Dissertationes Forestales 339

Conditions for cooperative forest management on Capercaillie (*Tetrao urogallus* L.) lekking sites in Finland

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Academic dissertation

To be presented, with the permission of the Faculty of Science, Forestry and Technology of the University of Eastern Finland, for public criticism in the auditorium C2 of the University of Eastern Finland, Joensuu, on 14th April 2023, at 12 o'clock.

Title of dissertation: Conditions for cooperative forest management on Capercaillie (*Tetrao urogallus* L.) lekking sites in Finland
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Dissertationes Forestales 339
https://doi.org/10.14214/df.339

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ISSN 1795-7389 (online)
ISBN 978-951-651-768-4 (pdf)

Publishers:
Finnish Society of Forest Science
Faculty of Agriculture and Forestry of the University of Helsinki
School of Forest Sciences of the University of Eastern Finland

Editorial Office:
Finnish Society of Forest Science
Viikinkaari 6, FI-00790 Helsinki, Finland
http://www.dissertationesforestales.fi

Ikonen P (2023) Conditions for cooperative forest management on Capercaillie (*Tetrao urogallus* L.) lekking sites in Finland. Dissertationes Forestales 339. 64 p. https://doi.org/10.14214/df.339

ABSTRACT

In Finland, private forest owners own nearly 60% of forest land. The average size of a private forest property is around 30 hectares. Many owners identify as multi-objective owners with varying management goals related to recreation, biodiversity, and scenery, in addition to timber production. The aim of this research was to assess how a cooperative approach to game-oriented forest management could be perceived by forest owners and also to evaluate the type of mechanisms that influence how cooperative management principles could be put into practice. Game-oriented forest management refers to forestry practices that aim to maintain the habitats of grouse species, such as the highly-valued game species capercaillie (*Tetrao urogallus* L.). The lekking sites of capercaillie are extensive (up to 20 hectares) and can be located on several private properties. Game-oriented management applied in lekking sites could improve the quality of the sites but would require a cooperative management approach across property boundaries. However, the openness of forest owners to game-oriented or cooperative forestry practices has been unknown.

This research consisted of two double-sampling survey studies that included three surveys (two for forest owners, one for forest professionals) and one qualitative interview study with forest owners, which together explain the use of game-oriented and cooperative forest management methods, the type of beliefs that forest owners associate with cooperative management of lekking sites, and how willing and ready they are to participate in cooperative forest management practices. The results indicated that game-oriented forest management methods are increasingly approved by forest owners, and that the forest owners are intrigued by cooperation. However, currently independent forest management, norms, restricted services and communication between forest owners may hinder their interest in participating in cross-boundary forest management. The findings also emphasise the importance of forest owners' decision-making power in cooperative forest management. Cooperative schemes promoted through cooperation between forest owners with similar goals could yield optimal management solutions across wide habitats of capercaillie.

Keywords: Forestry, Forest owner, Cooperation, Game, Habitat

TIIVISTELMÄ

Suomessa yksityiset metsänomistajat omistavat lähes 60 % metsäpinta-alasta. Yksityistilan keskikoko on 30 hehtaarin luokkaa. Moni metsänomistajista lukeutuu monitavoitteisiin omistajiin, joilla on puuntuotannon ohella virkistykseen, monimuotoisuuteen ja maisemaan liittyviä tavoitteita. Tämän tutkimuksen tavoitteena oli arvioida, kuinka tilanrajat ylittävän riistametsänhoidon konsepti vastaanotettaisiin Suomessa, ja millaiset seikat ja mekanismit voisivat vaikuttaa konseptin jalkauttamiseen käytännössä. Riistametsänhoito on valikoima metsänhoitotoimenpiteitä, jolla pyritään säilyttämään metsäkanalintujen, kuten laajasti arvostetun metson (*Tetrao urogallus* L.), elinympäristöt talousmetsissä. Metson soidinpaikat ovat laajoja (voivat ulottua jopa 20 hehtaarin alalle) ja teoriassa sijoittua useamman yksityisen tilan alueelle. Riistametsänhoidon soveltaminen soidinpaikoilla voisi parantaa soidinpaikkojen kytkeytyneisyyttä ja laatua, mutta edellyttäisi naapurimetsänomistajien yhteistyötä. Metsänomistajien avoimuudesta riistametsänhoitoa tai metsänhoitoyhteistyötä kohtaan ei ole kuitenkaan ollut tietoa.

Tutkimus koostuu kahdesta kaksinkertaiseen otantaan perustuvasta kyselytutkimuksesta, jotka sisälsivät yhteensä kolme kyselyä (kaksi metsänomistajille, yksi metsäammattilaisille) sekä laadullisesta metsänomistajien haastattelututkimuksesta. Yhdessä tutkimukset kuvaavat tämänhetkistä riistametsänhoidon ja metsänhoitoyhteistyön toteutusta, metsänomistajien uskomuksia tilanrajat ylittävästä riistametsänhoidosta soidinpaikoilla, ja metsänomistajien valmiutta osallistua vastaavaan metsänhoitoyhteistyöhön. Tulokset viittasivat, että metsänomistajat hyväksyvät riistametsänhoidon menetelmät enenevässä määrin ja metsänhoitoyhteistyö herättää heissä kiinnostusta. Metsänomistajien itsenäisyys, normit ja palveluiden kohtaamattomuus, sekä metsänomistajien välisen kommunikaation vähäisyys voivat kuitenkin hidastaa metsänomistajien mielenkiintoa osallistua tilanrajat ylittävään yhteistyöhön. Tulokset korostivat myös, että metsänomistajien päätöksenteko-oikeuden ja valinnanvapauden tulisi näkyä myös yhteistyössä. Yhteistyömallit, joita edistetään samanlaisia tavoitteita omaavien metsänomistajien välisen yhteistoiminnan kautta, voisivat tuottaa optimaalisimman metsänhoitoratkaisun metson laajoilla metsäelinympäristöillä.

Asiasanat: Metsänhoito, Metsänomistaja, Yhteistyö, Riista, Elinympäristö

ACKNOWLEDGEMENTS

This thesis has been a journey.

This journey would have not been possible without having some amazing people around me. I want to express my sincerest gratitude to my main supervisor Ari Pappinen for the support, patience, guidance and great discussions that have been seasoned with humour at all times. I also want to thank Teppo Hujala, who has always found the time for guidance – your support, precise comments and advice towards the improvement of this work have been priceless. I also want to express my deepest appreciation to Suvi Kuittinen, who has kindly and patiently guided me through this research journey. You have always found the right words to keep me going. I also want to thank Janne Miettinen for endless encouragement and steely expertise in wildlife and forest management topics. The curiosity that you have in your research work has been a great example to me. I would also like to thank Lauri Mehtätalo for the statistical counselling and advice throughout this journey. Many thanks also to all the other co-authors of the articles included in this thesis: Arto Haara, Jani Pellikka, Juho Matala, Mikael Luoma and Mirja Rantala. I am truly grateful for your contribution, expertise, and support. I also wish to thank the pre-examiners of this work, Associate Professor Therese Bjärstig and Associate Professor Christian Gamborg, for their critical review and helpful comments. Thanks also to all my colleagues and friends at the university for peer support and good times. Thanks Esa, Laura, Ossi, Roope, Ville and others!

The support provided by The Finnish Cultural Foundation – North Karelia Regional Fund, The Alfred Kordelin Foundation, the Doctoral Programme of the University of Eastern Finland and the Academy of Finland Flagship "Forest-Human-Machine Interplay – Building Resilience, Redefining Value Networks and Enabling Meaningful Experiences" (UNITE) is truly appreciated for making this research work possible. I have also had the opportunity to work and collaborate with people from various organisations, of which I feel truly honoured. I want to show my appreciation to the amazing people working in Finnish Forest Centre, Finnish Wildlife Agency and Natural Resource Institute Finland. Finnish Forest Centre also provided the contact data required for articles I and II, while the data for article III was collected in the project area of Metsokanta kasvuun ja tarinat talteen Kauhajoella -project. Your contribution is acknowledged with great appreciation. My sincere thanks also go to all the forest owners and forest professionals who participated in the interviews and surveys, and in this way, enabled this research.

I am the most grateful to my family for their support and care during this journey. Thank you all for being there for me. I want to thank my mother, Marjatta, for being the best example I could have ever hoped for and for always encouraging me towards my goals. I also want to remember my late father, Risto. I also want to thank my siblings, and their spouses and children: Thank you, Jenni and Antti, and Reijo and Miia – you and the kids have really provided joy in my life. I also want to thank people in Mäntylä: Merja and Heikki, Minna and Pekka, and others, for the kind care and support. Thank you also, Anni, my dear friend, for the long and lightening phone calls and discussions. My most sincere gratitude goes to my partner Toni – your support and the faith that you have had in me during this journey have been invaluable.

LIST OF ORIGINAL ARTICLES

This thesis is based on data presented in the following articles, which are referred to by Roman numerals (I–III). The articles are reproduced with the permission of the publishers.

I Ikonen P, Rantala M, Miettinen J, Kuittinen S, Hujala T, Mehtätalo L, Pappinen A. (2020) Grounds for improving the implementation of game-oriented forest management – A double sampling survey of Finnish forest owners and professionals. Forest Policy and Economics 119: 1002266. https://doi.org/10.1016/j.forpol.2020.102266

II Ikonen P, Miettinen J, Haara A, Matala J, Hujala T, Mehtätalo L, Pappinen A. (2022) Does Cooperation between Finnish Forest Owners Increase Their Interest in Capercaillie (*Tetrao urogallus*) Lekking Site Management? Society and Natural Resources 35(11): 1189–1205. https://doi.org/10.1080/08941920.2022.2101081

III Ikonen P, Miettinen J, Luoma, M, Pellikka J, Pappinen A (2022) Beliefs of Forest Owners toward Cooperative Capercaillie Lekking Site Management Operations: A Pilot Study. Human dimensions of Wildlife. https://doi.org/10.1080/10871209.2022.2146814

Piia Ikonen was the first author in all articles and had the main responsibility for data collection and analysis, interpretation of the results and writing the first drafts of the manuscripts. The work was supervised by Prof. Ari Pappinen, Prof. Teppo Hujala, Dr. Janne Miettinen and Dr. Suvi Kuittinen. Prof. Lauri Mehtätalo contributed to the design of the statistical analyses and planning of the studies for articles I and II, while Prof. Teppo Hujala participated in the design of conceptual framings of articles I and II. Docent Jani Pellikka assisted in the design of conceptual framing and study approach in article III. Mirja Rantala assisted in data collection for article I, and Mikael Luoma contributed to the data collection for article III. Dr. Janne Miettinen assisted with data collection and writing in all articles. Dr. Suvi Kuittinen commented and participated in the writing of article I. Dr. Arto Haara and Dr. Juho Matala participated in the design of the survey and writing of article II. Prof. Ari Pappinen was the corresponding author in all articles, with a supervising role in the research.

