UNIVERSITY OF HELSINKI
DEPARTMENT OF APPLIED BIOLOGY
PUBLICATION no 25

Management of wildlife richness in Finnish forests – interplay between game-related actors and actions

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ACADEMIC DISSERTATION

To be presented, with the permission of the Faculty of Agriculture and Forestry, for public criticism in Viikki, Auditorium B3 (Latokartanonkaari 9), Helsinki, on November 4th, 2005, at 12 o'clock noon.

Pellikka, J. 2005. Management of wildlife richness in Finnish forests – interplay between game-related actors and actions. 29 p.

This thesis is based on the following articles, referred to their Roman numerals in the text:

I. Pellikka, J., Lindén, H., Rita, H. & Svensberg, M. 2005: Motives for voluntary wildlife monitoring in Finnish hunting teams. (Submitted).

II. Pellikka, J., Rita, H. & Lindén, H. 2005: Monitoring wildlife richness – Finnish applications based on wildlife triangle censuses. Annales Zoologici Fennici 42: 123-134.

III. Pakkala, T., Pellikka, J. & Lindén, H. 2003: Capercaillie Tetrao urogallus - a good candidate for an umbrella species in taiga forest. Wildlife Biology 9: 309-316.

IV. Pellikka, J., Kuikka, S., Lindén, H. & Varis, O. 2005: The role of game management on wildlife populations – Uncertainty analysis of expert knowledge. European Journal of Wildlife Research 51: 48-59.

Cover: Olaus Magnus 1539

ISBN 952-10-2724-X (paperback)
ISBN 952-10-2725-8 (PDF)
ISSN 1457-8085
Yliopistopaino, Helsinki 2005

Contributions

	I	II	III	IV
Initial idea	JP, HL	HL, JP	HL, TP	SK, JP, OV, HL
Logic of reasoning	JP, HR	HR, HL, JP	TP, HL, JP	SK, OV, JP
Materials	MS	HL	TP, HL	JP
Analyses	JP, HR	JP, HR	TP, JP	JP
Manuscript	JP, HR, HL, MS	JP, HR, HL	TP, HL, JP	JP, SK, HL

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Abstract

In this thesis I explore the prerequisites for the successful management of wildlife richness in Finnish forests. Wildlife richness is a concept describing species richness and species abundance of well-known game species, which have social, cultural and economical value. The management of wildlife richness is described here as a sequence of actions, where 1) monitoring information of populations is collected by carrying out wildlife triangle censuses, 2) analyses are made in order to detect trends in wildlife richness and 3) game-related decisions are implemented in order to sustain or increase wildlife richness. These phases and the uncertainty relating to them are studied and evaluated focusing on the short-term actions of the interplaying actors in the field of game management.

Wildlife triangle censuses are largely carried out by groups of voluntary hunters. The resolution and participation on the wildlife triangle scheme (WTS) varies between regions. The resolution of monitoring information may be increased e.g. by motivating participants by improving the utility of monitoring results for them and actively recruiting additional participants especially among large hunting clubs.

Wildlife richness indices (WRI) are applications of the wildlife richness -concept and WTS data. The WRI can be flexibly used in the detection of spatial and temporal trends in wildlife richness. The performance of estimation and the choice of specification in the WRI are affected by the data, and guided by research or management needs and decisions on acceptable risks. Studying the statistical properties of the census data would improve the estimation of wildlife richness and risk assessment. The density of Capercaillie reflects relatively well the general state of wildlife richness, but great care should be taken in using it or any other species to represent wildlife richness or the welfare of other species.

The activities of local hunters can be restricted or supported in order to affect wildlife richness. Besides national or regional hunting regulation carried out by administrators, the information given to hunters may affect their voluntary activities. However, Finnish wildlife experts consider the effect of voluntary activities on wildlife richness and especially on grouse and small predators relatively small. This implicates that more detailed monitoring or further studying of the effect of game management may not be a key-uncertainty for the management of risks regarding wildlife richness.

Contents:

Introduction

An approach, where the welfare of many species is considered at the same time, has gained popularity during the last decades. This trend seems to be partly motivated by ecological reasons to monitor many species as early and sensitive indicators of ecosystem change (e.g. Schindler 1987) or unsustainable use, or e.g. the need to manage many species at the same time due to interactive species (Soulé et al. 2003, Lessard et al. 2005). Another motivation for multi-species approach may be the economical limitation to monitor or manage species separately (e.g. Simberloff 1998). Although this approach can be seen as tempting, its practical development and implementing as a multi-species management system is a challenging task.

The multi-species approach has been applied in the fields of conservation biology (e.g. as ecosystem management) and resource management (e.g. Grumbine 1994). Furthermore, it has been applied in management of fisheries (Fowler 1999), and principles and policies of this approach have also been adopted to international and national game management.

In Finland, the concerns of the sustainability (i.e. persistence of populations in time) of Finnish mammals and birds being hunted by man (henceforth game) have been emphasized for over the last century (e.g. Aho 1902) and the principle of sustainable use is a prerequisite for hunting according to the current hunting legislation (Metsästyslaki 1993). The recently introduced Finnish Natural Resources Strategy (Maa- ja metsätalousministeriö 2001) extends the goal of sustainability to include also the diversity of game communities, and expects that the risk for species extinctions is being decreased by the efficient interplay of hunters and game research.

In addition to the clearly defined management goals (as above), which are typically basing on the values expressed by politicians, many criteria subordinate to goals can be set for multi-species resource management. For example, Fowler (1999) suggests that multi-species management should 1) be consistent and be applied at various levels of biological organization, 2) account for uncertainty, 3) result in systems within their normal range of natural variation, 4) exercise precaution and consider risks for sustainability, and 5) be based on information (through interdisciplinary approaches). In addition, it should 6) include monitoring, research and assessment. Furthermore, multi-species resource management has to

7) be limited to controlling human activities and 8) include humans among the components of ecosystems and biosphere.

