvest that private ownership of hunting rights allows.

Moorland properties outside this size are less likely to be primarily focussed on producing grouse and may undertake more informal shooting and less formal assessments of harvestable stocks. If the population is to be harvested counting grouse at low densities may be more important than counting grouse at high densities as low density populations are more exposed to stochastic events. Game management plans and training in basic harvest strategies should be encouraged for all grouse shooting estates in Scotland.

Moose Alces alces in northern Sweden

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Introduction and Background

The moose Alces alces is arguably the most important game species in Sweden (Bergström et al. 1993; Mattsson 1989; 1990a; 1990b; Mattsson & Kriström 1987; Mattsson et al. 2008). In 2009, 88,000 moose were shot (Jägareförbundet 2010). In addition to the sporting value, moose is an important source of food in many rural households and a potent symbol of Swedish wilderness (Mattsson 1989; 1990a; 1990b; Mattsson & Kriström 1987, Mattsson et al. 2008, Svenska Jägareförbundet 2008). As a large forest herbivore the moose is also regarded as an important pest species, causing severe browsing damage to young forest stands (Hörnberg 1991; Ingemarson et al. 2007, Persson et al. 2000; Lavsund 2003). Moose also cause a significant number of road traffic accidents each year (Swedish Road Administration). Due to the many and sometimes non-complimentary interests in the moose, there is a need to develop moose management plans that balances the needs of many stakeholder groups. Here we

describe the existing process, summarised in Table 3, used to manage the hunting outtake of moose and the moose population. While there are regional differences the process described here outlines the general system used in Sweden.

Data gathering

Stakeholders have usually been commissioned by the government to gather data within their area of expertise. However, there are also many local voluntary initiatives which are difficult to assess in this report and where methods and quality are unknown.

Obligatory reporting of game bag data, categorized by sex and age, is used to assess the level of harvest and is reported to each County Administrative Board (local government) at the end of each hunting season. Data are compiled at the national level by the Swedish Association for Hunting and wildlife Management (SAHWM) as a part of their remit to lead on certain elements of wildlife management and hunting (Kindberg et al. 2009; Naturvårdsverket 2010).

Moose observation statistics (number of moose per hunting effort) are collected, voluntarily, by hunters during the hunting season to follow relative changes in population density, changes in the sex ratio and the number of calves per female adult (see Ericsson & Wallin 1999). Data are compiled by the SAHWM, in their governmental commission to lead on certain elements of wildlife management and hunting (Naturvårdsverket 2010).

Pellet count surveys are sometimes carried out by local, voluntary initiatives to aid in local decision making and moose management (Naturvårdsverket 2010). There is currently an effort underway, initiated by SAHWM and quality assessed by the Swedish University of Agricultural Sciences (SLU), to organise a regional-national level systematic pellet count survey (Naturvårdsverket 2010).

Moose damage inventories carried out by the Swedish Forest Agency, as a part of their government remit, and by larger forest companies are used to assess the extent of moose damage to young forests (Kjellander 2007).

There is a mandatory responsibility to report all vehicle collisions with moose to the police, who have a remit to compile statistics of road traffic accidents involving game species (http://www.viltolycka.se/hem.aspx).

In areas where more information is needed, for example if trends from moose observation data, bag data, or moose damage data show a sudden change in some area, or in the case of conflicting views of the stakeholders, aerial surveys may be used to assess the winter population size and age-sex structure (Hörnell-Willebrand In Press). The decision to carry out aerial surveys can be made, and paid for, by the County Administrative Board (through the county consultation group CCG, *Viltförvaltningsdelegationen*, see below, with funding from the moose management fund, see below) alone or in cooperation with one or several stakeholders, or may be initiated and financed by one, or more, stakeholders. For example, one forest company is currently carrying out aerial surveys of all of its land to better assess the current moose population within company forest holdings.

Analysis and interpretation

To understand the moose management system in Sweden it is important to appreciate that most moose hunting, at least in northern Sweden, is carried out by local hunting teams who lease or own an area of land (hereafter referred to as 'hunting area'), and that each hunting area is allotted a quota each hunting season (in some cases multi-year quotas for several hunting teams working together in larger areas). Therefore, the number of moose hunters does not affect the number of moose killed as a quota is assigned to each hunting area.

The moose management system in Sweden is largely built on local knowledge about the population and thus starts at the local level. Each spring, when all the data from the previous hunting season have been compiled and analysed (usually analysed by each stake holder groups own experts[1] but quality ensured by independent researchers) all stakeholders in each moose management area hold a local consultation to discuss and agree on the quota for the next hunting season. Apart from the data described above, other relevant information, for example information on migration patterns or new research findings, may also be taken into account. The composition of these local consultation groups (LCG) may vary according to local conditions, but as a rule, representatives from the hunters, the landowner's organisation, and larger forest companies should always participate. Other groups that may contribute relevant current knowledge should also be invited. The LCGs do not have the authority to make any decisions on the quota. The LCG is a forum for relevant stakeholders to present and discuss the data and view points. The goal of the LCG is to reach a consensus regarding the moose management in their moose management area. Each LCG meeting should conclude with a written suggestion on a moose management plan that strives to balance stakeholders' interests. In its recommendation the LCG should include; planned harvest, desired development of the local moose population, hunting quotas for the moose management area as a whole as well as for hunting areas within the management area to reach this development, principles of the harvest, timing and duration of the hunting season, habitat improvement and forest damage prevention measures. If a consensus can not be reached, the different opinions should be clearly recognized in the LCG's recommendation.

Management decisions and dissemination

The LCG proposal is sent to their County Administrative Board, where based on the proposals of each local moose management area consultation a county consultation group (Viltförvaltningsdelegationen, CCG) decide on a recommendation for each management area in the county. The CCG is a delegation for collaboration on issues related to wildlife management, formalised by and working within the County Administrative Board, which consist of county representatives of the main stakeholders, and with representation from the County Administrative Board. The recommendation of the CCG is then passed to the County Administrative Board for approval. In the case of conflicting views in any of the LCGs it is up to the CCG to make a decision, based on the available information. Usually, however, there is a consensus between the different stake holder groups in the LCGs, as it is usually considered better to agree a local compromise than let the CCG make the decision and risk losing local control. The CCG follow up the work of the LCGs and their results.

For each adult moose shot on a hunting area the hunting team for that hunting area pays an administrative fee to the County Board. This money is put in a moose management fund. The moose management fund is used to finance the work of the CCG. Other work regarding moose management, data gathering, information and education related to the management may also apply for funding from the moose management fund.

Relevance for commercial hunting

There is at least a perception, if not a real risk, that commercial hunting may lead to over-exploitation. For the sustainable development of hunting tourism it is therefore critical that hunting tourism operators demonstrate that their activity does not have a negative affect on the hunted population, nor critically the hunting opportunities of local hunters. Commercial hunting tourism of moose in northern Sweden is related to larger hunting areas; typically the size of an ordinary hunting area is 2 000 - 6 000 hectares. Typically hunting tourism operators will have leased an area from a forest company. The hunting tourism operator is treated in the same way as other hunting teams in the area, and will be allocated a quota suitable for the specific hunting area based on the suggestion of the LCG, recommendation of the CCG, and approved by the county board.

Willow grouse in the Swedish mountains

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Introduction and Background

Willow ptarmigan *Lagopus lagopus* is a popular small game species in Scandinavia. Prior to 1993, willow ptarmigan hunting in Sweden was an exclusive right for the Sami villages and considered an exclusive form of sport. In 1993, more than 60 000 km^2 of the state-owned Swedish mountain range were opened to the public for small game hunting, with willow ptarmigan being the most popular game species (Nettheim et al. 2002). After the opening of state land to public hunting the numbers of hunters increased rapidly, and generated a discussion if this would result in a risk of over harvesting (Willebrand & Hörnell 2001).