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ABBREVIATIONS

CAT	Collective Action Theory
DoI	Diffusion of Innovations (theory)
FFC	Finnish Forest Centre
IUCN	International Union for Conservation of Nature
NLS	National Land Survey of Finland
SES	Socio (or social)-ecological system
SSM	Soft Systems Methodology
TPB	Theory of Planned Behaviour
ÅSUB	Statistics and Research Åland

1 INTRODUCTION

1.1 Cooperative forest management

Many ecological functions in forests, such as nutrient cycling, pollination or habitat use are not limited by property boundaries (Campbell and Kittredge 1996; Crow and Gustafson 1997). An ecosystem or landscape-based approach to management acknowledges the primacy of forests and their ecological functions over their property boundaries (Campbell and Kittredge 1996; Jacobson 2002). This type of management may also be regarded as cross-boundary management (e.g. Gass et al. 2009), which may aim to pursue different management goals, such as timber production, but is simultaneously guided by desired future conditions at the landscape-level, such as improved habitat quality (Campbell and Kittredge 1996). The concept of landscape-level management has been increasingly discussed in forestry-related literature globally (Campbell and Kittredge 1996; Rickenbach et al. 1998; Jacobson 2002, Belin et al. 2005), and it appears as an interesting management alternative for a variety of forest ownership models and contexts (see also Kittredge 2005). However, implementation is complicated in circumstances that involve several non-industrial private forest owners, such as in north-eastern USA or in Finland, for example. Under such forest ownership conditions, the variable and likely numerous forest ownership objectives can make management across properties difficult (Campbell and Kittredge 1996; see also Irland 1994).

For cross-boundary management between private forest owners to function efficiently, cooperation across private ownership is necessary. The origins for forest-related cooperation vary between countries and thus cooperative forest management between private forest owners may refer to different actions in different contexts (Kittredge 2005). Forest owner cooperatives (forestry cooperatives, forest owner organisations) refer to jointly owned and controlled forest businesses that provide members with their own services, and which return at least part of the profits to their members (Kittredge 2003, 2005; Blinn et al. 2007). Community forestry, in contrast, is based on communal management of forests, and focuses instead on the production of community-based, environmental, or societal benefits (e.g. Christofferssen et al. 2008). Another related form of ownership is based on jointly owned forests, which refer to a situation where owners give up their independent decision-making right and instead attach their properties to a larger forest property that is owned and managed collectively by its shareholders (Finnish Forest Centre 2022b). However, cross-boundary cooperation in private ownership circumstances in the pursuit of landscape-level objectives refers more directly to neighbouring owners' endeavours to share plans, technical information or facilities (e.g. roads), synchronise forestry activities, use the same services, or hire the same professionals (for a detailed list, see Campbell and Kittredge 1996). Cross-boundary cooperation could also be used with timber sales or in the creation of recreational environments.

In a wider sense, *cooperation* (often used as a synonym for *collaboration*) accounts for a variety of actions associated with relationships between two or more stakeholders (Yaffee 1998). Specifically, cooperation could refer to working with others to achieve something (Cambridge Dictionary 2022), whereas collaboration has been considered as problem-solving or joint decision-making exercise (Yaffee 1998). In a forestry context, cooperative forest management could present an adaptive solution to secure landscape-level functions within management procedures, for which it is also conceptually close to adaptive co-management. Although there is no single definition for adaptive co-management, it has been

described as generating knowledge by learning-by-doing in different cooperative arrangements or partnerships among resource users and governmental parties (Berkes 2009, see also Plummer and Fitzgibbon 2004). The concepts of cooperation, collaboration and co-management that form the basis for cooperative forest management have their differences, but they also share many characteristics related to interaction implemented at different scales: legitimacy and compliance, equity, justice, and empowerment associated with the actions. In the co-management literature, these characteristics have been considered to illustrate both good resource management and the maintenance of relationships (Natcher et al. 2005; Berkes 2009).

As such, cross-boundary or cooperative forest management requires the acceptance of the local forest owners within the landscape area. Forest or biodiversity-based cooperative management is often considered most successful when based on voluntary participation of land or forest owners (Campbell and Kittredge 1996). Regardless, even voluntary management projects across properties rarely reach 100 percent participation, which may be related to the independent management of the forest owners, or the expected difficulty in reconciling a spectrum of varying forest owner attitudes (Sample 1994; Campbell and Kittredge 1996; Jacobson 2002). Therefore, voluntary participation is often considered to require promotion with organisational support, such as incentives and programs (see Campbell and Kittredge 1996). In this way, cooperation in natural resource management on private properties most often also involves other actors, in addition to the private owners.

Studies from Sweden (e.g. Bjärstig et al. 2014; Lindqvist et al. 2014), USA (Rickenbach et al. 1998; Jacobson et al. 2000; Jacobson 2002) and Australia (Meadows et al. 2013) have shown that private forest owners tend to regard cooperative activities in forestry matters or in ecosystem or population management quite positively. Although cooperation is often driven by self-interested motives that can be achieved only through cooperative measures (Yaffee 1998; Axelrod 2006), cooperation may simultaneously be grounded by the thought of reciprocity (Yaffee 1998). The owners perceive that cooperation could result in many economic and ecological benefits, but also in social benefits, for example, related to improved learning opportunities or shared responsibilities (Meadows et al. 2013). Indeed, cooperation between private forest owners has been demonstrated to not only enhance the connectivity and quality of wildlife habitats or improve recreational possibilities, but also improve the cost-efficiency of the management, and assist in communication among locals (Kittredge 2005).

However, the potential for cooperation may be restricted by lack of knowledge from the participants or access to information (Austin and Kaplan 2003), differing or conflicting management objectives between participants (Austin and Kaplan 2003; Gill et al. 2010; Meadows et al. 2013), or privacy and independency issues (Gill et al. 2010), for example. Time or finance-related constraints, as well as the age and physical abilities of the forest owners have also been reported as owner-origin barriers to cooperative action (Meadows et al. 2013). The cooperation may also be restricted by participants' lack of trust towards (or support provided by) institutions (Jacobson 2002; Meadows et al. 2013). Existing policy implications, services, and subsidy systems, for example, may create different conditions for cooperative activities and also influence the likelihood of owner participation. Indeed, a number of forces may promote and hinder cooperative actions (Yaffee 1998). From these forces and mechanisms, some may drive individual private forest owners away from cooperative behaviour and some may foster cooperation between them.

1.2 Capercaillie (*Tetrao urogallus* L.) lekking sites in a Finnish forestry context

Finland is called the land of forests (Niinistö et al. 2021) with more than 85% of the total land area considered as forestry land. This forestry land can be divided into forest land, poorly productive forest land and unproductive land. More than 52% of forestry land and 60% of forest land is owned by non-industrial private forest owners, who account for forestry partnerships, estates, and individual forest owners and forest owners who share the ownership with their spouse. The average size of a private property is just over 30 hectares (Niinistö et al. 2021). Nearly one third of Finnish forest owners identify as multi-objective forest owners, with a range of forest management goals related to recreation, working opportunities, or immaterial goods, in addition to timber production (Karppinen et al. 2020). Timber has provided important income and financial security to forest owners throughout history, and the economic aspects and traditions of forest management have played an important role in forest management decision-making. In Finland, more than 80% of the roundwood for industrial use is purchased from private forests (Parviainen and Västilä 2011; Official Statistics of Finland 2021), and during the period 2016–2018 for example, nearly half of private forest owners had sold timber at least once (Karppinen et al. 2020). Yet, the forests rarely serve as the only or the most central source of income to forest owners, for which it has become possible for forest owners to also pursue other types of forestry objectives. The amendments in the Finnish Forest Act (1093/1996) that came into effect at the start of 2014, diversified the selection of applicable forest management methods and thus strengthened the decision-making power of the forest owners. This has contributed to a better acknowledgment of the various forest values contained in commercial forests.

Capercaillie (*Tetrao urogallus* L.) is a large boreal grouse species. It inhabits the boreal forests of Fennoscandia and Eurasia (Birdlife International 2022). In Finland, it has been greatly valued as a game species and for its central role in forest biodiversity and culture. The species has also been recognised as a key species (Suter et al. 2002; Pakkala et al. 2003), whose presence in the forest may also indicate that the habitat is sufficient for other species. However, according to International Union for Conservation of Nature (IUCN), the overall capercaillie population trend is decreasing (Birdlife International 2022). In Finland and other Fennoscandian areas, capercaillie may have been affected by an abundance of small predators, climatic changes, and excessive hunting (Sjöberg 1996; Kurki et al. 2000), together with likely changes in its forest habitats (Helle and Helle 1991).

In Finland, rapid capercaillie population decline between 1960s and 1980s seemed to follow the changes in forest cover and structure that resulted from changes in forest management methods and policies at that time (Miettinen et al. 2010): Between 1950–1960s, large forest age-classes were cut (Leikola 1984), which subsequently resulted in a large proportion of young forests. The decreasing capercaillie population trend, in contrast, appeared to stop in the 1990s (Helle et al. 2003) as many of the forests were now 30–40 years old (Miettinen et al. 2010). Sirkiä et al. (2010b) suggested that the changes in the age structure of the forests, as such, did not entirely explain the decreasing capercaillie numbers in Finland, but instead suggested that the overall forest cover at large spatial scales was, and is, of greater importance to capercaillie viability (see also Lindén and Pasanen 1987; Miettinen et al. 2008; Miettinen et al. 2010; Sirkiä et al. 2010a). Although capercaillie was long considered to mainly inhabit mature coniferous forests, research has also shown the species to thrive in younger commercially managed thinning-aged forests (Miettinen et al. 2010) and in this way are quite tolerant to change (see Wegge and Rolstad 2011). Indeed, the current Finnish population seems to have stabilised (Helle et al. 2003; Helle and Lindén 2015), and the

population estimates are promising: for example, the 7-year cyclic variation of the species seems to have recovered (Helle and Lindén 2015).