Many characteristics of these criteria are such that they can be considered as research hypotheses in a sense that they define and guide the evaluation of any management system. By combining the views presented in the Finnish Natural Resources Strategy (Maa- ja metsätalousministeriö 2001) and Fowler (1999) one can hypothesise that a multi-species game management system in Finland should be based on 1) monitoring with high quality and resolution of data, 2) analyses on many scales, and 3) controlling hunter activity in order to affect populations. It should also 4) take into account the uncertainties affecting tactical and strategic decision making (see Kuikka 1998 for detailed discussion of the role of uncertainty in fisheries management).

In order to test if the Finnish game management system regarding wildlife richness fulfils these requirements, the system has to be structured and divided into smaller parts. A suggested structure compatible with the organisational structure of game management in Finland is to consider the system with three actions and several actors. The main actors in the Finnish game management system are local hunters and their associations (henceforth hunting clubs), administrators in the regional and national level and game researchers.

The actions are sequential: 1) monitoring (and measuring) of populations and human activity, 2) analyzing the monitoring information and 3) decision making and implementing. The actions have a cyclic dynamics, where measuring can be seen both as a part of the new research activity and as feedback of the former management action. Together, these Finnish actors and actions of the management system define the study framework of this thesis (Fig. 1).

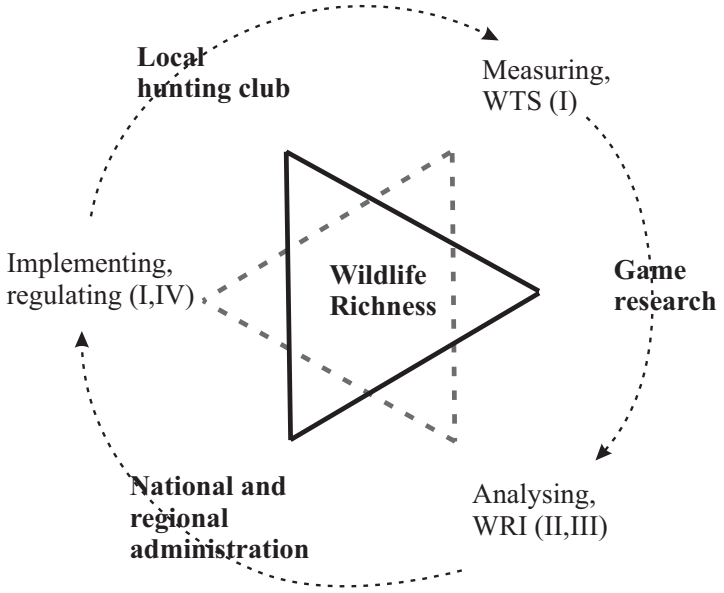


Fig. 1. The framework of this thesis. The triangle with a solid line connects the actors of the system (in bold). The triangle with a dashed line connects the actions, which are generated by the interplay between the adjacent actors in the triangle. A cycle of actions (arrows) defines the dynamics of this system. The roman numerals refer to the articles in this thesis.

Objectives

In this thesis attempts are made to explore the Finnish game management system associated with wildlife richness in respect of the above mentioned four requirements. The scope of the proposed framework includes the management of wildlife richness in Finnish forests and mainly in the short term. In this temporal context the forest habitats are given (as such) and not targets of the operations. The focus is on the interplay of the separate management actions carried out by local hunters, game researchers and hunting administrators. The results of this summary can be seen as evaluation of the need for further studies and support for policymaking regarding the management system.

Background of the framework

In the following I describe in more detail the actors and actions of the game management process in Finnish forests as background information for this framework and the articles of this thesis.

Monitoring game populations

Temporally and spatially extensive monitoring of forest-living game species began in the 1940s. The monitoring was organized by the Finnish Game Foundation (Lampio 1967), and it was based on yearly questionnaires made for hunters about the population trends of popular game species. The censuses of grouse populations were started in 1963 (e.g. Rajala 1974). These route censuses were carried out by voluntarily participating hunters in groups of at least three persons. The number of participants in the censuses grew rapidly, and continued increasing until 1983, when about 900 groups (i.e. 4 000 hunters) took part in the censuses (Rajala & Lindén 1984). Alongside with this method, other monitoring methods were also applied for e.g. forest-living ungulates and large predators.

The wildlife triangle scheme (henceforth WTS) replaced the route censuses in 1988. The Finnish Game and Fisheries Research Institute (henceforth FGFRI) organizes the WTS twice a year; in addition to the monitoring of grouse populations in summer censuses, the monitoring of about 25 other species was started by using winter censuses (Lindén et al. 1996).

The WTS is mainly carried out by members of the hunting clubs. The yearly WTS-censuses are carried out by about 7 000 participants (2 % of the Finnish hunters) and 800-1 000 participating groups (Fig. 2a-b), i.e. more than 20 % of the registered and unregistered hunting clubs carry out the WTS. The summer census has been more popular than the winter census as measured with the number of census locations or the frequency of group participation.

a)