Approximately 13% of the land in Sweden is state owned, with the largest extent in the northern most counties in mountainous alpine areas. While the length of the hunting season is regulated by the state, decisions on, for example; daily bag limits, number of hunters, are devolved to the local level and are made by each County Administrative Board. The situation after 1993 promoted cooperation between game biologists/scientists and the County Administrative Boards, which has led to an open management process that has focus on scientific hypotheses and experimental frameworks to develop a management tool for willow ptarmigan in these areas.

The present case study describes the strategies to manage hunting on willow ptarmigan on the state-owned land in the Swedish mountain range, and describes how hunting is managed, what type of data are used, and how the decision making process works, the process is summarised in Table 3.

Data gathering

Data gathering is carried out along walked line transects with the aid of pointing dogs across the Swedish mountain range. Population density (i.e. number of willow grouse per km^2) is estimated by distance sampling (Buckland et al. 2001) and the use of program DISTANCE (Thomas et al. 2010). Breeding success (chicks per pair) is estimated from the raw data.

In August each year, the autumn willow ptarmigan line transect counts are carried out by groups of hunters and dog handlers (Hörnell-Willebrand 2005). The hunters are all volunteers and have to go through mandatory training before participating in the counts. The autumn counts are carried out by several hundred volunteers, while this kind of voluntary activity is rare in Europe it is quite common in game species management in Scandinavia (Lindén et al. 1996; Elgmork 1997; Ericsson & Wallin 1999; Solberg & Sæther 1999; Hörnell-Willebrand 2005; Mysterud et al. 2007; Pedersen & Karlsen 2007). The County Boards organise the counts in close cooperation with scientists. The participation of local hunters in the autumn counts has greatly facilitated stakeholder understanding of management decisions and the regulations set by the County Boards. During the pre-count planning meetings participants have the opportunity to hear new research which gives the volunteers a unique status among local hunters.

All hunters on state owned land in Sweden have to buy and activate their hunting permit before they hunt and provide information in which hunting area they are going to be active in. To be able to activate a hunting permit hunters must report their bag statistics, otherwise it is not possible to activate the permit again. The hunting permits have to be activated every five days. Hunters that do not report hunting statistics are not allowed to hunt on the state-owned land the following hunting season. This system has lead to a very high percentage of reported hunts and during recent years more than 90% of all ptarmigan hunters report when, where and what they have shot.

Analysis and interpretation

Data from the line transect counts are reported over internet by the voluntary hunters before the 15th of August. Scientists working within the Wildlife Program in the Environment Monitoring and Assessment program at the Swedish University of Agricultural Sciences analyse the data and report back to the County Administrative Boards before the 20th August. This work is funded by government subsidy through the Swedish University of Agricultural Sciences.

The change in accumulated effort (number of hunters per unit area per day) has a larger influence on the bag size than variation in ptarmigan density. A 10% increase in effort produces more than twice the change in bag size compared to the same change in total density. Increasing the bag size by 1 ptarmigan would require more than a 10 times increase in ptarmigan abundance (Willebrand et al. 2010 submitted manuscript). Thus, results from the ptarmigan counts are primary used to evaluate previous years management strategies. However, years when results from the counts indicate very low densities (< 5 ptarmigan per km^2), number of accumulated hunting days per km^2 are decreased by 30 – 60% for day permits.

Hunting statistics are analysed during the first two weeks of the hunting season to evaluate if Catch Per Unit Effort (number of ptarmigans shot per hunter and day, CPUE) has changed compared to previous years. Different hunter categories, i.e. Swedish, Scandinavian (Norwegian and Finnish hunters) and European (non Scandinavian) hunters have different CPUE with European hunters being four times more efficient than Swedish hunters and three times more efficient than Scandinavian hunters (Lindberget 2009). If number of European hunters increase in one area, harvest will be higher than expected. This means that number of accumulated hunting days per km^2 will be reduced for day permits.

Management decisions and dissemination

The management system for willow ptarmigan harvest on state land in Sweden is based on a threshold for maximum harvest rate (Aanes et al. 2002), a relationship between effort and harvest rates (Hörnell-Willebrand 2005) and the use of buffer zones (areas permanent closed to hunting) (Willebrand & Hörnell 2001). The relationship between effort and harvest rate are used because bag size greatly underestimate the population densities. Increasing the bag size with one willow ptarmigan would require more than ten times the increase in grouse abundance. A fixed annual effort results in a stronger relationship between grouse density and bag size and reduces the risk of high harvest rates and substantial additive mortality. Buffer zones are used based on the study of Willebrand & Hörnell (2001) who showed that about 75% of the area could be left open to hunting even if the level of harvest is close to the extinction level. Furthermore, it is quite simple and does not need a resource-demanding control system. A harvest strategy which sets aside a part of the area as a buffer, and places a limit to the harvest effort in units open for hunting, is a cost-efficient system with only a small risk of over harvesting.

There is a daily bag limit of 8 grouse per hunter, but this limit is reached by less than 2% of hunters (Hörnell-Willebrand 2005, Lindberget 2009). It is possible to close a hunting unit when the effort has reached 3–5 accumulated hunting days per km² (30 – 45% of autumn population) but this mechanism is seldom needed.

If average ptarmigan densities in one municipality are less than 5 ptarmigans per km^2, number of hunting days per km² is decreased for day permits. Only once has a whole county been totally closed for ptarmigan hunting, in 2009/2010 average ptarmigan density in the county of Jämtland less than 3 ptarmigan per km^2.

Hunting permits are based on an open access system where all hunters can buy short term hunting permits on a daily basis. Those permits have to be activated, i.e. the hunter or hunting permit seller needs to register, over the internet, in which area and during which dates the hunting will be performed. Members of the European Union can hunt on the state owned land on the same basis as Swedish hunters. Local hunters can purchase annual hunting permits and can still hunt when a management area has met the designated number of hunter days. One third of the income from the hunting permits goes to the Sami villages active in hunting units, one third goes to the Sami development fund and one third to the County Administrative Boards for management of willow ptarmigan.

Relevance for commercial hunting

In the southern part of the mountain area in Sweden, hunting areas on state-owned land can be set aside exclusively for commercial hunting operators. Operators have to be registered at the County Administration Board and there has to be an agreement between the local Sami villages, local hunters and the County Administration Board. On settling an agreement the area will be closed for all other hunters during the agreed time-period, though the same quota and maximum number of hunting days per km^2 still applies as for open access areas in the county.

Forest grouse species on state land in northern Finland

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Introduction and Background

In Finland the woodland grouse species (capercaillie *Tetrao urogallus,* black grouse *Tetrao tetrix*, hazel grouse *Tetrastes bonasia and* willow grouse *Lagopus lagopus*) are important game species, and are also challenging to manage sustainably. Annual and regional variation in adult mortality and recruitment (e.g. Lindén & Rajala 1981; Ranta et al. 1995; Kurki et al. 1997: Kurki et al. 2000; Ludvig et al. 2006) make it difficult to assess population status and assign sustainable hunting quotas. Here we describe the current processes to control hunting pressure, by both local hunters and non-local permit hunters (hunters that have to purchase a day card for a specific area), of woodland grouse on state land in northern Finland. In this case study we will focus on area 8 § - where local residents have the legal right to hunt freely on state land within their home municipality. This area, consists of 16 separate hunting management areas managed by the Metsähallitus´ Natural Heritage Services (MNHS), and includes Lapland and eastern parts of the northern Finland (approximately 48 000 local hunters live in the area). We present the different data sources used, analysis of data, and finally the decision making processes to control the length of hunting season and hunting mortality (hunting days and bag quota/region), the process is summarised in Table 3. The sustainability of the existing process is then discussed in relation to possible development of hunting tourism.