Yet, the habitat requirements of the species are complex and the habitats may be influenced by the forestry practices that influence forest cover especially. For example, the diet of the species changes from a summer diet to winter diet, and male/females use different forest habitats to varying extent during the year (Sjöberg 1996). Capercaillie requires wide and continuous forest areas for their group display, the lek, which takes place in the spring (Wegge and Larsen 1987). Fine-grain forest fragmentation has a positive effect on lek persistence (Sirkiä et al. 2010a; 2012), and the viability of the leks appears to be correlated with the abundance and continuity of mature coniferous forests around the leks (Sirkiä et al. 2010a; see also Kaukonen et al. 2018) and the wider landscape structure (Miettinen et al. 2005). It is conceivable that fragmented property structure, for example, may impinge on the forest cover and the continuity of mature forests, which are important for viable lekking sites.

Indeed, the locations of established lekking sites are considered rather permanent, but sites might change location due to extensive clear-cuts or changes in land use (Valkeajärvi and Ijäs 1991; Sjöberg 1996: Valkeajärvi et al. 2007). The lekking area includes a lekking centre, lekking sites and the home ranges of the males. The lekking centre is where mating occurs and is located on the lekking territory of the dominant male (Valkeajärvi and Ijäs 1991). The lekking site consists of the territories (1–3 hectares) of the territory-holding males (e.g. Hjorth 1970; Valkeajärvi and Ijäs 1991). These territories are located around the lekking centre. The day territories (home range) of males can extend up to 1 km from the centre (Wegge and Rolstad 1986; Lindén and Pasanen 1987; Rolstad and Wegge 1987; Helle et al. 1994) and are used by the males to feed and rest between display and mating (Wegge and Larsen 1987; Sirkiä et al. 2010a). Thus, the centre, the lekking sites and day home territories of the males formulate the lekking area, which could cover an area of up to 300 hectares (Wegge and Larsen 1987; see also Sirkiä et al. 2010a; Kaukonen et al. 2018; Figure 1), and encompass several private forest properties.

It has been suggested that in capercaillie habitat management, the connectivity of the forest areas should be considered at the levels of the home range and population scale (Sirkiä et al. 2012), which refers to landscape-level forest management in their habitats. In Finland, the lekking sites and areas have been mapped and managed in extensive state-owned areas, and approximately 2,500 locations are known (Rautiainen et al. 2017). A number of forest management guidelines for lekking sites and grouse habitats, which also permit timber harvesting, are also available for private forest owners (Helle et al. 1999; Lindén et al. 2019) in addition to those applied in state-owned forests (Kaukonen et al. 2018). While the locations of the lekking sites on private lands have been mapped mainly by different studies, projects, and organisations (e.g. Metsoparlamentti in central Finland), there is no systematic mapping establishment or registry of the lekking sites, and it is conceivable that forest owners may not be aware of lekking sites on their properties. The private forest owners' knowledge, and attitudes towards the forest management methods suitable for grouse habitats are not well-known, nor are the levels of implementation of such practices in private forests.

While individual forest owners can apply forest management methods that are suitable for grouse habitats in their properties, the most efficient lekking site management occurs at the landscape-level. Such management appears possible only for forest owners with large continuous forest properties (Melin et al. 2020). Another possibility for landscape management by private forest owners is based on cross-boundary cooperation between forest owners of adjacent properties (see Grouse Management Plan, p. 12, Ministry of Agriculture and Forestry 2014).

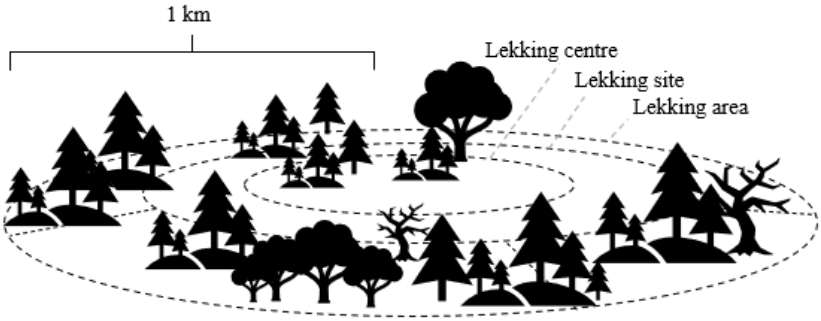

Figure 1. A non-scale schematic representation of the lekking habitat of capercaillie, including the levels of the lekking centre, lekking site (lekking territories) and the lekking area. Representation follows the illustration of lekking area represented in, for example, the guide by Kaukonen et al. (2018). The segments in the outer edge represent the day territories of the males.

1.2.1 Available measures for grouse habitat management

Game-oriented forest management is a forestry approach that consists of a selection of voluntary techniques that aim to maintain and improve the forest and mire habitats of the Finnish forest-inhabiting grouse species within applied forestry practices. The implementation of the techniques is considered so as not to restrict the utilisation of the forests for other purposes, such as timber production (Lindén et al. 2019). The method also acknowledges the habitat requirements of other important game animals, such as moose (*Alces alces* L.) and mountain hare (*Lepus timidus* L.), although these species can cope without special habitat management measures.

In addition to capercaillie, black grouse (*Tetrao tetrix* L.), hazel grouse (*Tetrastes bonasia* L.) and willow grouse (*Lagopus lagopus* L.) are other common grouse species that inhabit Finnish forests and mire types. The habitat characteristics of these species may vary in relation to each other, but they also share many characteristics, which can be quite efficiently acknowledged in forestry practices. In particular, the brood environments are often similar between the species. Game-oriented forest management might be focused on these brood habitats and their characteristics, since it is important to secure suitable habitat conditions for the young chicks, which might otherwise be more vulnerable to habitat changes than the adult birds (Melin et al. 2020).

In all forest habitats used by the birds, mixed-tree species, variance in the stand density and structure, underbrush cover and thickets, and the presence of bilberry (*Vaccinium myrtillus* L.) are valuable habitat characteristics (Melin et al. 2020). Bilberry provides nutrition to both adults (leaves, berries) and to broods, which during their first weeks, feed on the small insects that live on the leaves (Wegge et al. 2005, see also Lakka and Kouki 2009). The spruce mires, banks of creeks and transitional zones between the mire and forest ecosystems are also key habitats and thus may need special attention in forestry practices (Melin et al. 2020), although these could already be areas of low timber productivity. The capercaillie lekking sites are also special types of habitats, and their management is focused on maintaining sufficient cover and connections to mature forests (Kaukonen et al. 2018), in addition to securing the other above-mentioned grouse habitat characteristics.

In recent Finnish studies, game-oriented forest management has also been called game-friendly forestry (Haakana et al. 2020) and grouse-friendly forest management (Rautiainen et al. 2017; Haara et al. 2021) and is considered as a rather cost-efficient forestry practice for forest owners (Haara et al. 2021). Although it may be impossible to create explicit instructions that are suitable for all forest stands, commonly suggested methods include the preservation of game thickets, favouring mixed tree species distribution, and avoidance of excessive clearing of the underbrush (Melin et al. 2020). In and around lekking sites, management might focus on the avoidance of simultaneously implemented wide clear-cutting and the implementation of other forestry practices (thinning, tending) so that fine-grain forest fragmentation is promoted, although forests would otherwise be in commercial use (Kaukonen et al. 2018).

The first Finnish written guidelines for game-oriented management were likely published in the 1980s (e.g. Finnish Forest and Park Service 1991, first edition in 1989). The term game-oriented forest management (*Riistametsänhoito* in Finnish) was first promoted by the Finnish Wildlife Agency in 2014. Due to the amendments in forest legislation in 2014 that enabled the application of more versatile management methods, game-oriented practices have become more available to forest owners. Objectives and techniques of game-oriented forest management also became more visible to a wider audience via the Grouse Management Plan (Ministry of Agriculture and Forestry 2014), and via the new Recommendations for game-oriented forest management (2014, updated 2019; see Lindén et al. 2019). The latter was published by Tapio, an advice and consulting service provider owned by the government of Finland (Tapio 2022). Different best practice recommendations for forest management have been provided by Tapio for decades and have been greatly valued and used to assist in decision-making by forest owners. These guidelines have also supported practical forest work by professionals.

In addition, the Finnish Wildlife Agency has provided forest owners with published field work instructions for game-oriented forest management (Miettinen et al. 2019; Riistametsänhoidon maasto-ohjeet 2019), internet pages and information, and has promoted the incorporation of game-orientation in the education of forest workers, foresters and harvester operators (see concluded projects of the Finnish Wildlife Agency, Finnish Wildlife Agency 2022). Currently, forest certification systems also support game-oriented management to some extent, as the commonly used systems, FSC (Forest Stewardship Council Finland 2011) and PEFC (Programme for the Endorsement of Forest Certification Suomi 2022), recommend the preservation of game thickets in forestry practices. Financing for sustainable forestry (known earlier as Kemera but will be changed to Metka) in Finland also enables some game habitat management practices, such as the preservation of game thickets, within supported forestry practices (for Kemera, see Act the Financing of Sustainable Forestry 34/2015). Yet, little is known of the levels of implementation of these game-oriented management methods in practical forestry.

1.2.2 Cooperative management of lekking sites in Finland

A cooperative agreement for game-oriented practices on lekking sites or joint planning of management among forest owners could improve the landscape-level habitat requirements (e.g. connectivity and forest cover) on the capercaillie lekking sites. For many multi-objective forest owners, biodiversity, scenery, or species wellbeing (e.g. viability of capercaillie lekking sites) might represent direct forest management values, or they may have indirect value through recreation possibilities. In the abstract, forest owners could find value in

managing habitats within forestry practices, especially as forest owners have tended to regard grouse species in particular in a positive sense, compared to other Finnish game species (Herrero et al. 2020). According to Hujala et al. (2010), as many as half of Finnish forest owners consider that forest management should be planned in cooperation with neighbours if it is concerned with biodiversity or game issues.