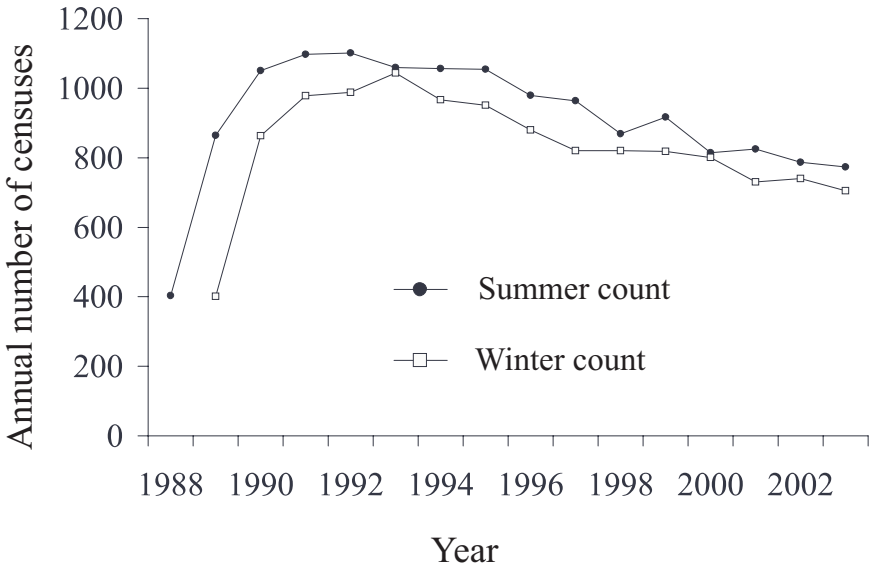
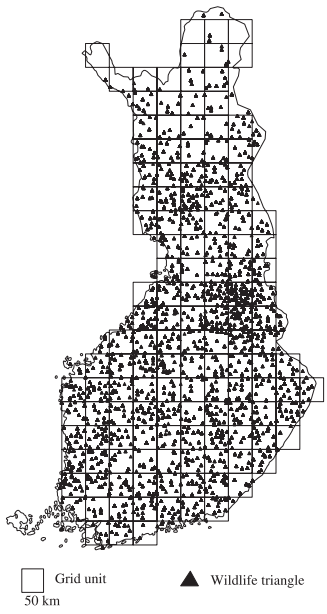


Fig. 2. The resolution of the WTS data. The graph in a) describes the annual number of census events in Finland during 1988–2003. During the last 15 years censuses have been carried out at least 12 times in approximately 50 % of the locations in summer, and 40% in winter. The map in b) describes the spatial resolution of the WTS data and 50 × 50 km grid units. The total number of census locations is more than 1600.

b)



Analysing wildlife richness

The general idea of the richness of game, high abundance of different game species, exists in many forms in Finnish art and literature (e.g. Olaus Magnus 1539 (see cover)). However, it was not until 1999 when Lindén et al. (1999) defined this idea as a concept of "wildlife richness", which describes species richness and species abundance of well-known game species having social, cultural and economical value for society.

In order to be used in multi-species monitoring and analyses of wildlife communities in Finnish forests, Lindén et al. (1999) also introduced an indicator named the Wildlife Richness Index (henceforth WRI) as an application of the concept and WTS data. The basic idea of the WRI is to relate the observed abundance of each species to the abundance of the same species in other time or space. The index value is based on the summation of these species-specific abundance ratios (see Fig. 3 and 4 for interpretation of the index value).

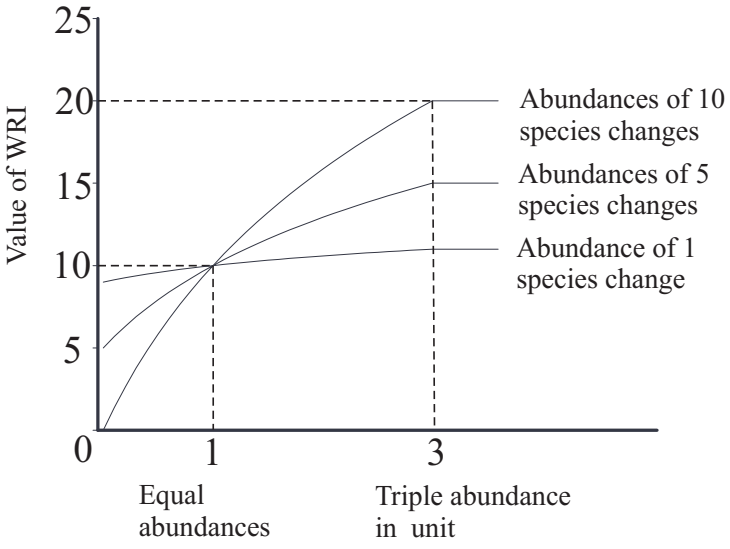


Fig. 3. An example of the interpretation and sensitivity of the WRI. Solid lines describe the changes in the log2-scale, when abundances of one, five or ten species out of ten monitored species change simultaneously in respect of the reference abundances. Note that high species-specific ratios may be cut (here, ratios higher than three will not increase the index value) in order to prevent a single or few species dominating the WRI.