Data gathering

Population estimates of woodland grouse are based on wildlife triangle survey data (e.g. Lindén et al. 1996; Pellikka et al. 2006), and in the case of willow grouse also on transect counts using pointing dogs in the most northern parts of Lapland (e.g. Hörnell-Willebrand 2005). Both of these surveys are conducted after the breeding season in early August and provide regional estimates of density and breeding success (proportion of chicks) for each species. Wildlife triangle surveys are carried out by local hunters and organised through hunting clubs. MNHS organises willow grouse transect counts together with volunteers having suitably trained pointing dogs. Finnish Game and Fisheries Research Institute (FGFRI) analyses both data sets and make the results public through the internet.

Data on hunting activity and bag statistics are collected from two sources. The number of local hunters with free hunting rights in each municipality is available from sale statistics of national hunting licenses which all hunters are legally required to purchase in order to hunt. Hunting activity and bag statistics of local hunters have been studied twice; in 2003 and 2008 which were years of moderate and low grouse densities respectively (e.g. Kangas 2006). These results are used to estimate the hunting mortality caused by local hunters.

The number of non-local permit hunters (i.e. hunters that have to buy a day card) is known from the sale statistics of each hunting management area. All permit hunters on state land are asked to report the species and number of animals shot after hunting, and the response rate has been around 30%. Combining these two sources of information it is possible to estimate the mean hunting mortality caused by non-local permit hunters (bag per unit effort).

Analysis and interpretation

Data from both wildlife triangle censuses and willow grouse transect surveys are analysed by the FGFRI which is a government funded organisation. MNHS uses these density estimates as parameters to model sustainable hunting quotas for each hunting management area. In addition to data on grouse density, hunting activity and bag statistics, models require limits for sustainable hunting mortality. During the past years a limit of 30% has been used for willow grouse in the northern Lapland, while in the rest of the region the limit has varied between 10–15% for all grouse species (see review by Kangas 2006).

After estimating the hunting bag quota for each region, the quota is allocated between local and non-local permit hunters. In general, the local hunters receive priority in the quota allocation and their hunting quota is reserved in the first stage. The proportion of the quota reserved for local hunters varies (approximately 60-80 %) between regions. The rest of the quota is allocated to the non-local permit hunters and transferred to sellable hunting days in the form of day cards. There are fixed bag limits per hunting day associated with day cards.

Management decisions and dissemination

There are three main ways to control hunting mortality in the given management area: shorten the length of hunting season, control the number of hunting days (i.e. day cards) sold to non-local permit hunters or limit the daily bag quota allowed for non-local permit hunters. There are no quota limits for local hunters, but local game management associations have sometimes given recommendations on annual quotas for local hunters.

The length of hunting season can be shortened at three different management levels: (i) at the national level, the Ministry of Agriculture and Forestry decides the length of hunting season for all species annually, (ii) the board of each game management district (consisting of local hunters) can shorten the hunting season if grouse densities are very low (this right might be removed from 2011 onwards), and (iii) as administrator of state land the MNHS can shorten the hunting season of non-local permit hunters. In deciding whether to shorten the hunting season, and the number of day cards sold to non-local permit hunters, the FPS consult with regional hunting management associations to discuss the preliminary proposal. The final decision, however, is taken by MNHS which is also a legal authority in this issue. Furthermore, the decision making body within MNHS is autonomous and in this role directly responsible to the Ministry of Agriculture and Forestry.

Hunting licences, i.e. day cards, for non-local permit hunters are sold in two phases before the hunting season. Approximately 50% are sold in early June, before population surveys have been carried out, and the remainder in August, after the grouse surveys have been conducted. This provides the opportunity for hunters, to some extent plan to plan their hunting, whilst also allowing the MNHS to adjust the quota if grouse densities estimated through field surveys are lower than predicted. However, only independent hunters can purchase licences, hunting tourism operators have not been permitted to purchase licenses since 2005.

Consequences for the development of hunting tourism

The existing system is well accepted among key stakeholders (e.g. local hunters, non-local permit hunters). Even though it can be difficult to obtain licences for the desired time period and hunting grounds, non-local permit hunters consider the system to be fare (Keskinarkaus et al. 2009). The allocation of

sellable licenses is based on annual population data, therefore the risk of over exploitation, even with increasing pressure from hunting tourism, is considered minimal. This is due to fact that hunting tourism is based on sellable hunting allocated to non-local permit hunters and the process to control hunting pressure and quota allocation is the same. For hunting tourism operators however the present system posses' problems because they can not buy licences for their clients nor plan their business activities before the beginning of the hunting season when the second tranche of permits are released for sale. This makes business development and especially marketing to international customers difficult. To summarise, the present system is able to control hunting pressure even in the case of increasing hunting tourism and it is also accepted among key stakeholders (local hunters and non local permit hunters).

Evaluation and Discussion of Case Studies

Ptarmigan in Island

Stakeholder involvement seems very limited; hunters are involved in data collection, but analyses and decision making appears to be closed and confined to government bodies and ministries. Data and results of analyses are however publically available. Objective, results are open, very sensitive species and connections to national culture. Monitoring methods seem reliable and part of a larger, long-term government funded monitoring programme. Hunting pressure is regulated by length of hunting season and a request that hunters limit their bag size to personal needs – but, there is no quota given. Although the system seems to be rather closed and top-down and there does not appear to be any mechanism for conflict resolution built in, the system appears to be effective and accepted by stakeholders.

Red grouse in Scotland

Red grouse shooting takes place on private land, where the landowner (or tenant) has almost total control over management and the level of harvest, often combined with excellent knowledge on the status of the population. At the local level population assessment is based on expert knowledge of the game keeping and estate staff, and is often supported by formal pre-harvest counts. Data at the national level is more limited, but does not appear to hinder sustainable management and provides a useful benchmark. Local bag statistics and national game bag statistics provide indices of harvesting pressure and, at the regional level, population trends (Aebischer & Baines 2008; Aebischer & Haradine 2007). As a privately owned resource which form part of a larger estate land owners have considerable vested long term interest in ensuring sustainable management of grouse stocks and there appears to be little, if any risk, of overharvesting. Monitoring and management cost are covered by the landowner.

As private entities sporting estates have traditionally had little consultation with other stakeholders, which has lead to negative perception of hunting states by the wider community (Fawcett & Costley 2010). Conflict over grouse management occurs against a backdrop of a wider debate over land tenure and discussion over the positive and negative impacts associated with intensive grouse more management (Chenevix-Trench & Philip 2001; Fletcher et al. 2010; Harrison et al. 2010; Macmillan et al. 2010; Smith 2009; Sotherton, Tapper & Smith 2009; Thirgood & Redpath 2008; Wightman 1996; Wightman et al. 2002).

Moose in Sweden

From the ecological perspective moose populations are unnaturally high (due to habitat alterations caused by forestry and also exclusion of wolf during past decades), there is therefore no real ecological concern about over exploitation of the moose population. The conflicting views of stake holders are the main issue; local hunters want as high moose numbers to maximize hunting success and satisfaction, while some other parties, for example forestry companies, would like to decrease moose numbers to reduce browsing damage, or other negative biodiversity or societal impacts.

The whole process, from data gathering through to the recommendations (which are invariably accepted) submitted to the County Administrative Board, is a local, bottom up, stake holder led system. The system is controlled by public authorities and process is open to all key stake holders. Methods are

under ongoing continuous scientific development. Therefore, the management decisions appear to be accepted by the different stakeholder groups.