However, knowledge of cooperative actions between Finnish forest owners is scarce and little empirical research of the topic has been carried out. Hujala et al. (2010) reported that forest owners have carried out cooperation previously, mainly in construction and maintenance of forest roads and ditching, which are also cross-boundary projects. Some cooperation has occurred in relation to the sale of timber. However, these cooperative practices are considered to rarely refer to true cooperation and interaction between forest owners, as the practices are often projects initiated by an external forest-related organisation. Therefore, previous cooperation cannot be regarded as truly collaborative or communicative, although forest owners have likely been aware of the goals and actions of others during the projects.

According to Kurttila and Jokimäki (2002), the technical premises for cross-boundary planning or management coordination already exist, but experience in practice is lacking. In previous Finnish research, forest planning across property boundaries has been shown to be possible with planning models (Kurttila 2001; Kurttila et al. 2001; Jumppanen et al. 2003), and different participation examples have been introduced for the purpose of regional planning in private forests (e.g. Kurttila et al. 2005). As private forest owners are the decision-making power in their forests, a cooperative approach to management would directly concern the forest owners affected by the location of the lekking site. However, a cooperative approach to management would influence the operations of other actors as well. For decades, forest owners have relied extensively on the advice provided by forest professionals and forestry experts (Hujala et al. 2007; Hujala and Tikkanen 2008). Often forest management decisions have been formulated in dialogue with consulting professionals (Hujala and Tikkanen 2008), and harvesting operations and timetables are on many occasions discussed and agreed in consultancy with timber purchasers (Hujala et al. 2007). Currently, web-based services or other online customer services are much valued for their easiness and free-of-charge nature (Pynnönen 2020), and their use may have decreased the need for face-to-face meetings with forest professionals and service providers, for which much of the communication may occur online. Operations in areas larger than 0.3 hectares are also reported to the Finnish Forest Centre with notifications of forest use, for compilation of forest statistics (Finnish Forest Centre 2021). Although the forest owners are the focal decision-makers in their forestry practices, in this way, local administration authorities, forest service providers and other forest professionals are also focal actors in Finnish forest policies (e.g. Berglund 2001; Primmer 2010) and services. These actors could also be involved with cooperative management.

In Finland, interactive forest management cooperation among private owners may be considered as an entirely novel and innovative approach. Aside from studies that map the technical premises for landscape-level planning and coordination (Kurttila 2001; Kurttila et al. 2001; Jumppanen et al. 2003; Kurttila et al. 2005), forest owners' responses to such management approaches are unknown. Studies from USA that have indicated positive attitudes to cooperative activities have also shown that forest owners' forest management objectives are often related to non-monetary benefits, such as outdoor recreation, privacy, aesthetics, and wildlife habitat quality (Campbell and Kittredge 1996; Kittredge 2005; Butler et al. 2016). Most of these objectives can be promoted through cooperative activities on

spatial scales that exceed individual properties (Kittredge 2005), which could have contributed to the overall positive attitude to ecosystem management. In many cases, timber management, which in Finland has been commonly valued, has not been considered as important as the other goals (Campbell and Kittredge 1996). In Finland, the goals, actions, and norms of forest owners have not been appraised for their relevance for cooperation. In this way, the associated practical and social mechanisms that potentially influence the owners' willingness to innovatively cooperate with other forest owners are not known. Thus, it has been difficult to also estimate the positions of Finnish forest owners with regard to cooperative activities.

While it could be reasonable to assume that forest owners might see the potential benefits of cooperative forest management on lekking sites and consider cooperative forest management as worthwhile, cross-boundary forest management on lekking sites would necessitate that forest owners adopt and engage in cooperative activities, communication and interaction, and implement available grouse-friendly management methods on their properties. Knowledge of these aspects is scarce. This research focuses on formulating a basic understanding of the current conditions and the potential for a shift to a cooperative approach to game-oriented forest management.

1.3 Aim of the research

In Finland, capercaillie is a species whose habitat viability can be used as a forest management objective for the development of innovative and novel (cooperative) forest management concepts. An example case on cross-boundary capercaillie habitat management may be used to assess how forest owners perceive and regard a cooperative management approach in a forestry context characterised by the strong decision-making power of individual forest owners. Indeed, while capercaillie could benefit from landscape-level forest management on private lands, landscape-level management appears problematic and complex in nature.

With respect to the premises described and terminology selected, the main aim of this research was to explore the current conditions that influence how a cooperative approach to game-oriented forest management could be put into practice. This aim of this research was divided into three specific result sections that were descriptions of a) the practices and norms of forest owners and the use of game-oriented and cooperative management measures, b) the willingness and readiness of forest owners to cooperate for game-oriented forest management, and c) communication relevant for game-oriented forest management and cooperation. These parts were drawn up with the components provided by three different publications (I–III), of which the specific aims were to assess

I) the current implementation/adoption of game-oriented forest management, the suitability of forest policy instruments (information) for implementation, and the need for knowledge among forest owners and professionals,

II) the willingness of forest owners to participate in cooperative forest management on lekking sites, and whether the possibility for cooperation influences the forest owners' interest to manage lekking sites, and

III) the type of beliefs expressed by forest owners with regards to cooperative forest management on lekking sites, and how these may reflect the readiness of forest owners to participate in cooperative management.

While these elements give insights into current forest management and cooperation, and the awareness and knowledge around solutions for grouse habitat management, conceptually they are used to mirror the different adoption and communication mechanisms and service and policy adaptations that underpin implementation decisions of management practices. The current conditions for cooperative management principles to shift into practice are discussed from the viewpoints of forest owners' practices and openness to cooperate, forest services and forest policies, and communication and information exchange relative to forestry decision-making.

Finally, this research formulates a critical inspection of the social and practical mechanisms and phenomena that may enable and/or inhibit how a cooperative approach to management could be put into practice, and itemises questions for further research.

2 CONCEPTUAL FRAMING

2.1 Shifting cooperative management principles to practice – a systems approach

Cooperative forest management on lekking sites may be seen as adapting the human (societal) objectives of forest management (e.g. timber production) to the ecological functioning of a capercaillie lekking site. Adaptive management and co-management respond to the multi-scale environment-society dilemmas and pressures that emerge in complex socio-ecological systems (Armitage et al. 2008). Such interdisciplinary approaches, which link learning and cooperation to the creation of effective governance and management, aim to shift challenging ecosystem management principles into practice. When these aspects are considered, the management of lekking sites may be observed in the context of a *socio-ecological system* (SES, or human-environment system, see Turner et al. 2003). The lekking site with its ecological requirements delineates the physical boundaries of the ecological system, the use of which is determined through different utilisation pressures set by a social system.

The SES approach or framework (Ostrom 2009; Partelow 2018) is also closely linked to the Ecosystem Approach, which embodies policy and management decisions as societal choices underpinned by knowledge of ecological processes, and the temporal and spatial scales that these processes occur and operate within (Haines-Young and Potchin 2010). The SES approach comprehends different aspects and dynamics of the interaction between social and ecological systems, and their outcomes (Binder et al. 2013). In Finland, recent studies that have applied the SES approaches were related, for example, to the improvement of waterfowl resilience through the development of human-made wetlands (Mustonen and Kontkanen 2019) and to storm-water management in a city environment (Vierikko and Niemelä 2016). Here, SES is applied as an umbrella context for the management of lekking sites.

The term *socio-ecological* is, however, often used instead of *ecological* to emphasise the integrated role that humans, the *social system*, play in natural ecosystems (Berkes and Folke 1998; Haines-Young and Potschin 2010). Social systems may be seen to consist of actors that are engaged by a common goal or a problem (Rogers 1995), or social groups that define the social structure for systems (Ziółkowski 1988). A system can also be seen to cover the networking linkages between the actors, and the purpose and practices of the human efforts in question (Carlsson et al. 2002; Lawrence et al. 2020). Different systems approaches

(including SES) aim to organise the contemplation and management of complex realities with many "interrelated and interdependent factors" and various stakeholder perspectives (Reynolds and Holwell 2010), and have thus been often employed in forest and natural resource management studies (e.g. Bellamy et al. 2001; Lawrence 2020). Systems approaches also link with *systems thinking*, which refers to the promotion of holistic views, the definition of problem situations and knowledge gain by observing the relationships between objects (for further definition, see Reynolds and Holwell 2010).

With regard to lekking sites in Finland, the utilisation pressures correspond to different management objectives and forest uses, which are determined by forest owners, often in deliberation with professionals, and implemented in compliance with available forestry practices. Forest owners' positions with regard to ecosystem management are considered to be rooted in different social and psychological influences (such as inner values, norms, or education, see Brunson 1998), but could also be related to potential facilities provided by policies and services. While shifting novel management methods into practice requires their assimilation by forest owners in the system, shifting biodiversity-oriented management into practice in non-industrial private forests also requires a change in the working principles of public and private actors and the organisations that operate in or influence the operation in the forests (see Primmer 2010). Conceptually, this refers to *institutional adaptation* and has been profoundly studied by Primmer (2010), who found that traditions, habits, professional norms and the tendency of the companies to follow consistent guidelines, for example, direct how organisations respond to the need to protect biodiversity.

In this way, the associated social, political, and professional subsystems can provide both constraints and facilities for the development of upper-level socio-ecological systems and the adoption of management methods within these systems. Another social or human systems approach that emphasises the need to acknowledge these interconnected influences and is tightly linked to socio-ecological systems is *Soft Systems Methodology* (SSM, Checkland and Poulter 2010). This deals with complex "soft" problems that are associated with multiple divergent views about (or definitions for) the problem. The methodology focuses on problem solving or managing change in practices and is based on modelling of notional *human activity systems* that are influential in the problem-solving situation. A human activity system refers to a system where purposeful human activity is expressed to reach a goal. Important principles in SSM (also applicable here) are to understand the social and political dimensions of problem situations and to also research the tensions between the current situation and the visioned solution in order to reach a change that is both *desirable in principle* and *feasible to implement* (Checkland 2000). These are two important criteria for change that could improve a problem situation. Although this approach is not applied in this research, it is important to acknowledge it here as it deals with the functioning of human systems. The approach demonstrates the importance of understanding the different relationships and practices with regard to forest owners and professionals in a forest management context, and to notionally model the development of these systems.