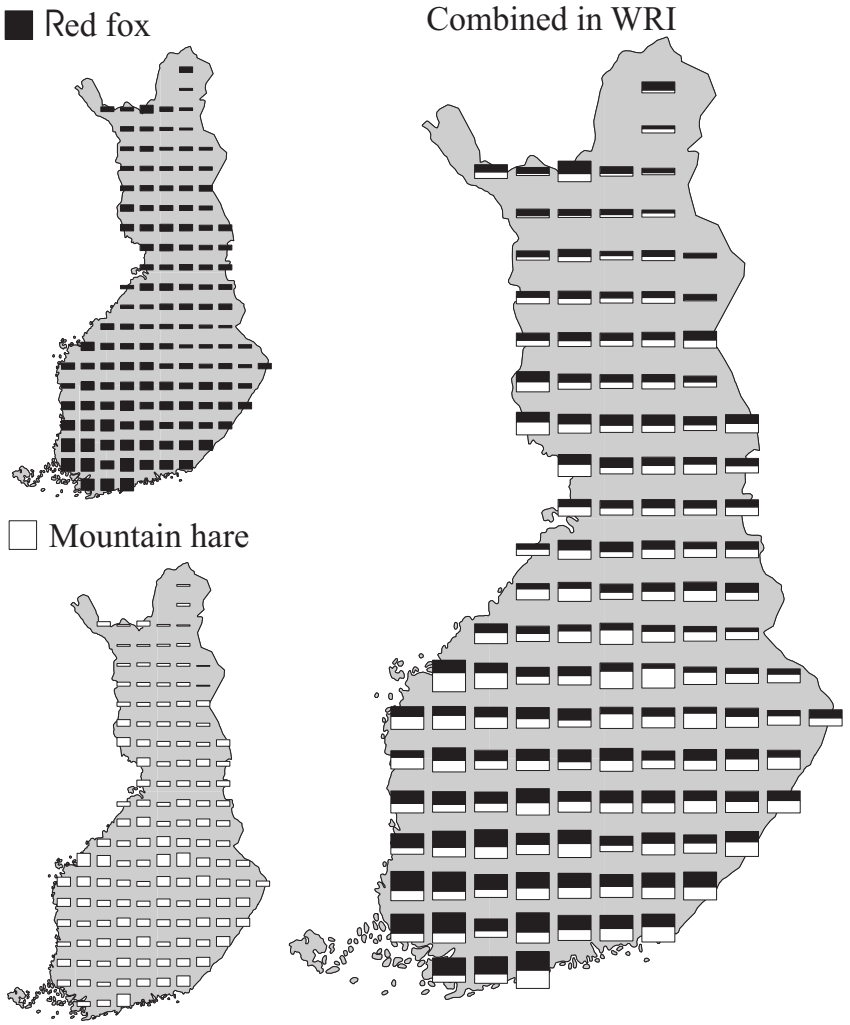


Fig. 4. A simplified two-species illustration of the difference between single-species- and multi-species approaches in the case of wildlife richness. The maps on the left side describe separately the spatial pattern in the relative abundances (measured with track index) of mountain hare and it's main predator, red fox. This information can be utilised in single-species management with no need or ability to consider species-interactions. The map on the right side describes the wildlife richness being composed of only these two species. This map reveals clearly the decreasing spatial trend from west to east and from south to north (which would be harder to see, if more species would have been chosen here to represent wildlife richness). However, the map also reveals the changes in the relative composition. This information can be helpful, when deciding on an efficient way of managing these species.

Affecting wildlife richness

The national decisions affecting game animals are mainly made on three spatial scales in Finland: the national scale (the parliament, ministries, organizations), the regional scale (e.g. Game Management Districts) and the local scale (land owners, hunting clubs and individual hunters) (for details, see e.g. FACE 1995).

Many aspects of wildlife richness in Finnish forests can be affected. For example, relocating game animals (e.g. wolverine *Gulo gulo* and wild forest reindeer *Rangifer tarandus fennicus*) and introducing new species (e.g. white-tailed deer *Odocoileus virginianus*) have been used during the last century to increase the species richness of game animals, but these methods are no more allowed (Maa- ja metsätalousministeriö 2001). Nowadays, restoring and improving living habitats of game have been emphasized as long-term management methods (e.g. Maa- ja metsätalousministeriö 2001). In the short term, however, large scale changes to the forest habitats, land use or forestry practices are not conceivable options. Instead, affecting the hunting mortality has a potential of being a very significant regulating factor for game species, especially for moose *Alces alces* (Luoma 2002), and it may potentially have a rapid effect on populations. In addition, one may consider regulating of hunting as a feasible method for society, because there is a limited number of hunters, whose activities need to be regulated or whose source of livelihood is dependent on these activities.

Game management regarding hunting regulation on the national scale has been typically focused on the length of the hunting season and the efficiency of the hunting equipment (mentioned in the law and the statute of law), and by educating hunters. The regional regulation of hunting by game management districts is typically based on quota setting for the allowed hunting bag of some species (e.g. moose) and providing educational information for local hunters.

The active and important role of locally made (community-based) resource management has been emphasized in many contexts during the last decade. This may be partly due to realizing that the capacity of states to coerce their citizens into management actions is limited, and local management has long historic experience and many methods for regulating harvesting (e.g. Agrawal

& Gibson 1999). In Finland, decreasing the regulation of hunting (e.g. on roe deer *Capreolus capreolus* in 2005) on a national and regional scale can be interpreted as a reflection of the trend toward decentralized management.

Finnish game management on a local scale is typically based on voluntarily made hunting regulation and other activities (e.g. feeding of wildlife): According to a questionnaire study made by the Hunters' Central Organization (Vikberg et al. 2002a), local hunting clubs regulate the hunting effort of their members with various methods. These regulation methods can be potentially effective, since Finnish hunters spend 55% of their hunting time on the clubs' hunting area (Ermala & Leinonen 1995). In addition to hunting, the hunting clubs have long traditions in other associated activities (Salo 1976). Nowadays, most hunting clubs provide extra food for game animals, especially to mountain hare *Lepus timidus*, moose, roe deer, white-tailed deer and black grouse *Tetrao tetrix* (Vikberg et al. 2002b).

Objectives of the separate articles

As previous descriptions indicate, the basis for successful management of wildlife richness on many spatial and temporal scales exists. However, there is much uncertainty in actions, and in the interplay between the actions and actors, which may affect the overall performance of the management of wildlife richness. In the following I introduce the objectives of the articles separately in order to explicate their roles in the evaluation of the management system of wildlife richness.

I. Motives for voluntary wildlife monitoring in Finland

An important prerequisite regarding monitoring is the spatial and temporal resolution of monitoring information. The WTS data are gathered by volunteers (i.e. local hunting clubs) in Finland in cooperation with the FGFRI. The participants and the factors affecting their monitoring activity are not well known, as the international evaluation (Ministry of Agriculture and Forestry

1999) of the FGFRI has pointed out. This kind of voluntary activity is rare in Western Europe.