The process is largely publically funded, so from hunting tourism entrepreneurs' point of view the process is free of charge – there are of course costs, but these are included in the cost of buying or leasing ground and associated hunting rights but costs are relatively low. Increasing commercial interest in moose hunting does not, in our opinion, necessitate further information or regulation. Hunting tourism entrepreneurs are allocated a quota based on the area of land according to the same – hunter led – system of allocating quotas. Conflicts are principally between forestry companies and hunters over optimal moose population densities. There appears to be little conflict between hunting tourism entrepreneurs and local hunters.

While it is not possible to completely regulate hunting, know exactly where animals are, where they are shot, or the exact number of animals shot, nor balance competing land use demands this not really the problem.

Willow grouse in Sweden

The case of the willow grouse in the mountainous regions of northern Sweden shares similarities with the management of Swedish moose and Finnish woodland grouse systems. The willow grouse monitoring and management processes involve considerable stakeholder involvement and two way knowledge transfer. Data are collected by stake holders and analysed by independent academics using an established and evaluated survey technique. The data and analysis arguably represent the best example among these case studies. The results are freely available, though raw count data are not open to so as to protect high density areas from artificially high harvesting pressure. Another, notable aspect of the process is the use of 'closed' or 'protected' areas where hunting is not allowed, providing a strong 'source' population, which along with the closure of hunting areas after a preset number of hunting days greatly reduced the risk of over exploitation.

Willow ptarmigan hunters on the state owned land in the Swedish mountain range have to report number of harvested birds after the hunt. Hunters that do not return harvest statistics are prohibited from buying a license in the next hunting season. This has lead to a very high report rate, > 90%. The accuracy of the harvest statistics reported by hunters on the state owned land has been evaluated by comparing bag data with the returns of hunters who participated in a scientific project who reported honest statistics. There were no differences between the distributions of the two datasets which corroborates that hunter on the state owned land report correctly. However, even if close to 100% of the hunters report what they have harvested it does not mean that harvest statistics alone are useful. Effort should always be measured when collecting bag statistics and the relationship between bag size and population change should be evaluated carefully.

Woodland Grouse in Finland

The process of monitoring grouse abundance, harvest and integrating these data in to management decisions with the involvement of a broad range of stakeholders and is generally considered to work well. Relevant stakeholders are involved at all levels, data and decisions are objective, and the data effectively reveal regional differences in grouse densities. The process receives input from a range of stakeholders, but is largely government funded so effectively 'free at the point of delivery'.

The decision making process is however very complex. The length of time taken to complete the process means that some decisions are taken before the latest data are available, for example the length of the hunting season is decided before all the data from the wildlife triangle surveys are available. From hunting tourism entrepreneurs point of view the Finnish system is considered quite unpredictable and management decisions do not always well related to population data. However, this system is generally free of conflict because entrepreneurs are treated the same as other hunters in the apportionment of day permits. Lack of high quality bag statistics may be a problem because the mandatory reporting of bag statistics runs alongside a maximum bag limit, which may promote false reporting. Critically, because the annual quota is adjusted in relation to estimated abundance and hunting tourism does not increase the overall harvest level hunting tourism is not thought to increase risk for over exploitation, though this kind of risk does exists particularly at the local scale.

Discussion

Even the five case studies presented show considerable diversity in all aspects of the system, but all appear to be working with minimal risk of over exploitation. The dominant difference between the cases lies in the level of stakeholder participation and the balance between bottom-up stake holder led systems and top-down government dominated systems. Operating in an almost monopolistic system the Scottish case study represents a unique case where, usually, private landowners have significant control over all aspects of the monitoring and regulatory process with minimal or little external input to management decisions, though national designations of conservation areas and protected species can over ride local management. With a high level of local control red grouse harvesting appears to be sustainable and promotes entrepreneurial activity. At the other end of the spectrum ptarmigan hunting in Iceland is carried out on government and privately owned land and appears to be dominated by top-down government regulation with little stakeholder involvement. Despite this the system appears to be stable, harvesting sustainable, and stake holders appear content. The high level of government regulation may hinder entrepreneurial development of hunting tourism, but ensures all stakeholders have equal access to hunting rights.

Hunting tourism is however a commercial activity, and while the proceeding case studies all demonstrate ecological and social sustainability in order to develop hunting tourism, plan business activity and facilitate quality entrepreneurs need timely, robust, local level population data that is relatively easy to collect and analyse. As while formal population data may be available the business critical information may not be available in time for entrepreneurs to plan their business activities and while established survey methods are available these are often expensive and require considerable skill and knowledge to implement, analyse and interpret. Expert models have been proposed as a reliable, effective, affordable complimentary or alternative method to monitor local populations. Here we evaluate the use of expert models to monitoring small game populations in the Scandinavian boreal forest system.

Table 1

Legislation	Acronyms	Further Information	
Convention on International Trade in Endangered Species of Wild Flora and Fauna	CITES	www.cites.org	Aims to regulate international trade in endangered species and species that may become so unless their exploitation is controlled. Monitoring wild populations of CITES-listed species is critical to inform decisions on whether allowing trade in a particular species will affect its conservation in the wild. The Convention was agreed in Washington in 1973, came into force on 1 July 1975 and was ratified by the UK in 1976; Iceland, Norway, Sweden, Finland.
Convention on the Conservation of European Wildlife and Natural Habitats	Bern Convention	www.ecnc.nl/doc/europe/legislat/bernconv.html	Provides for the conservation of wildlife and wildlife habitats in general and for the special protection of strictly protected plant species listed in Appendix I, strictly protected animal species in Appendix II and protected animal species in Appendix III. Signatories are obliged to protect all breeding and resting sites of the species on Appendix II and to take necessary measures to maintain populations of all species of animals and plants at levels corresponding to ecological, scientific and cultural requirements. The UK gave effect to the Convention in Great Britain through the passing of the Wildlife & Countryside Act 1981 (as amended). The Convention was agreed in 1979, ratified by the UK in May 1982 and came into force in June 1982. Iceland, Norway, Sweden, Finland
The Convention on the Conservation of Migratory Species of Wild Animals	Bonn Convention	www.wcmc.org.uk/cms	Ensures strict protection for all species in Appendix I; species considered to be endangered, by imposing strict conservation regulations on signatories that are Range States, and conclude legally binding agreements for the conservation of species listed on Appendix II; migratory species that have an unfavourable *conservation status* and require international agreements for their conservation, or would significantly benefit from international cooperation. Implicit in ascertaining the conservation status of species on Appendix II, , is the requirement to monitor distribution and population trends. The Convention was concluded at Bonn in June 1979, came into force on 1 November 1983 and was ratified by the UK in July 1985.
Convention on Biological Diversity	CBD Earth Summit, Rio Convention	www.biodiv.org	Two of the objectives of the convention are the conservation of biological diversity and the sustainable use of its components. Article 7 requires that contracting parties should "monitor, through sampling and other techniques, the components of biological diversity, paying particular attention to those requiring urgent conservation measures and those with the greatest potential for sustainable use." UK: Ratified by the UK in 1994 the CBD is implemented through the UK Biodiversity Action Plan (BAP; Biodiversity Steering Group,1995; www.ukbap.org.uk). Based on a number of criteria including recent decline in numbers or range, and endemism the UK BAP has produced a 'Long List' of species of conservation concern and a 'Short List' of species that have been prioritized for Action Plans. Listed species include a number of Scottish game and pest species, for example; roe deer, brown hare, mountain hare, stoat, weasel, and red grouse.
European Communities Directive 92/43/EEC, on the Conservation of Natural and Semi-natural Habitats and of Wild Flora and Fauna	The EU Habitats Directive	ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm	Under the terms of the Directive which aims to establish a network of protected areas throughout the European Community designed to maintain both the distribution and abundance of threatened species and habitats, Member States must maintain and restore "favourable conservation status" of species listed in Annexes II, IV and V. Article 11 of the Directive states that 'Member States shall undertake surveillance of the conservation status of the natural habitats and species referred to in Article 2 with particular regard to priority natural habitat types and priority species.'