Thus, to contemplate the potential shift towards cooperative forest management in the Finnish forestry context, an understanding must be obtained from the forest owner-origin conditions, the forest service and policy-origin conditions, as well as an understanding of the relationships and pathways that these actors interact in this context. In this way, the human activity (in terms of the positions of the forest owners/professionals with regard to novel management practices and the social and practical dimensions of associated adoption behaviour) refers to the functioning of the *social system* in the context of cooperative management of lekking sites.

2.2 Diffusion of novel management practices in the social system

According to the Diffusion of Innovations theory (DoI, Rogers 1995), the diffusion of an innovation, method, or concept in a social system is influenced by the adopters and their communication, by time, the social system, and innovation characteristics. In this theory, the adopters are categorised into five types for their innovativeness and rate of adoption. The adopter groups are innovators, early adopters, early majority, late majority and laggards. The latter categories require more persuasion or pressure for them to adopt the innovation (Muth and Hendee 1980; Rogers 1995). The time needed by the adopter to take on the concept refers to the rate of adoption, which also resonates with innovativeness (the degree of an individual's relative earliness in adoption). The individual decision-process to adopt or to reject a concept consists of five stages: awareness/knowledge, persuasion, decision, adoption, and implementation. Decisions can be optional by individuals, collective by groups, or authoritative by individuals in charge (Rogers 1995). Practical innovation characteristics, such as advantageousness, compatibility, complexity, trialability and its observable influences, are judged by individuals to evaluate the applicability of the innovation. Awareness and knowledge lead individuals to form positive or negative attitudes toward novel concepts, which then define whether the concept is approved for its characteristics.

Rogers (1995) has demonstrated that previous practice, felt needs for the innovation, the innovativeness of the adopters, and the prevailing system norms and traditions are the preceding circumstances required for the adoption process and, thus, diffusion of the innovation (Figure 2). Communication behaviour inside the social system can also be seen as one of the important prior conditions for the diffusion of the concept. In this case, current forest management practices, levels of implementation of game-oriented methods or cooperation could act as relevant examples of previous practice in the context of cooperative approach to management of lekking sites. Together with the forest services provided and applied, these could also reflect the innovativeness of the forest owners and how they have felt the need to carry out such management concepts. The system norms (standardised patterns of the social system) are indicators for the individual as to what actions are expected and accepted (Rogers 1995; Checkland and Poulter 2010). Norms serve as a social guide for the behaviour of an individual inside the system. In socio-ecological systems literature, norms are associated with *institutions*, which are formal and informal constraints that structure and regulate the human interaction (Ostrom 1992; Berkes and Folke 1998). Norms are often more informal guides, such as habits and codes of conduct, whereas laws and binding rules are formal constraints on behaviour. In this way, norms may either enhance or inhibit the adoption (see Rogers 1995) of management practices by individual forest owners.

Communication can also be seen as a factor that either facilitates or impedes the adoption of novel concepts, depending on the functioning of the communication and the course of forwarded messages (positive or negative) about the concepts. Communication influences the other conditions for diffusion of the concept as it emerges in all stages of the diffusion and adoption processes – innovations are *communicated* forward. Thus, the role of communication is highlighted in a very practical sense in generalisation of novel concepts: The spread of related knowledge and the concept itself occurs in a series of different communication channels and forms of communication between the actors inside the system and associated actors outside the system. In this way, DoI is often referred to as a communication theory. This relies on the thought of social capital in terms of effective communication and functioning of individuals as social groups (Boland 2020).

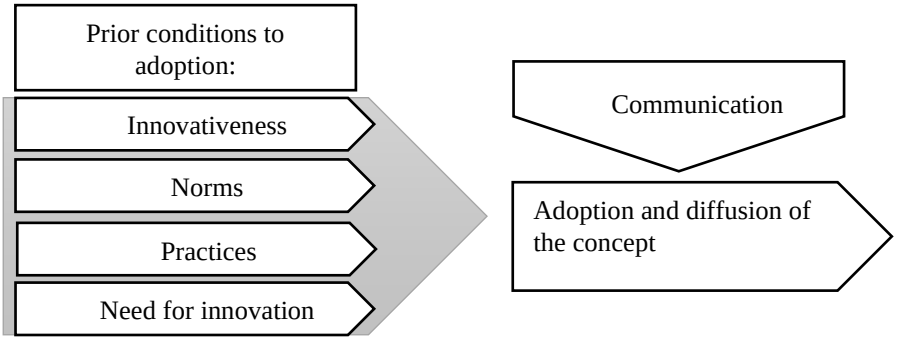

Figure 2. Prior conditions (innovativeness, norms, practices and need for innovation) for the individual adoption process and diffusion of an innovation, which are further influenced by the communication that emerges in the social system (Rogers 1995, Diffusion of Innovations).

The importance of interaction among similar individuals for diffusion is emphasised, as they tend to establish more effective communications, which promotes the diffusion of novel concepts. Peers are the similar others that an individual most often choose to interact with (Muth and Hendee 1980). Most people base their acceptance on the subjective evaluations and experiences of equals (Rogers 1995), and in this way the peer forest owners' opinions may be seen as trusted with regard to the application of new management methods (Muth and Hendee 1980; West et al. 1988). Peer-to-peer learning has also been considered to efficiently complement the forestry-related information provided by forest professionals (Hamunen et al. 2015a, see also Kueper et al. 2013).

However, knowledge exchange can also involve dissimilar actors in the social system. These can be the example-providing pioneer forest owners inside the system (Muth and Hendee 1980), opinion leaders who are often early adopters themselves, but have significant influence on the latter adopter groups especially. They are often highly trusted and thus can efficiently diffuse their knowledge to others. In a forestry context, this learning model has been acknowledged in different Master Volunteer Programs in USA, in which volunteering owners take part in short but intensive education periods to increase their knowledge on different forestry topics, and to later diffuse their skills and knowledge to other owners while promoting stewardship ethics (Allred et al. 2011; Ma et al. 2012; Eiseman et al. 2022). The dissimilar actors in the system may also be external change agents, who usually introduce an innovation into a system and then aid the adopters in recognising the need for it. They are associated with high expertise with regards to the innovation and have their own motivations to promote the innovation (Rogers 1995). While opinion leaders may be sometimes understood as such agents (e.g. Ma et al. 2012), in many studies, forestry professionals have also been assumed and identified as change agents for the adoption of forestry innovations (West et al. 1980; Korhonen et al. 2013; see also Muth and Hendee 1980). As Finnish forest owners have traditionally relied on the advice of professionals, communication with professionals and the applied forest services may also help to understand the practices and norms in this forest management context.

Alongside DoI, different approaches may be used to assess the positions of individuals with regard to adopting and diffusing novel concepts (see Figure 3). Theory of Planned Behaviour (TPB), for example, demonstrates that the extent of an individual intention or readiness towards an action may be seen based on attitudes, norms, and behavioural control of individuals, which are further founded on individual beliefs (Ajzen 1991; 2020). The behavioural beliefs reflect positioning (positive, negative attitudes) towards the action, control beliefs that reflect the perceptions of the factors that enable or hinder action, and normative beliefs that illustrate the considered social pressures inside the system. In this way, positive and negative pressures together formulate the level of motivation and readiness of an individual to engage in action (cooperation here). The TPB framework provides guidelines to measure the social-psychological constructs that define the actions of individuals (Sok et al. 2021), and has been used in various research settings that focus on forest management. In a Finnish forestry context, TPB has been applied in studies that contemplate forest owners' decision-making relative to forest regeneration methods (Karppinen 2005) and forest improvement (Karppinen and Berghäll 2015). Elsewhere, forest-related research has used TPB to help describe the reactions of forest owners to invasive forest insects (Holt et al. 2021), for example, or participation in forest groups to promote close-to-nature management (Van Gossum et al. 2005).

In contrast, Collective Action theory (CAT) focuses on the willingness to engage in cooperative actions. In CAT and associated literature (e.g. Ostrom 1992; Stallman and James 2015; Fischer et al. 2019), the willingness of an individual to switch from independent management to coordinated (cooperative) management depends on the extent that the individual shares perceptions of the cooperative concept with others. The individuals need to see that independent management might cause harm to the common resource (which coordinated action will reduce), that others in a group can be trusted, and that coordinated action will provide benefits (Ostrom 1990; 1992, see Figure 3). And vice versa, a lack of shared understanding of the nature of the problem, management implications, coordination, trust, and reciprocity in terms of an absence of social capital can undermine cooperative strategies (e.g. Jacobson 2002; Austin and Kaplan 2003; Meadows et al. 2013).

While TPB and CAT may not be entirely compatible with communication theories, such as DoI, or the concepts and research practice around social (socio-ecological) systems, the theories do share many aspects related to individual decision-making (Figure 3). Different determinants of behaviour and perceptions of the individuals are relevant indicators of the functioning of the social system, and potential enablers of the diffusion or cooperative action. Indeed, in terms of DoI, individuals' subjective evaluations of their preparedness to participate and the forms of communicating these evaluations forward may be of importance for others as they form their acceptance of the concept.

However, this research does not combine existing theories in order to formulate new theory for the assessment of adoption or diffusion of cooperative forest management. Instead, together with the selected terminology they may provide insights into the social and practical mechanisms in place prior to the adoption of management practices. Due to the potential incompatibility of TPB and CAT with DoI, the former theories were used here merely as angles of approach to elicit the functioning of the social system and to determine the conditions for forest owners to put a cooperative approach to management of lekking sites into practice.