The purpose of article I is to characterize the hunting clubs participating in wildlife triangle censuses with respect to the inactive clubs, and to explore the plausible explanations for the hunting clubs' interests in carrying out the WTS in cooperation with game researchers.

II. Monitoring wildlife richness - Finnish applications based on wildlife triangle censuses

To meet the different research needs for the management of wildlife richness, the basic ideas of the interplay between WTS data and the WRI have to be extended with corresponding applications. The interplay in this context refers to the procedures, which enable the detection of different aspects in wildlife richness on various scales, and to the choice of species in the WTS to represent wildlife richness. In a broader sense, the interplay can also be seen as cooperation between game researches and administrators.

The purpose of article II is to make various specifications to the WRI. In addition to presenting the administrative background of the needs for developing multispecies monitoring, several applications are introduced. The usability of these applications with wildlife triangle data is also illustrated.

III. Capercaillie Tetrao urogallus - a good candidate for an umbrella species in taiga forest

All the 17 game species chosen by Lindén et al. (1999) to reflect wildlife richness have forests as their primary habitat. There are many prey species, their predators and species which prefer different habitats, forests and successional stages. In order to understand more thoroughly the interpretation of the index values, it is important to study if a trend in the species assemblage indicates in addition to sustainable use also a change in the richness or welfare of other forest-living species.

The purpose of article III from the perspective of wildlife richness is to be a case study, which sheds light to the association of capercaillie (one of the species chosen to reflect wildlife richness) with habitat characteristics, the

abundance and richness of forest birds, and the other species chosen to reflect wildlife richness. Note that this perspective differs from the purpose mentioned in the original paper.

IV. The role of game management on wildlife populations – Uncertainty analysis of expert knowledge

Very little is known about the effect of different implementing options on local populations or wildlife richness. This is an interesting question especially in Finland, because the hunting regulation of many game species is typically carried out on the local level. Since the effects and controllability of hunting and hunters on the local scale as well as the future trends of these factors are very uncertain, it is difficult to estimate the population responses on current actions and to adapt the actions to the future threats. This may be a problem especially to the strategic decision-making of administrators on the national or regional scale. In addition, only few studies have focused on the long-term impact of game-related decisions on human interests (see e.g. Pellikka & Nummi 2002).

The purpose of article IV is to explore the current knowledge and agreement between the experts regarding the trends of game management activities and wildlife richness as indications of uncertainties and future risks. In addition, the impact of game management on populations of game species (reflecting wildlife richness) on a local scale is studied, as well as the administrators' controllability of local hunters. In addition, the populations' connection to game-related human interests is illustrated.

Material and logic of reasoning

The material used in this thesis originates from the following sources (a detailed description can be found in the original papers):

The nationwide material on the monitoring of wildlife in the hunting clubs (I) was based on a questionnaire study made by the Hunters' Central Organization in 2001. This material included information about 889 hunting clubs. The wildlife triangle census data from 1988-2003 (Fig. 1) were used in the estimation of wildlife richness (II and III). This data maintained by the FGFRI include nationwide information on e.g. forest grouse populations in 14 219 census events in the summer, as well as information on other 13 species chosen to reflect wildlife richness in 12 513 census events in winter. In III, the bird census data in 1987-2002 including 41 locations analyzed in this paper were collected by Timo Pakkala, and the land-use and forestry data from 1986-1994 were based on the Finnish multi-source national forest inventory (Tomppo 1991). Expert knowledge was obtained by interviewing eight Finnish wildlife experts in 2002 (IV).

The logic behind the reasoning in this summary is to evaluate the management of wildlife richness 1) by organizing the actors and actions to a framework, then 2) by separately describing the interplay of the factors included into the framework based on the results of the articles and 3) by studying the performance of the system and the need for further studies. To support the reasoning, relevant objectives, data, logic of reasoning and main results of the separate articles are shortly represented in this summary from management point of view.

There is a limited amount of prior information from available studies about the phases and functioning of the management process, and consequently, the nature of this thesis is primarily to explore these questions, and to serve as a basis for the formation of further hypotheses. Since the management system includes social and ecological dimensions, the choice to apply an interdisciplinary approach seemed justified and even required (for discussion of this topic, see Ludwig et al. 2001). Even so, the way of developing the understanding was mainly based on the hypothetico-deductive approach, where research hypotheses are evaluated by making predictions to

be validated with the tests on data (Underwood 1990). This conceptual approach was applied in this summary, in articles I and III, and in IV (in sensu lato). To be more specific, the inference of the articles was based on the following logic:

In order to explore the factors explaining the hunting clubs' participation in the WTS (I) study hypotheses were generated regarding the rationale behind participation, and predictions were made to be tested against the data. The statistical tests were made in many contexts by studying a sub-set of factors at a time with and without statistically controlling the effects of the other factors. This procedure (adopted from Rita & Lehtonen 2005, unpubl.) provided a way of studying the motives for participation in the censuses from different point of views.

In article II, the general idea was to show how the interplay between the WRI and WTS data can be flexibly used in order to meet different needs. As an argument for this claim several applications were introduced, examples were given, and illustrations of the usability of these applications with wildlife triangle data were made.

In order to test the research hypotheses regarding the existence of an association between capercaillie and forest birds as well as other species chosen to reflect wildlife richness (III), predictions regarding the existence of an association to be found in the data were made and tested. In addition to the choice to use the hypothetico-deductive approach in article IV, also another methodological choice worth noticing was made: unlike in I, II, and III, where the frequency interpretation of probability was applied, article IV takes advantage of Bayesian interpretation of probability (for details of differences, see e.g. Ellison 1996). The reasoning behind this choice was to be able to describe the uncertainty in the current expert knowledge of trends in a form of subjective probabilities. These probabilities were seen as expectations about reality, i.e. as hypotheses. This enabled testing and validation of the experts' degree of beliefs, and served as a reasonable way of increasing understanding of the study question at issue.