European Communities Directive 2009/147/EC on the conservation of wild birds	The Birds Directive	ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm	Initially adopted in 1979 (79/409/EEC as amended) is the EU's oldest piece of nature legislation providing protection for all wild bird species naturally occurring in the Union. The directive recognises that habitat loss and degradation are the most serious threats to the conservation of wild birds. It therefore places great emphasis on the protection of habitats for endangered as well as migratory species (listed in Annex I), especially through the establishment of a coherent network of Special Protection Areas (SPAs) comprising all the most suitable territories for these species. Since 1994 all SPAs form an integral part of the NATURA 2000 ecological network. The Directive recognises hunting as a legitimate activity and provides a comprehensive system for the management of hunting (limited to species listed in Annex II - II/1 allows hunting in all Member States; II/2 allows hunting in listed Member States) to ensure that this practice is sustainable.

Table 2

Stage	**1**	**2**	**3**
	Date Gathering	Analysis & Interpretation	Management Decisions & Dissemination
Description	Collection primary data on population status. Data will include data on all or some of; distribution, estimates or indices of abundance or density, population performance, bag records, and hunting effort. Data may include anecdotal accounts, bag records, snow tracks, aerial surveys, transects. This process usually takes place before the hunting season, but may also continue throughout the hunting season.	Assimilation, collation and analysis. This step includes estimating abundance, density or indices of abundance, identification of trend, or population performance. Data may be contextualised by comparison with historic data. May include population and/or harvesting modelling. Results of analysis, possibly with recommendations, are passed on to step 3. This step would normally take place before the hunting season, but may continue through the season to monitor bag and advise when to close the season.	The process of assimilating the results of the analysis and other data sources (including expert/stake holder opinion) to reach a decision on the management of game populations for a particular season or longer period of time. Includes how that decision is communicated.
Stake holders	Hunters, foresters, conservationists, amateur naturalists, land owners, entrepreneurs, government and non-government agencies.	Land managers, land owners, entrepreneurs, and government and non-government agencies.	Hunters, foresters, conservationists, amateur naturalists, land owners, entrepreneurs, government and non-government agencies.
Funding	Voluntary, club/membership organisation, government, non-government.	Voluntary, club/membership organisation, government, non-government.	Voluntary, club/membership organisation, government, non-government.
Scale	Local, regional, national	Local, regional, national	Local, regional, national

Table 3

Stage	1: *Date Gathering*	2: *Analysis & Interpretation*	3: Management Decisions & Dissemination
Iceland: Ptarmigan			
Description	Ptarmigan counts in 23 areas (of known size) all around Iceland. Line transects counts in four areas gives basic status of the population. Road line transects counts on 17 areas gives basic status of the population. Bag statistics and hunting activity data of all hunters (response rate > 90 %).	Local and regional densities describing population status (density per km^2, breeding success). These analyses are done by the IINH funded by the Icelandic government. Results and time-series of relative change in density and breeding success are presented at an annual Ptarmigan meeting and the IINH web site. Scientists at the IINH and specialists at the WMD make recommendations on length of hunting season and sustainable harvest to The Ministry for the Environment.	Number of permissible hunting days is decided by The Ministry for the Environment who may also close certain areas to hunting if they are showing decreasing numbers of ptarmigan.
Flow of Information	Hunters submit their bag numbers to the WMD. Hunters and scientists have access to all that information.	Scientists from IINH analyse data from ptarmigan counts and report results to the Ministry for the Environment and the WMD. The information from the IINH is open to the public.	The Ministry for the Environment discuss with scientists of IINH and WMD if there is a need to adjust the number of hunting days. The Ministry for the Environment reports its decision on the coming hunting season on the internet.
Stake holders involved	Icelandic Institute for Natural History. Wildlife Management Division of the Icelandic Environment Agency. Hunters. Icelandic Hunters Association.	Icelandic Institute for Natural History. Wildlife Management Division of the Icelandic Environment Agency. Hunters. Icelandic Hunters Association.	Icelandic Institute for Natural History. Wildlife Management Division of the Icelandic Environment Agency. Hunters. Icelandic Hunters Association.
Funding	The IINH and the WMD are both government funded. The IINH ptarmigan research has also been funded by the Hunting Card fund (paid for by the hunters).	Government and income from sale of Hunting Cards.	Government and income sale of Hunting Cards.
Scale	Local, regional, national	Local, regional, national	Local, regional, national

Scotland: Red grouse			
	Data Gathering	Analysis & Interpretation	Management Decisions & Dissemination
Description	Block and transects counts of variable number and distribution on private properties. GWCT conduct block counts using Distance Sampling techniques on up to forty 100ha sites per year. Give basic status of the population in August (density, sex ratio, breeding success). Statistics about number of days shot, guns involved and shots fired for most days recorded in private datasets. Bag statistics recorded in private datasets. Some private bag data centrally recorded in National Game Census.	Population status (density, breeding success), bag data compiled in some estate records. GWCT compile and analyse regional trends	Harvest level managed on a daily iterative basis by land manager.
Flow of Information	Data collected by estate land managers or contractors, fed back to management team and owner.		Expert knowledge used by contractors, land management team and/or owner to set harvest levels.
Stake holders involved	Landowner. Land manager (gamekeeper). Commercial managers/Estate Office staff. Game & Wildlife Conservation Trust.	Landowner. Land manager (gamekeeper). Commercial managers. Game & Wildlife Conservation Trust	Landowner. Land manager (gamekeeper). Commercial managers. Game & Wildlife Conservation Trust
Funding	Private, Charitable (GWCT).	Private, Charitable (GWCT).	Private, Charitable (GWCT).
Scale	Local (private properties), National (GWCT).	Local (private properties), National (GWCT).	Local (private properties), National (GWCT).

Sweden: Moose			
Stage	1	2	3
	Date Gathering	Analysis & Interpretation	Management Decisionsns & Dissemination
Description	Moose observations during hunting. Hunting bag statistics. Damage by moose on young forest stands. Moose-vehicle collision statistics. Flight inventories when necessary. Local/regional initiatives. Pellet counts. Age determination. Slaughter weights.	Stakeholders analyse and interpret their own data. All relevant data is presented and reviewed in LCGs. If needed, the CCG reanalyse the data.	Management decisions are always decided by the county board. However, a recommendation for the decision is prepared by the CCG.
Quality control/assurance	All of the data described gathered by the different stakeholders, as well as how to analyse and interpret the data, have been evaluated by researchers There is a constant and ongoing process to further develop, improve and validate methods through independent researchers to try to achieve a common trust of different data sources. Currently there are ongoing improvements and/or quality insurance regarding pellet counts, aerial censuses and moose damage censuses.	Independent researchers are often involved in the process, especially when there are odd outcomes or when conflicts arise between stakeholders. There is no special research group for this, usually the most qualified researchers in the specific area are asked to participate.	Before decisions are made data and analysis is reviewed by the CCG.
Stake holders involved	Local hunters. Hunter associations. Forest authorities. Forest companies. Police authorities. Researchers.	Local hunters. Hunter associations. Forest authorities. Forest companies LCGs. CCGs . Researchers.	CCGs . County boards.