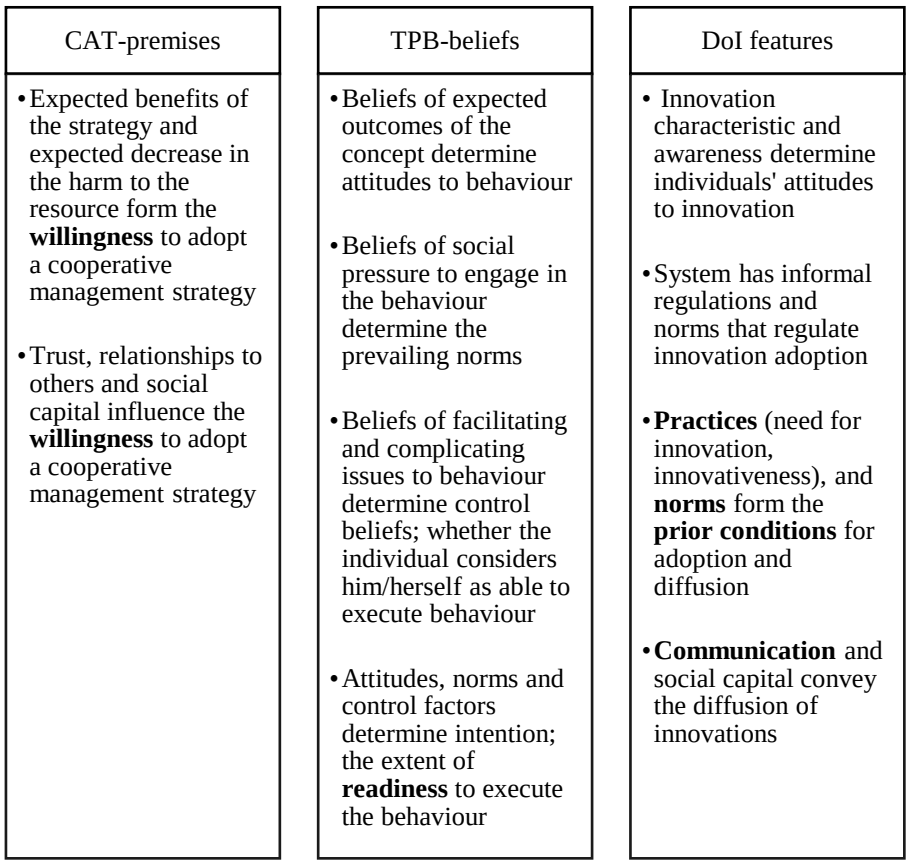

Figure 3. Draft outline of the pathway that selected theories, such as Collective Action theory (CAT), Theory of Planned behaviour (TPB), and Diffusion of Innovation theory (DoI), share similar concepts in the context of individual decision-making, relative to the adoption of novel practices and the explanation of pre-adoption actions and pre-diffusion (of innovation) processes. Willingness and readiness, and the practices (innovativeness and need for innovation as parts of these), norms and communication of individuals are the central elements raised in this research.

Thus, in this conceptual framing, conditions for a shift in novel forest management principles into practice relate to the forest owners' 1) actions and practices, norms, 2) willingness and readiness towards the management principles, and 3) the communication and knowledge exchange related to forest management decision-making (Figure 4). These represent the combined results of this research, which are discussed by means of a systems approach (see section 2.1), which embodies three different dimensions to shift principles into practice: the course of the forest owners' actions, the facilities offered by forest professionals, services and policies, and the relationships and communications between these actors in this context. In this way, this context-bound framework was used as an analytical lens, through which the results were composed, observed, and contemplated (Figure 4).

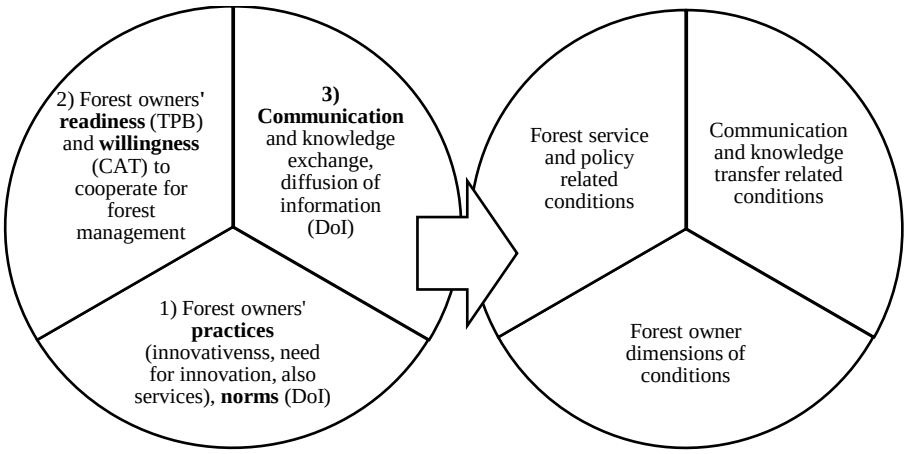

Figure 4. Three components (Nos.1 and 3 originated from Diffusion of Innovations theory (DoI, Rogers 1995; and No. 2 originated from Theory of Planned Behaviour (TPB, Ajzen 1991) and Collective Action theory (CAT, Ostrom 1990; 1992)) that demonstrate the current conditions for cooperative management principles to shift into practice, which were used to derive the forest owner dimension, forest service and policy dimension and communication-related dimensions of these conditions.

3 MATERIALS AND METHODS

3.1 Approach to research

This research employed two types of data to fully elicit the current conditions for the adoption of cooperative and game-oriented management measures by the main forest actors. Studies in articles I and II were based on nationwide surveys carried out in Finland to provide generalisable results of the implementation of game-oriented management methods and the cooperation and phenomena that occur around their implementation. The quantitative approach utilised here enabled the evaluation of the reactions of a large number of forest owners and professionals to the study questions, and the use of different statistical methods for their interpretation.

The study in article III was based on a qualitative approach and in-depth interviews were used to provide a more profound understanding of the decision-making mechanisms that underpin game-oriented management and the cooperative approach, and actions related to these. The qualitative approach here enabled a detailed case study, which provided more profound understanding of the phenomena and details associated with the study context, although the findings can be seen less generalisable than the quantitative results presented in articles I and II. Here, the combination of the two study approaches, together with the analytical lens provided by the utilised theories and concepts (Figure 4), served as a triangulation for a description of the results. The used data, methodological choices, and the reliability and limitations of studies I–III are described in the following sections.

3.2 Double-sampling surveys (articles I and II)

Article I focused on the provision of reliable estimates of the adoption levels of game-oriented forest management methods by forest owners and professionals. The data were collected in Finland with nationwide surveys targeted at Finnish forest owners and forest professionals. The contact registers were provided by the Finnish Forest Centre (FFC), a state-funded organisation that carried out tasks related to the promotion of forestry and the enforcement of forestry legislation (Finnish Forest Centre 2022a). FFC holds registers of private non-industrial forest owners (whose properties located on mainland Finland) and forest professionals. A sample of 1,300 forest owners was randomly selected from those forest owners whose contact information included both an email address and a phone number. A sample of 1,300 forest professionals was selected similarly.

It should be noted that the forest owners on Åland Island were excluded from the forest owner sample as (a) the number of properties in that jurisdiction was low, and (b) given the labour-intensive data permit procedure required by the regional government of Åland Islands, the value of the information was considered minor. In addition, due to a lack of resources and the schedule of this research, the surveys were not translated into Swedish. Over 5% of Finns are native Finland Swedish speakers (Statistics Finland 2022), as are most of the residents of Åland Islands (ÅSUB 2021). This could have affected the response rates, given that few survey feedbacks were related to language issues.

The study described in article I was positioned conceptually within innovation and institutional adaptation research. Survey questions focused on current implementation of game-oriented forest management and the availability of related information and services. This was carried out to gain insight into the current state of game-oriented management and to ascertain the associated level of knowledge. The survey forms and questions were tested prior to sending them to the forest owners and professionals. Testing was carried out with small sub-groups of forest owners (n=20) and professionals (n=20) from the sample group. This reduced each survey sample group size to 1,280. The aim of testing was to detect problems with the surveys and to introduce modifications to improve their fluency and terminology. The test answers were not included in the final results. The final surveys were conducted with an online system called SurveyPal (SurveyPal Inc. 2022) in 2017. Study I resulted in response rates of 33.2% (425 forest owners) and 37.5% (480 forest professionals).

The survey approach was based on double-sampling, in which the data were collected in two phases: After the initial surveys, second surveys were targeted at the non-respondents of the initial surveys (see Thompson 2012). The aim of this approach was to produce reliable and generalisable population estimates, in which the so-called volunteer bias or non-response is minimised by combining the results obtained in the initial and second-phase surveys. In voluntary surveys, participants who are interested in the survey topic tend to respond more frequently than those who are not interested, which causes an interest-related non-response and volunteer bias. Obtaining answers from the initial non-respondents, who do not tend to be interested in the survey topic, requires intensive effort. Thus, a second-phase survey was conducted via phone: a procedure also known as the call-back method (see Thompson 2012). The non-respondents were randomly reordered and were contacted systematically until a number of responses were obtained. In article I, 15 forest owners and 16 forest professionals were approached and interviewed with questions related to the initial survey. None of the individuals who answered the call refused to participate in the survey, so the second-phase data could be considered free from volunteer bias. This improved the reliability of the final population estimates.

The results were obtained by calculating the unbiased estimates of population means and their variances as described by Thompson (2012). The unbiased estimate of the population mean was calculated with the double-sampling stratified estimator:

$$\bar{y}_d = w_1\bar{y}_1 + w_2\bar{y}_2 \quad (1)$$

where $w_1 = n'_1/n'$ represents the weighting of the respondents, and $w_2 = n'_2/n'$ represents the weighting of the non-respondents of the initial survey. n' is the sample size (1,280, and 1,300 in study II) selected from the total population. $\bar{y}_1$ represents the estimates of respondent population means of the initial survey, whereas $\bar{y}_2$ represents the estimates of the non-respondent population means obtained in the second-phase survey.

In article I, the estimates and weightings were calculated using the question-specific numbers of responses, which led to estimates that did not include the question-specific non-response (i.e. a non-response resulted when a survey participant ignored a question). However, as it is meaningful to acknowledge those who were not willing to take a stance on certain questions, the approach was changed in study II, which otherwise employed the same survey approach. In study II, the estimates and weightings were calculated with survey-specific numbers that led to unbiased estimates that also highlighted the question-specific non-response. Regardless, since the proportion of such respondents was considered minor in article I, both described approaches led to practically the same results and conclusions: The difference in the unbiased estimates calculated with the two different approaches was greatest at 1.1 percentage points (pp), and least at 0 pp (average 0.3 pp). In article I, an unbiased expression for the variances associated with $\bar{y}$ with double sampling was obtained with the following equation with sample variances of the second-phase sample (Thompson 2012):

$$\widehat{\mathrm{var}}(\bar{y}_d) = \frac{N-1}{N}\sum_{h=1}^{L}\left(\frac{n'_h-1}{n'-1} - \frac{n_h-1}{N-1}\right)\frac{w_h s_h^2}{n_h} + \frac{N-n'}{N\,(n'-1)}\sum_{h=1}^{L} w_h\left(\bar{y}_h - \bar{y}_d\right)^2 \quad (2)$$

where N stands for the total population of forest owners, h the stratum (1 = initial survey, 2 = second-phase survey), and n_h, $w_h = n'_h/n'$ and s^2_h are the number of respondents, weighting, and estimated standard deviations of y in stratum h. Standard errors were calculated as the square root of the variances:

$$s_d = \sqrt{\widehat{\mathrm{var}}(\bar{y}_d)} \quad (3)$$

Confidence intervals with upper and lower boundaries were calculated with the resulting standard errors:

$$\bar{y}_d \pm z s_d \quad (4)$$

where z = 1.96 is the 0.985^{th} standard normal quantile resulting in two-tailed 95% confidence intervals.