The deduction in IV was based on two methods largely adopted from Kuikka & Varis (1997): First, the experts named a set of plausible factors affecting the trends in the populations (and wildlife richness). Then, the experts' expectations about trends on factors and populations were compared

as such. Finally, the expectations were tested by comparing the prior beliefs on each variable's future trend with posterior beliefs. This was obtained by using the beliefs of factors affecting populations and assumed causal relationships between factors as data.

Main results

This chapter describes those results of the articles I-IV, which are essential for the deduction to be made in the next chapter. A more detailed description of the results can be found in the original papers.

The monitoring of forest wildlife by hunters (I)

The analyses revealed that the activity in participating in the WTS varied strongly between districts and hunting clubs, as well as between hunters (I). Hunting clubs in the game management districts of Northern, Eastern and Western Finland carried out censuses with a higher probability than hunting clubs in Southern and South-Western Finland. The differences between and within districts were partly associated with the sizes of the hunting clubs: larger clubs (measured with the number of members and hunting area) were more active in the WTS than smaller ones irrespective of the district. This observation may be explained with the need and utility of monitoring results as well as the easiness of gathering a required number of participants and the amount of monitoring effort per participant.

The participants have many kinds of motives for participating (I, Pellikka et al. 2005). A participant may feel that it is his responsibility to provide information for the researchers and administrators even in the case, where he sees no personal utility value for the monitoring results. The motives for hunting (Hendee1974, Decker & Connelly 1989) have similarities to the motives for taking part in the censuses: these include the enjoyment of the

company of the other participants, the nature and the collecting of experiences. One may also view censuses as a tradition or training for young hunters.

Analysis of wildlife richness (II & III)

The general form of the index can be defined with the following formula introduced in article II:

$$WRI_g = \sum_{i=1}^{S} \log(\frac{a_{it}}{R_{iT}} + 1)$$

where WRIg is the wildlife richness index in unit g (e.g. grid or administrative unit), S is the number of species used, a_{it} is the abundance of species i in time point (or time period) t in unit g and R_{iT} is the abundance of the same species during time period T in the reference area.

The WRI can be used to describe the general response of a chosen species assemblage on disturbances. These disturbances include e.g. cases, where many of these species are directly affected by hunting, and indirectly by species interactions or by habitat alterations. The indicator is a biological measure enabling analyses and graphical illustrations on community level (Fig. 4), but it should primarily serve administrative needs, acting as an "alarm bell" for unexpected changes.

Solutions to several research and management questions could be found with the interplay of the WRI and WTS data (II): Typical monitoring questions relate to the recognition of change due to e.g. disturbance or management action (i.e. the WRI serves as feedback). The flexibility of the WRI is mainly based on the choices of units, references and species assemblage, but also on species-specific weighting. The applications introduced (II) can primarily be used in the recognition of a temporal and spatial trend on different scales.

Even single species chosen to reflect wildlife richness may to some extent indicate richness of other species in the chosen species assemblage, as well as richness of many other forest-living species, at least in the case of capercaillie – a potential "umbrella species" (III). The mechanism behind the association of capercaillie with other forest birds seems to be the same kind of requirement

for large, continuous tracks of old forests. For capercaillie these forests serve as surroundings for the lek, but for many other forest birds they serve as good breeding sites.

Affecting wildlife richness on a local scale (IV, I)

There were great uncertainties in the expectations regarding future trends in management activities on a local scale, especially in the feeding of wildlife (IV). The experts were less uncertain about the directions of the trends in the populations of game animals: They agreed that the populations of small predators, large predators and ungulates will increase during the next decades. The value of the hunting bag and the value of commercial hunting were expected to increase in the next few decades.

Disagreement between the experts was found in their views about the direction of a future trend regarding forest grouse, even if the hunting of these species is intensively regulated and associated with the local hunters' monitoring activity of these species (I). Large predators and ungulates were seen to be almost independent of hunter activities on the local scale, but that was because the experts viewed that those species groups are strongly regulated by regionally set quotas and managed according to regional goals.

The amount of information given to hunters and the number of hunters were seen as the most important factors affecting game populations on a local scale in short term in addition to the national or regional regulations on the length of hunting season and efficiency of hunting methods. However, the local regulation of game management was neither seen as an important factor responsible for the uncertainty, nor as an efficient factor affecting wildlife richness in long term.

Evaluation of the results in respect of the framework

Monitoring: what is the quality and availability of data?

The important questions relating to the monitoring data in the management of wildlife richness are 1) how reliable are the observations made by volunteer hunters regarding population trends, and 2) what factors affect the availability of WTS data.

The reliability of monitoring information

At least three points of view need to be considered in answering this question:

First, is there any difference between the performance of hunters and wildlife professionals in recognizing animals or their tracks? British experiments (Newman et al. 2003) revealed that even a person with little earlier experience could perform relatively well and improve his skills in monitoring wildlife with brief training. In Finland, hunters have been trained in the early years of wildlife census to recognize also tracks of rare species (Helle & Wikman 1991), and they are also well-trained monitoring volunteers in a sense that common species under monitoring are game animals; the success of hunting relies heavily on the skill to recognize tracks and animals. According to Pellikka et al. (2005), many persons having decades of hunting experience also participate in the WTS regularly. This observation seems to support the general belief that volunteer hunters in Finland are capable of providing good monitoring information.

Second, one may ask if it is problematic that hunting quotas or other restrictions may be based on the monitoring information gathered by hunters (e.g. Finnish Game and Fisheries Institute 1997). According to the results (I) this seems not to be the case; at least the hunting clubs participating in the

summer WTS also voluntarily restrict their own hunting effort more commonly than other hunting clubs.