Funding	Voluntary hunters and hunting clubs. Hunters (from hunter fees, administrated by the government). Forest authorities (Government). Forest companies. County boards (moose management fund). Police authorities (Government).	Hunters (from hunters fees and the moose management fund, administered by the government and the County board). Forest authorities (Government). Forest companies. County boards (moose management fund). Police authorities (Government).	County boards (moose management fund (CCG) and government).
Scale	Local	Local, regional,	Regional
Sweden: Willow Grouse			
Stage	1	2	3
	Date Gathering	Analysis & Interpretation	Management Decisions & Dissemination
Description	Description of the hunting areas (statistic of land use, conservation areas etc.). Line transects counts since 1994 (three areas since 1970. Gives basic status of the population in August (density, sex ratio, breeding success). Statistics about number of hunters at subunit level. Bag statistics and hunting activity data of all hunters (response rate > 90 %).	Local and regional densities describing population status (density per km^2, breeding success). These analyses are done by the Swedish University of Agricultural Sciences funded by the Swedish government. Results and time-series of relative change in density and breeding success are presented on the county boards' home-pages. Number of permissible hunting days per km^2 is decided by County Boards after discussion with scientists at the Swedish University of Agricultural Sciences.	Adjustments of accumulated hunting days per km^2 in years with low ptarmigan densities.
Flow of Information	Local hunters and dog handlers collect information on ptarmigan densities – reports over internet to County boards and scientists.	Scientists analyse data from ptarmigan counts and report results to county boards.	County boards discuss with scientists if there is a need for adjusting accumulated hunter days per km^2. Report decision on internet.
Stake holders involved	County boards. Local hunters. Hunters Central Association.	County boards. Swedish University of Agricultural Sciences. Hunters Central Association.	County boards. Local hunters.

Funding	Voluntary hunters and dog handlers, 1/3 of income from hunter permits.	Government and income from hunter permits.	Government and income from hunter permits.
Scale	Local, regional, national	Local, regional, national	Local, regional, national
Finland: Woodland Grouse	Date Gathering	Analysis & Interpretation	Management Decisions & Dissemination
Description	Description of the hunting areas (e.g. statistic of land use, conservation areas). Wildlife triangle surveys since 1989 (older transect survey data 1966-1988) provide basic status of the population in august (density, sex ratio, breeding success). Transect surveys of willow grouse (*Lagopus lagopus*) using pointing dogs in the mountain area of Lapland. Statistics about number of local hunters with free hunting rights at municipality level and their hunting activity based on questionnaires in 2003 and 2008. Regional bag statistics and hunting activity data of non-local permit hunters (response rate about 30 %).	Regional indices describing population status (density, breeding success). These analyses are carried out annually by the FGFRI which is a government research institute. Results are freely available on the internet. Sustainable hunting quota and allocation between local and permit hunters are modelled using population density and hunting activity data. This is done by the MNHS which is governmental organisation and responsible for hunting management on sate own land.	Based on population densities, the length of hunting season is decided. This can be done at three geographic levels. At the national level ministry of Agriculture and Forestry annually decide on the length of the hunting season for each species. This can be shortened by the board of hunting district or Forest and Park Service. However, they cannot lengthen the hunting season. MNHS makes an initial proposal on the size of the hunting quota and allocation between local and non-local permit hunters. This proposal is discussed with local hunters before final decision, which is then taken by FPS.
Stake holders involved	Local hunters and hunting clubs. FGFRI. Hunters Central Organisation. MNHS	FGFRI. MNHS.	Ministry of Agriculture and Forestry. Regional Game management districts and Local Game management associations (both consisting of only local hunters).
Funding	Voluntary hunters and hunting clubs, government.	Government.	Government.

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Evaluation of Expert Models for Monitoring Game Populations

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Introduction

In many parts of the world hunting is an important recreational activity with, in some cases, significant cultural value as well as being an important source of food and income (Matilainen 2007; Bergstrom 2008; MacMillan & Philip 2008; Müller-Wille et al. 2008; Mfunda & Røskaft 2010). Game populations may be considered a renewable resource as long as they are not over-exploited (Gordon 1954; Hardin 1968). To determine and demonstrate the sustainability of current levels of harvest and to prepare for population changes, monitoring of game populations and their fluctuations is essential (Milner-Gulland & Akçakaya 2001). There is large body of literature on the subject of population assessment (See e.g. Sutherland 2006). While objective information through appropriately designed field sampling is desirable, it is not always possible within the resource and budget constraints of a management unit. The cost of collecting field data, in terms of time, expense and necessary resources can be large and may substantially reduce the budget available for management (Field et al. 2004; Seoane, Bustamante & Diaz-Delgado 2005).

Commercial hunting entrepreneurs must balance the many demands of running a business and game management. Many hunting entrepreneurs in Nordic countries have a commercial interest in a common, public resource as they are using state owned land or leasing company land to make a profit (Dahl & Sjöberg 2010). Considering the very traditional hunting culture in the northern parts of the Nordic countries, where hunting is considered a public right that should have a limited cost, hunting entrepreneurs must consider social sustainability and balance social sustainability with ecological and economic sustainability (Gunnarsdotter 2007; Matilainen & Keskinarkaus 2010). For the entrepreneurs, economical sustainability is the main motive for their activity but without their business being socially accepted in the local community their chances of succeeding are small (Matilainen & Keskinarkaus 2010).

Collecting and interpreting population data based using scientifically established methods is challenging for small entrepreneurs due to the lack of capacity and resources. An efficient source of less expensive information can be expert knowledge gained from extensive experience. Although many studies (e.g Scoles & Biggs 2005; Mace 2005; Yamada et al. 2003; Martin et al. 2005; Seoane et al. 2005) have demonstrated the valuable contributions expert opinions can provide in assessing or evaluating natural resource management no one has yet, at least to our knowledge, evaluated if expert assessments can be used as a simple and cost-efficient proxy for more established methods to assess population density and productivity of game populations. In this report, we evaluate the following questions:

(i) How well do expert assessments predict relative changes in density and reproduction of a population compared with the previous year?

(ii) How well do expert assessments predict the absolute density and reproduction of a population?

(iii) Is there a difference in assessments between different groups of experts with different interest in the species population concerned?

(iiii) Can the accuracy and precision of estimates be improved by information about previous population development?

(iiiii) Can the accuracy of estimates be improved by encouraging experts to also take into account other sources of information within their personal network when building their own conceptual model?

Methods

Study area

The study was carried out in the alpine zone in the county of Jämtland, in the southern part of the northern mountain range in Sweden. The area is 12 500 km^2 large and dominated with low shrub vegetation, heaths, poor bogs, alpine birch forest (Betula spp.) and willow (Salix spp.) ranging from 500 – 1050 meters above sea level.

The model species

The willow ptarmigan was selected as model species for our evaluation. The willow ptarmigan is, after the moose, the most important game species for hunting tourism in northern Sweden (Eriksson et al. 2006; Dahl & Sjöberg 2007). As many small game species the willow ptarmigan exhibits large fluctuations in density and reproduction between years (Hörnell-Willebrand 2005), which is an important factor in their ecology and management and must be taken in to account by hunting entrepreneurs in their business plans and operations. Willow ptarmigan is a well studied species in this area (Hörnell-Willebrand 2005). Densities and reproduction are calculated with distance sampling methodology (Buckland et al. 2001) each autumn (Hörnell-Willebrand 2005). We used data on population densities and reproduction from 10 areas evenly distributed within the county. Mean annual population densities and reproduction values were calculated using data from 1996 – 2009.