Article II applied the same survey approach (similar sample size, data collection and analytical procedures) but focused on the willingness of forest owners to engage in cooperative forest management on lekking sites. In addition, article II assessed the levels and forms of previous forest-related cooperation and whether the possibility of cooperation influenced the forest owners' interest to manage capercaillie habitats. Article II was

positioned in a conceptual framing that included both forestry adoption literature and collective action literature. The survey was targeted only at forest owners.

The survey questions in article II were specified around forest owners' willingness to apply different game-oriented methods, previous and future forest-related cooperation, and knowledge of lekking sites and their management. Together, the questions were used to reveal aspects of forest owners' willingness to jointly manage wildlife habitats as capercaillie lekking sites. Similar to article I, the survey forms were tested beforehand, although in this case, the forms were tested with a group of forest owners (n=6) outside the main sample group, thereby maintaining a study sample size of 1,300. In this study, the online system SurveyPal was again used to collect the survey responses. The data were collected in spring 2020. A response rate of 25.7% (334 forest owners) was obtained.

Despite careful planning of sample sizes, the survey in article II produced fever responses than was expected. The reason for lower response rate was not revealed, however, the survey was sent in early spring 2020, when the Finnish government had just declared Covid-19 pandemic restrictions for all citizens. It is likely that survey studies were considered insignificant at that time, and time and efforts were allocated elsewhere. It is also likely that the willingness of forest owners to participate in the survey may have decreased due to the rather long survey form, which they may have considered complicated. This may not have been detected given the fewer test responses in comparison to article I.

In article II, call-back efforts for secondary data resulted in 52 total and 2 partial responses by forest owners. As more call-backs were made in article II in comparison to article I, the number of forest owners that refused to participate in the call-back survey also increased, which could be a potential source of volunteer bias in the call-back results. However, of the 18 forest owners that took the call and refused to participate in the survey, only one declined with a reason that could be associated with the survey topic. Thus, the second-phase data in article II could also be considered free from interest-related volunteer bias.

Aside from the slight modification of the interpretation of the equations described above, the data analysis followed the same procedure as in article I. Only the sample variances were calculated with a slightly modified formula:

$$\widehat{\mathrm{var}}(\bar{y}_d) = \sum_{h=1}^{L} \left(\frac{n_h' - 1}{n' - 1}\right) \frac{w_h s_h^2}{n_h} + \frac{1}{(n' - 1)} \sum_{h=1}^{L} w_h \left(\bar{y}_h - \bar{y}_d\right)^2 \quad (5)$$

Equation (5) differs from equation (2) so that it ignores the finite population corrections. The infinite population corrections were removed from the equation due to their marginal influence on the variances.

3.3 Qualitative forest owner interviews (article III)

The exploratory study in article III aimed to reveal the type of beliefs (behavioural, normative and control-related) that forest owners hold with respect to a cooperative approach to lekking site management, and also to explore the readiness of forest owners to participate in cooperative forest management in a lekking site management context. The Theory of Planned Behaviour (TPB, Ajzen 1985; 1991; 2020), in which the individual action is considered based on intentions that are guided by different beliefs and behavioural determinants, was employed as the conceptual framework in the study. TPB has often been used in quantitative survey

studies in a forestry context (e.g. Karppinen 2005; Karppinen and Berghäll 2015; Holt et al. 2021), although prior to the creation of a survey form, knowledge is needed on context-specific beliefs (Fishbein and Ajzen 2010; Sok et al. 2021). Thus, in this pilot study, the TPB framework was used as a tool to obtain and analyse the context-specific beliefs.

The data were collected with interviews targeted at forest owners in southern Ostrobothnia in western Finland, where the property structure (oblong and narrow properties) could, in theory, necessitate cooperative solutions in forest management. The sample was selected with purposeful sampling (Patton 2002; see also Palinkas et al. 2015) of forest owners, whose lands included part of an active lekking site. Purposeful sampling relates to selective sampling methods (Coyne 1997) and is used to identify those informants or interviewees that have the best information or understanding needed to answer designed study questions (Patton 2002). As the study followed the TPB framework and TPB-beliefs should be obtained from a sample representative with regard to the study of interest (Fishbein and Ajzen 2010; Ajzen 2020), such a sampling procedure was considered especially relevant here. The careful sampling procedure used to identify the study site and context of the study can also be seen to improve the validity of the obtained results (see Leung 2015).

Verified information of the locations of the lekking sites were provided by a local hunting club. To be able to define a sample group, theoretical framings of 20 hectares around the assumed centre points of the lekking sites were created. The names of the forest owners whose lands were inside these framings were obtained from the land registration numbers held by the National Land Survey of Finland (NLS, National Land Survey of Finland 2022). However, the sample size was reduced to maintain the validity of the data: estates and real property partnerships were excluded from the sample group as the aim was to focus on the decision-making of individual private forest owners. Persons linked with the work of the hunting club that had provided information of lekking site locations were also removed from the sample group, which created a sample size of 19 forest owners.

An interview "guide" or framework was established to assess the TPB-based behavioural, normative and control beliefs related to the cooperative lekking site management. The questions aimed to reveal the context-specific beliefs of forest owners by the creation of an open discourse on the topic of cooperative approaches to management. Questions related to the expected effects of cooperative forest management on lekking sites were asked to reveal behavioural beliefs; questions related to others' roles in forest management (and their expectations) were asked to uncover normative beliefs; while questions related to phenomena that could hamper or enable cooperative management were asked to evaluate control beliefs. Forest management and decision-making, capercaillie habitat management, game habitat management in general, and cooperation were also topics that were discussed in the interviews. This was carried out to ensure that the interviewed forest owners focused on the addressed topic and that the interviewees understood the subject matter (context, people, and resources), which is a necessity for a TPB pilot study (see Sok et al. 2021). Prior to the actual interviews, the framework was tested with a small group of voluntary forest owners outside the sample group and was modified accordingly by issues raised by that group (e.g. terminology was standardised). Test responses and discourse were not included in the results.

The interviews were conducted during September 2019 via phone. Not all 19 forest owners participated in the interviews as some phone numbers were not available, some forest owners did not answer the call, and some forest owners did not want to participate for reasons not related to the interview topic. Indeed, refusal with reasons related to the interview topic would have represented a low readiness towards cooperative lekking site management. As a net result, 12 interviews were conducted. It should be noted that reducing the sample size to

maintain the validity of the data also limited the number of forest owners that could be approached, which contributed to the rather moderate number of interviews. Strong emphasis was placed on ensuring the anonymity of the forest owners that participated in the interviews, and all details regarding lekking site locations or potentially sensitive information related to the forest owners were removed from the published text. Although this was carried out to improve the validity and ensure the ethicality of the study, it also somewhat reduced the transferability of the research. For example, article III lacked a detailed description of the study location and characteristics of the study sites.

The interviews were discussion-focused and in-depth in nature, as the forest owners were encouraged to answer and express their thoughts freely. However, the interviews also included a more formal/structured section, in which the forest owners were asked some important background information. Interviews were recorded with the permission of the interviewees. After transcription, the interview data was imported into an analysis tool NVivo 12 Plus (QSR International 2020), which was used for data organisation and analysis.

The data analysis was also qualitative to contextualise the perspectives that had emerged in the interviews. The approach combined inductive and deductive methods that ensured the full utilisation of the captured discourse: The opening inductive phase involved an exploration of the data without any predefined theoretical assumptions and was carried out to gain an understanding of the data (Patton 2002; see also Elo and Kyngäs 2008; Hays and McKibben 2021). It also ensured that all the meaningful beliefs expressed by the interviewees were captured. In the inductive phase, aspects that appeared meaningful with regard to the study questions (readiness to cooperate in forestry matters and capercaillie habitat management) were raised from the data and assigned non-hierarchical codes (for a similar approach, see Nolan et al. 2019).

In the deductive phase, the meaningful aspects were categorised under the conceptual terminology and framing of the study (three types of beliefs: behavioural, normative, control). This enabled the aspects to be categorised as in more traditional content analyses (see Elo and Kyngäs 2008; Grbich 2013; Hays and McKibben 2021) and provided a way to reorder the contents to represent the elements behind the behavioural determinants of TPB. Finally, these determinants were discussed for their relevance and used to evaluate the readiness of forest owners to cooperate. Full utilisation of the theory and related literature also advanced the generalisation of the results.

4 RESULTS

4.1 Forestry practices, norms, and game-oriented and cooperative management

Finnish forest owners showed to have varying forest management objectives related to economic aspects, nature values, traditions and heritage, and household use (articles II and III), which define the framing for their current forest management approach (see Figure 5). Quite often, the economic objectives were the most valued objectives, and their influence on the management decision-making was likely highlighted (article II). Timber production and incomes were the most important objectives for almost 40% of owners and financial security was important to 15% (article II). Many of the interviewed forest owners (7 out of 12) indicated that their forests had economic importance for them (article III). However, many forest owners also had multi-objective management approaches (article III), not always

guided merely by economic or financial objectives (Figure 5). Recreation and free time, for example, were the main management objectives for more than 13% of forest owners (article II).

The forest owners seemed to regard their forest management and related decision-making as rather personal issues and the independency of management was greatly valued (by 8 of the 12 owners, article III). Neighbours were considered to have low influence on decision-making and cooperation was considered to influence freedom of action (of the forest owner), whereas family seemed to influence the decision-making both directly and indirectly through the long history of forestry traditions and associated family values (article III, Figure 5). This seemed to further support the tightly rooted norm of independent management (article III).