Third, assuming that observations are made without biases, how reliable are the abundance estimates of game animals with the sampling methods used in the WTS? A linear transect would have more optimal sampling properties than a triangular one, but triangular and other closed forms are more economical and practical to the assistants to carry out (Högmander & Penttinen 1996). The overall detectability of grouses in the summer censuses is about 80 % (Brittas & Karlbom 1990). However, less is known about the factors affecting the statistical properties (e.g. precision and bias) of the abundance estimates regarding the species monitored by counting tracks in winter. Improved understanding of plausible factors and their relevance on the estimation of population trends would be useful for the research and also the management of wildlife richness.

The factors affecting the availability of WTS data

The hunters' motives for carrying out censuses may play an important role in the availability and continuity of high-resolution monitoring information. As results demonstrate (I, Pellikka et al. 2005), the censuses provide utility and recreational values as well as a sense of responsibility for the participants. Without good motivation the persistence of participation may not last. By contrast, motivated participants or large hunting clubs with a high number of potential participants and a lower amount of effort per participant may successfully carry out censuses for decades.

According to the results (I) there are many large hunting clubs in every district with potential for carrying out wildlife triangle censuses on a permanent basis. The utility value of the censuses may be improved by e.g. speeding up the transfer of feedback including hunting recommendations to the participants (Finnish Game and Fisheries Institute 1997). However, it may be more difficult to affect in large extent the personal recreational values.

Pellikka et al. (2005) found that the amount of animals detected may affect the personal motivation of the participants. The prevalence of this motive among the participants has not been analyzed quantitatively. If this factor

strongly affects also the hunting clubs' probability of participating in the WTS, this would present a challenge for the successful management of wildlife richness depicting a decreasing trend, because the amount of obtained information would decrease alongside with richness. Therefore, additional studies opening this question would be helpful in managing potential risks.

How trends in wildlife richness can be analysed?

The performance of estimation and the choice of specification in the WRI are affected by the properties of the monitoring information, and guided by the research or management needs and the decision makers' choices on acceptable risks. A challenge in the estimation of trends is to deal with the statistical properties of the data, to incorporate the properties of the data to the estimates of the WRI, and to separate natural variation of the populations (e.g. cycles) from the long-term or especially from the drastic short-term trends. The relevance of the latter question associated with long-term trends will decrease with time, i.e. when a time series is clearly longer than known cycle lengths. Since the WTS data have been collected for over 18 years, misinterpretations of the long-term trend should not be an important source of error. However, the recognition of drastic short-term trends from the noise of the data or from the natural variation may not be efficiently improved, supporting the need for risk assessment and management (e.g. Marcot 1998).

It should be noted that the usage of the WRI as a monitoring tool does not try to replace the need for species-specific monitoring. The combined trend in the species assemblage tells only a little about the trends of many individual species in assemblages (for detailed discussion of this topic, see Link & Sauer 1996). In addition, one should be careful in using single species or assemblages as an indicator of the welfare of other species. The indicative role has to be studied species- and case-specifically (e.g. Landres et al. 1988): In the case of capercaillie it was found out (III) that the extent of the observed associations between capercaillie and birds was sensitive to the chosen spatial scale (300 m vs. 1 000 m). Furthermore, the associations between capercaillie

and wildlife richness vary between regions in Finland being, however, mostly positive.

The uncertainty and controllability of wildlife richness

Fowler's (1999) suggestion for successful multi-species management includes the criteria of accounting for the uncertainty and risk-averse attitude (reflecting the pre-cautionary principle). These criteria have been emphasised during the recent decade in many fields of resource management (e.g. Ludwig et al. 1993, Kuikka 1998), including game management (Nichols et al. 1995, Williams 1997). In addition to risks relating to the uncertainty in the knowledge of wildlife populations, also the partial controllability of harvesters, other management actions and uncontrollable environmental variation may increase the uncertainties of population responses to decision-making (e.g. Williams 1997, Williams et al. 2001). If the pre-cautionary principle was applied to the management of wildlife richness, it would mean that high uncertainty in the knowledge of the condition of wildlife richness, or high uncertainty about the condition and impacts of any factors affecting wildlife richness should lead to a lower level of hunting and a higher level of hunting regulation until the uncertainties could be decreased.

In addition to the uncertainties involved in the monitoring and analysis of wildlife richness (discussed above), one can also ask, if there are significant uncertainties related to the activities of hunters, which may affect the probability of managing wildlife richness according to the goals. At least three aspects need to be considered in order to evaluate this question: 1) What is the pressure and the impact of hunting now and in the future, 2) what is the level and the impact of other management actions carried out by hunters, and 3) what is the controllability (and need for control) of Finnish hunters. In addition, one should also consider what of those aspects need to be studied or monitored.

What is the pressure and impact of hunting now and in the future?

In addition to the monitoring of population trends, also the size of the hunting bags and the number of hunters are monitored in Finland as indications of sustainability (Maa- ja metsätalousministeriö 1999). This way of action seems to be consistent with a risk-averse attitude, since neither monitoring of populations nor monitoring of hunting bags alone is an unbiased way of detecting changes (e.g. Sutherland 2001). The experts viewed (IV) that the number of hunters was seen as one of the most important factors affecting hunting mortality and other game management actions, thus supporting the decision to monitor hunting effort. To better predict the future states of large predators' population sizes, the amount of illegal hunt should be known more accurately and managed effectively. However, at the same time the experts unanimously expected that the population trends of ungulates as well as small and large predators will increase, whereas the number of hunters will decrease during the next decades in Finland. These results seem to indicate that the future level and impacts of hunting are considered as small risk factors for the sustainability of wildlife richness.