The experts

We define an expert as a person having a special interest and/or competence in the target species. Forty-nine experts, from three different groups of stakeholders, were selected from local residents. All experts were familiar with the ecology of the willow ptarmigan and spent a lot of time outdoors in the mountain range during summer each year. The following groups were used in the study;

(i) Professional hunting entrepreneurs and guides (22) were selected because of their professional interest and experience in willow ptarmigan. For them, keeping track of the population was a matter of keeping track of their own livelihood.

(ii) State employed mountain rangers (10) were selected because of their experience of game species in the mountain range in general and that they spend a lot of time outdoors on the state owned land as part of their job.

(iii) Sami reindeer herders (17) were selected because they spend a lot of time out in the mountain range during summer, while herding their reindeer. Sami reindeer herders do not have a professional interest in the ptarmigan, but do have enough knowledge to make competent assessments.

How did we do?

After explaining the purpose of the study we asked each expert eight questions (Appendix 1) about the willow ptarmigan population. All experts were personally interviewed and each interview occasion took approximately ten minutes. We used a variety the Delphi technique to reduce variability between experts in the assessment (Dalkey & Helmer 1962; Linstone & Turoff, 1975; MacMillan & Marshall 2006). High variability and disagreement between experts may arise due to difficulties in assigning personal experience in to a wider setting, for example; without knowledge on the minimum, maximum or average population density experts may find it difficult to ascribe their assessment to a meaningful scale. The Delphi technique aims to achieve reliable and consistent judgments within the expert group by means of consecutive questionnaires and controlled feedback. The Delphi technique is also a learning process in which the experts can adopt new points of view and new knowledge via other experts' statements. Here we evaluated another type of information to reduce the variation and provide bounds to the answers within reasonable ecological limits. In a second round of questions the respondents were given the mean, minimum and maximum population density in the area during the past 13 years, thus providing some figures to relate their own estimates against. This can also be seen as a calibration of their judgments. The experts were given the opportunity to check their first response to the density estimate, to change it, or to leave it as it was. Finally to evaluate the value of collective local knowledge as a foundation for developing an internal conceptual model we also asked each expert to report the number of information sources (other hunters, newspapers, internet forums etc.) they had used in arriving at their estimate.

Data analyses

Ptarmigan per km^2 and breeding success were log-transformed to achieve normality before analysis and R (R Development Core Team 2010) was used for all data analysis.

Results

Days spent outside by the expert groups

Sami reindeer herders spent significantly more days outside compared to professional entrepreneurs and hunting guides (t-test P<0.005). Mountain rangers spent more days outside compared to professional entrepreneurs and hunting guides, although this was not significant (t-test, P=0.06). There were no significant difference in days spent outside between Sami reindeer herders and mountain rangers.

Changes in relative density and reproduction

Results from the distance sampling survey made after the experts were questioned, showed that the density of ptarmigan increased from a very low level in 2009 to an average level in 2010. Breeding success was unusually poor in 2009 and increased to the highest breeding success registered, since the distance sampling surveys started in 1996, in 2010.

Professional hunting entrepreneurs and guides assessment was that there were more ptarmigan this year while Sami reindeer herders and mountain rangers thought there were less ptarmigan. Professional entrepreneurs and hunting guides also thought this year represented better reproduction but both Sami reindeer herders and mountain rangers thought it was worse.

Absolute breeding success

Experts were given two questions concerning breeding success; number of chicks per female with chicks, and proportion of females with chicks. This could then be compared with results from the distance sampling surveys where breeding success is measured as number of young per female including unsuccessful females. Professional hunting guides and entrepreneurs expert assessment was very close to true breeding success, 4.8 young per pair compared to 5.13 young per pair estimated from the distance sampling survey (table 1). Sami reindeer herders' assessment was 2.7 young per pair, and mountain rangers assessment was 2.6 young per pair which both were significantly different from the distance sampling survey and assessments of professional hunting guides and entrepreneurs (t-test, P<0.01)(table 1).

Absolute density

When asked to quantify number of ptarmigans per km^2 before being given information about average densities in the area, the same patterns as above emerged. Professional entrepreneurs and hunting guides assessment was similar (12.0 ptarmigans per km^2) to the result from the ptarmigan survey (12.0 ptarmigans per km^2) (table 1). The assessments of sami reindeer herders (4.6 ptarmigans per km^2) and mountain rangers (3.2 ptarmigans per km^2) were statistically lower than the assessment of the professional entrepreneurs and hunting guides and the result obtained from the ptarmigan survey (t-test, P<0.01). Again there were no significant difference between answers given of Sami reindeer herders and mountain rangers.

After being given information on mean densities of willow ptarmigan per km^2 from the ptarmigan surveys on state owned land in the area, professional entrepreneurs and hunting guides changed their assessment only a little (table 1). Sami reindeer herders and mountain rangers adjusted their assessment to a higher estimate but still significant lower (t-test, P<0.01) than the value given by professional hunting guides and entrepreneurs, and the estimate from the ptarmigan survey (table 1, figure 1).

Effect of information about historical population development on variation within experts

Professional entrepreneurs and hunting guides and Sami reindeer herders decreased the variation associated with their estimates after taking the new information into account, while mountain rangers increased their variation (table 1). However, this was not significantly different in any group.

Effect of multiple sources of information per expert on the accuracy of their conceptual models

Sami reindeer herders used significantly more sources as a base for their assessments compared to mountain rangers (t-test, $P<0.02$). There were no significant difference between Sami reindeer herders and professional entrepreneurs and hunting guides, although there was a tendency for Sami reindeer herders to use more sources compared to professional entrepreneurs and hunting guides (t-test, $P=0.07$). When pooling all groups there was a tendency for a negative effect from multiple sources on estimates of density (figure 2) ($P=0.08$). For every additional source of information expert assessment decreased with 1.3 ptarmigan per km^2.

Discussion

Professional hunting entrepreneurs and guides assessment of ptarmigan population density and reproduction were accurate and in close agreement with density and reproduction estimates derived from line transect surveys and distance sampling. Other expert groups were less accurate, but they did improve their estimates when provided with information on maximum, minimum and mean estimates from the previous years. The same pattern was apparent in the relative estimates; professional hunting entrepreneurs and guides accurately described the observed population development while the other expert groups were considerably less accurate. As it seems, a professional interest in the species may be more valuable than spending excessive time in the area. It is possible that there is a threshold in time spent in the area when there is enough information to make a correct estimate. It is however necessary with more data to find out if this can be reproduced year after year.

Sami reindeer herders and mountain rangers did improve their estimates after taking into account historical data, although assessments were still inaccurate. It still seems sensible to allow experts to calibrate their assessments against estimates derived from independent and established methods to help minimize systematic error in their subjective assessments. It is also likely it will take several years before their internal personal models are calibrated so that their assessments are at least consistent. Further it seems possible that historical data may help to decrease the variation between experts to give more precise estimates, provided that the experts are willing to utilise this information.

Involving additional sources of information into their assessment did not improve accuracy; in fact their assessments became worse. This result was somewhat unexpected. If anything, collective local knowledge was expected to improve accuracy. It is possible that expert models work best using only the assessments of the experts, and using only experts that have a professional or otherwise strong interest in the species.

Expert models are not yet fully evaluated, but show potential when used by professionals. Combined with bag data and observation statistics from the hunts expert assessments can be a simple method to

help ensure ecological as well as social and economic sustainability of the company. In worst cases this may be a self-auditing of the company, but more likely the combined data can also be compared to regional survey data and used as a potential alert if assessments are diverging. Setting ecological threshold values may be a useful and simple approach to local game population management. Such thresholds can likely be recognized by serious experts after calibration and some years of experience. Below the limit it is time to be cautious, set conservative quota, and carryout responsible marketing.

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Tables and figures

Table 1. *Expert assessments of absolute density and reproduction, and results from the ptarmigan survey.*

Expert group	**ptarmigans per km² before information**	**ptarmigans per km² after information**	**young per pair**
Professional entrepreneurs and hunting guides	12.0 (SD 12.0)	12.4 (SD 7.7)	4.8 (SD2.0)
Sami reindeer herders	4.6 (SD 7.0)	5.5 (SD 5.2)	2.7 (SD 2.5)
State employed mountain rangers	3.2 (SD 2.8)	4.6 (SD 3.6)	2.6 (SD 1.6)
Results from the ptarmigan survey	12.0 (SD 2.7)	12.0 (SD 2.7)	5.1 (SD 2.0)



Figure 1. *Expert (Professional hunting entrepreneurs and guides, Sami reindeer herders, state employed mountain rangers) assessments (Median, max, min, 3rd quartile) of number of ptarmigans per km² after being given information about historical mean density, maximum and minimum values in the area, compared with the distance sampling survey of ptarmigan.*

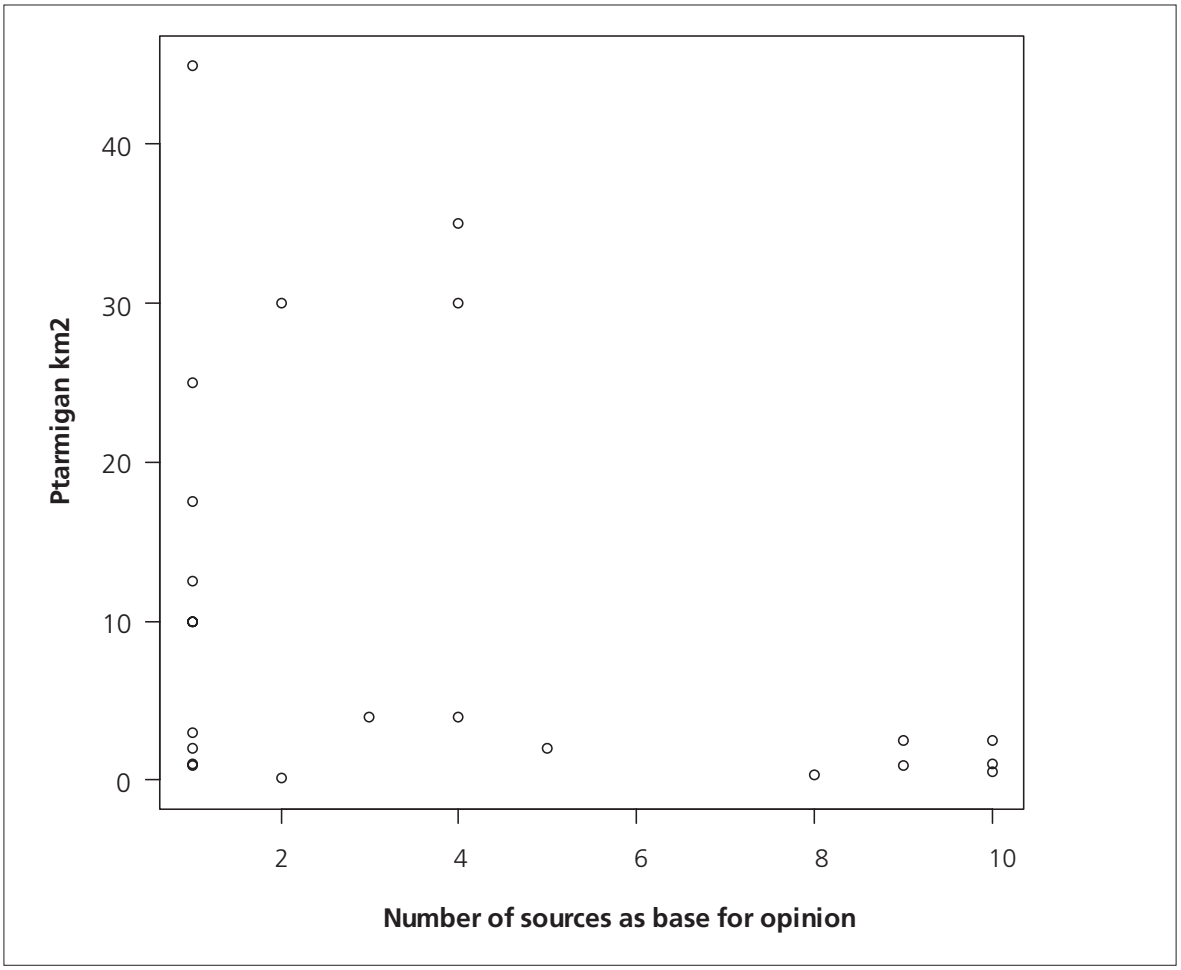


Figure 2. *Number of sources used by experts as base for their assessment, plotted against assessment of ptarmigan density. All groups of stakeholders pooled.*

Appendix 1. Questions asked to interviewees

QUESTIONS	
In what area have you been active during june - early august?	Southern or Northern part of the county
How many days have you been out in the field this summer?	1-10; 11-20; more than 21
Compared to the same period last year, do you think it is more or less ptarmigan in total this year?	much less; less; same; more; much more
How many ptarmigans per km2 do you think that represents?	Exact number
Compared to the same period last year, do you think breeding success are better or worse this year?	much worse; worse; same; better; much better
How many chicks per female do you think it is on average? (only females with chicks included)	Exact number
How large proportion of the females have chicks?	Exact proportion
How many sources do you base your opinion on?	Own observations and/or others opinions; number
HERE THEY ARE GIVEN INFORMATION ABOUT AVERAGE DENSITIES AND BREEDING SUCCESS IN THE AREAS	
How many ptarmigans in total do you think it is this year per km2 based on this new information?	Exact number
Have your participation in this study last year made you more observant this year?	Yes;No

Overall Discussion and Conclusions

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- Robust and reliable monitoring of game populations is critical for the development of hunting tourism.

- However, monitoring alone is not sufficient if stakeholder do not perceive management decisions to e legitimate. The decision making process and participation of stakeholders is equally important.

- Theory and case studies suggest that the risk of over exploitation is greater under an open access model than under a monopolistic model where there is a clear right of ownership and responsibility. Ecological sustainability thus seems more assured under a monopolistic system.

- The cases show that, under an open access model conflicting interests and competition for game resources have made the monitoring and management process more open, and with greater emphasis on objectivity as well as knowledge.

- Finding low cost methods to estimate status of game populations at local level is important for hunting entrepreneurs. Our assessment suggests that expert models show potential when used by professionals. Combined with bag data and observation statistics from the hunts expert assessments may represent a simple method to help ensure ecological as well as social and economic sustainability of the company. In worst cases this may be nothing more than self-auditing of the company, but more likely the combined data can be compared to regional survey data and used as a potential alert to identify possible short comings in expert assessments. Setting ecological threshold values may be a useful and simple approach to local game population management. Such thresholds can likely be recognized by serious experts after calibration and some years of experience. Below the limit it is time to be cautious, set conservative quota, and carryout responsible marketing. The results are encouraging and reason for further study.

- The cases presented here reveal considerable diversity in the approach to monitoring and decision making process, however, all the systems assessed here appear ecologically sustainable with minimal risk over exploitation or stakeholder conflict.

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ISBN 978-952-10-6473-9 (pdf)
ISSN 1796-0630 (pdf)
www.helsinki.fi/ruralia