Another viewpoint to the role of hunting is to consider the hunting regulation practices. Various pragmatic and theoretic techniques are available for supporting the decision making about the level of sustainable harvesting (Ludwig 1995, see Sutherland 2001 for review). The prevalence of using the available techniques in Finland is unknown, and little scientific information is available about the impact of regulations on hunting mortality or population trends (except for black grouse (see Lindén 1981)). However, Finnish hunters seem to believe in the effects of hunting regulation, since they are known to voluntarily regulate their hunting effort on a local scale (Vikberg et al. 2002a) in addition to the regulating of hunting by game administrators. Hunting clubs, and especially the hunting clubs participating in the summer WTS, have been active in regulating the hunting of forest grouse (I), but regulating the hunting of other game species on a local scale seems not to be as common among hunters (Vikberg et al. 2002a, Pellikka et al. 2005). These findings seem to support the conclusions made on the results of article IV.

What is the level and impact of other management actions carried out by hunters?

Little scientific information exists about the effects of the hunters' management actions (e.g. feeding) made on a voluntary basis on a local scale. A nationally defined criterion for sustainable game management is that it should affect positively the population trends of game species (Maa- ja metsätalousministeriö 1999, 2001). The Finnish wildlife experts generally viewed (IV) that relatively little uncertainty of the future trends of many wildlife populations (and wildlife richness) is inherent to the currently high uncertainty of the extent of the hunters' management actions on a local scale. In addition, the experts expected that land use or forest habitats affect more population trends e.g. of forest grouse during the next decades than hunting regulation or management actions carried out by hunters. These results support the views presented in the Finnish Natural Resources Strategy (Maa- ja metsätalousministeriö 2001).

What is the controllability of Finnish hunters?

No scientific information is available on the administrators' influence (i.e. controllability) on game management actions made on the local scale. The experts had an opinion that especially the national or regional regulation of hunting methods and the length of hunting seasons, in addition to the education or information given to hunters (IV), are currently the most effective ways of controlling hunter activities on a local scale.

Summarizing the hunters' role for the management of wildlife richness, one may conclude that Finnish hunters on a local scale can be seen as "prudent predators" in some respects of hunting and hunting regulation, and the information given to them seems to have many kinds of effects on their activities. The activity of the hunters in monitoring wildlife richness is essential. At the same time, the wildlife experts viewed that the effect of hunting and other game related activities on wildlife richness especially during the next decades is small, even though they believed that hunting interests towards game (e.g. hunting bags, recreational value of hunting, value of

commercial hunting) will increase. Therefore, from the perspective of the manager considering the value-of- information (i.e. the utility of information in helping to reach objectives in respect of the cost of obtaining it (e.g. Clemen 1996)), further studies on the effects of hunters or more detailed monitoring of hunter activity may not be a cost-efficient way of improving the management of wildlife richness.

Instead, additional studies on the association of wildlife richness with land use and forestry may be more helpful in order to decrease the uncertainty of decision making, even if the controlling or regulating of these factors in order to sustain wildlife richness may not be as feasible a solution as the regulation of hunting and associated activities.

Conclusions

The implications of the explorations made on this thesis to the management of wildlife richness are:

• The resolution of the wildlife triangle census data is dependent on participant motives which are related to utility, various recreational values and a sense of responsibility. The utility of the monitoring results for the participants can in some extent be improved. Large hunting clubs are the most potential participants for carrying out the censuses on a permanent basis.
• The WRI can be flexibly used as a tool in the detection of spatial and temporal trends in wildlife richness on many scales. However, it will not replace the need for species-specific monitoring.
• Studying the statistical properties of the wildlife triangle census data and the wildlife richness index (WRI) would improve the estimating of the WRI and the associated assessment and management of risks.
• The voluntary activities of local hunters (in a restrictive and supportive sense) can be controlled. Besides national or regional hunting regulation, the information given to hunters may affect their activities, and consequently wildlife richness.

• The general effect of voluntary activities on wildlife richness, and especially on grouse and small predators, was seen as relatively small in long term in respect of some other effects (e.g. land use and forestry). This implicates that more detailed monitoring or further studying of the effect of game management may not be a key-uncertainty for the management of risks regarding wildlife richness.

Acknowledgements

Since I was a child, I have had a close connection with game animals and hunting. I remember many unforgettable encounters with moose, capercaillie, fox, mountain hare, only to mention a few. I have spent several enjoyable hunting days in the forests with my father, grandfather, brother and friends.

Undergraduate studies in the field of wildlife management in Viikki gave me new, more theoretical insights to the ecology of game animals and populations, but also introduced me to the decision analytic way of structuring management questions.

I continued with my journey of exploration to the relationships between human and other animals in my graduate studies. This journey has increasingly made me to wonder at the complexity and high number of different viewpoints on the phenomena in question. This observation, as well as my innate tendency for analytical thinking, has encouraged me to explore the scientific methodology as a more solid ground for my understanding.

Alongside with an increasing respect toward the complexity of the reality, I have learned to deeply respect the thinking and skills of my supervisors Harto Lindén, Hannu Rita, Sakari Kuikka, and Kari Heliövaara, as well as my colleague Petri Nummi. Their guidance is largely to be thanked (or blamed) for my progress as a student and as a person. I would also like to thank Timo Pakkala and Olli Varis for cooperation and my past and current community in the Department of Applied Biology for their fellowship and help: Veli-Matti Väänänen, Esa Pienmunne, Salla Hannunen, Mikko Peltonen, Lena Huldén, Larry Huldén, Reetta Kettunen, Leena Tulisalo and Leila Lehto.

I am very grateful to my parents and brother for their support during my studies. A special thank belongs to my wife Ullis, who has frequently encouraged me in my work, and who has by request provided comments regarding the language of my manuscripts - even on the day, when our daughter Emma was born.

The constructive comments of both reviewers are acknowledged. This work was funded by The Ministry of Agriculture and Forestry, The Finnish Game and Fisheries Research Institute and The University of Helsinki Fund, which I would also like to thank for their respective support.

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