Nearly 60% of forest owners were aware of game-oriented forest management practices (article I), yet a smaller number of forest owners (40%, early adopters in terms of Rogers' (1995) theory) had substantially adopted the practices in their own forest management (article I). However, the game-oriented forest management concept received increasing approval from forest owners, since the data collected approximately three years later (for article II) showed that forest owners regarded the methods positively and were quite willing to apply them in their forests. In this later research, forest owners appeared to be more eager to apply workable, smaller game-oriented methods than larger management approaches (article II), which could be most beneficial when applied at the landscape-level over property boundaries of individual forest owners. The majority of forest owners accepted mixed-tree species distribution (83.4% of owners) and the maintenance of bush vegetation (79.5% of owners) and game thickets (76.3% of owners). Management approaches that could be potentially suitable for game habitats, such as continuous cover forestry were widely accepted by more than 71% of owners, whereas forest conservation was accepted by less than one third of owners (32.9%) and a lengthening the stand rotation period was accepted by less than half of the owners (49.1%). For reference, 4 out of 12 owners retained some scepticism to game-oriented management practices (article III).

A considerable proportion of forest owners did not know if capercaillie lekking sites were present on their land (48.8% of owners in article II, most owners in article III). The availability of forest management methods to be used specifically on lekking sites were not known in many cases (article III). Indeed, it seems that only a minority of forest owners have adopted lekking site management on their properties, as only 8% of forest owners acknowledged a lekking site in their forestry practices (article II). Regardless of the uncertainty associated with capercaillie lekking site management, the capercaillie species was well-known by the forest owners (articles II and III), who also seemed to consider its habitat management to be important (8 out of 12 of forest owners, article III). Despite their elevated opinion of capercaillie, more than 64% of owners were not hunters (article II), which would indicate that the species was also valued for something other than game (article II, see also article III).

Forest professionals appear to be trusted by the forest owners, and their guidance in forestry matters is commonly valued, since 7 out of 12 owners indicated appreciation and trust in forest service providers, and 9 out of 12 owners acknowledged that their management was influenced by the forest professionals or those who provided services (article III). Only a minority of owners (3 out of 12) expressed a wish to be less reliant on their guidance (article III).

The forest professionals seemed very aware of, and competent in, game-oriented forest management practices (article I). Practically all the forest professionals were aware of game-oriented practices (99%), and most considered game-oriented forest management to be a part

of their work (74.8%, article I), even though their employers rarely provided education for game-oriented forest management practices (article I). Most forest professionals also wanted to promote game-oriented forest management in their work (97.9%) and many had already promoted it (88.0%, article I). However, the majority of forest owners (94.8%) indicated that such promotion or specific guidance to game-oriented forest management had not been provided to them, and nearly 60% of owners were unaware of the availability of game-oriented forest management services (article I). This would suggest that such services are subsumed to more traditional services, that the forest service sector is still adapting to game-oriented methods (article I), and that forest professionals could benefit from more education related to game-oriented forest management (article I).

Nearly half of forest owners (45%) had experience of some type of forestry-related cooperation (article II), which could suggest that at least the same number of forest owners are aware of the opportunities for cooperative actions in forest management. Previous cooperative activities in forestry matters were related to the construction of forest roads (68.1% article II, 7 out of 12 owners in article III), hunting (59%, article II), ditching (54.5% article II, 7 out of 12 owners in study III) and timber sales (48%, article II). The type of cooperation carried out and the results obtained would suggest that previous projects were likely initiated by an external organisation (articles II and III). This would mean that cooperation has been offered to forest owners as a service.

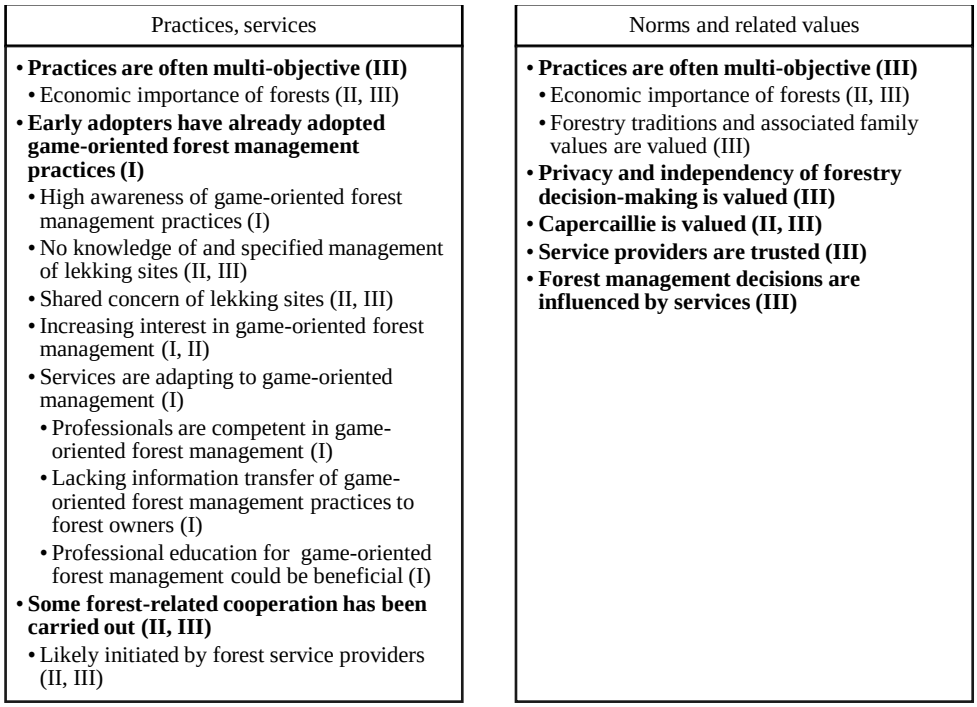

Figure 5. Factors that have contributed to decision-making relative to game-oriented management or lekking site management practices of forest owners divided into categories that represent practices (and services) and norms. Due to the artificial categorisation and interconnected concepts, some factors overlap and are located in both categories (e.g. multi-objectivity of owners). Roman numerals (I, II, III) in the figure indicate related article number.

4.2 Forest owners' readiness and willingness to cooperate

While forest owners seemed to regard cooperative activities in forestry in a positive sense in general and indicated a willingness to participate in cooperative lekking site management (more than 75% of owners in article II, 8 out of 12 owners in article III), the results suggest that forest owners also approach cooperative management with careful consideration (articles II and III). Potentially, cooperative activities in forestry could be considered to include coordination that differs from traditional independent management (article III) and forest-related decision-making (article II). The forest owners appeared to question the type of commitments required and how and to what extent they can agree on the commitments (10 out of 12 of interviewed forest owners in article III). Uncertainty with regard to other forest owners' goals was suggested to influence the forest owners' openness to participate in cooperative activities (article II).

In some instances, the forest owners did not consider that any positives would accrue from cooperative management (3 out of 12 of interviewed forest owners, article III). The uncertainty of forest owners to engage in cooperative activities seemed obvious, especially as given the high rates of 'I don't know' answers (23.6–34.5% per question, article II) received in response to questions regarding cooperation. The differing response rates between articles I and II also supports the assumption of uncertainty associated with cooperative activities. The response rate to cooperative activities in study II was rather low (25.7%) in comparison to the response rate in study I (33.2%) related to management activities on individual properties.

When forest owners contemplated their readiness to participate in cooperation, they also considered how cooperative management of lekking sites influenced capercaillie wellbeing, forest use or their decision-making rights (article III). The possibility to improve capercaillie populations and provide benefits for recreation seemed to encourage cooperation, whereas beliefs that addressed the limited decision-making rights (in cooperation) and restrictions in forest use appeared to suppress the readiness to cooperate (article III). A small number of forest owners (3 out of 12) considered that age and health issues limited their openness to participate in cross-boundary management (article III). Indeed, the results suggested that many forest owners were already pensionable (articles II and III): The mean age of respondents was 63 years in article II (the same as the currently lowest retirement pension age), whereas in article III, the mean age of interviewed owners was 64 years.

Economic objectives associated with forest management also seemed to play a role in the readiness and willingness to participate in cooperative management as forest owners often seemed unsure of the need or the possibility to gain compensation for cross-boundary management on lekking sites (articles II and III). Some owners (25.7%) considered the cooperative management concept interesting, provided compensation for participation was available (article II). Yet, in most cases where forest owners wished to receive compensation for participation, the compensation claims appeared financially low (15.5% of forest owners) or comparable to compensation claims on individual properties (25.8% of owners, article II). This question was also regarded with considerable uncertainty by forest owners; captured by the 34.5% of 'I don't know' answers.

The forest owners seemed to value reaching a common goal and the active participation of others in cooperation, rather than monetary compensation for cooperative activities (article III). For this reason, the monetary aspects did not seem to determine the owners' decisions to participate in cooperative habitat management. Many forest owners seemed interested in cooperative management, although those who considered themselves less active in forestry

work or unable to manage their own forests, considered cooperative management to be especially valuable (4 out of 12 of interviewed forest owners, article III). The majority of interviewed forest owners (10 out of 12) considered lekking site management to be easier to implement in cooperation than independently (article III; see also article II). Most (8 out of 12 of interviewed forest owners) also regarded the cooperative management alternative to be more effective for habitat management purposes (article III). In this way, different social and economic aspects associated with cooperation were seen as relevant drivers for cooperation, although the results indicated that ecological and public goods viewpoints were also important for forest owners (articles II and III).

The openness of forest owners to participate seemed to be also influenced by the potential to have an external person/organisation to lead the cooperation action: 7 out of 12 forest owners trusted professionals and expressed a wish that professionals would lead cooperative activities, especially if several forest owners were to be included in the cooperation (article III). The results suggested that joint action by forest owners requires additional planning and implementation tools, and exchange of knowledge (article II), and that finding forest owners with similar interests could result in socially and ecologically optimal cooperative solutions (article II). In this regard, the results inferred that cross-boundary habitat management may be regarded as more appealing by forest owners if based on a voluntary approach, in which the forest owners' property rights are assured (see articles II and III).

4.3 Communication for game-oriented forest management and cooperation

Forest-related decisions appeared to be often influenced by family and communication with other forest owners was not highlighted (article III). Forest owners also addressed beliefs that cooperation would restrict their valued freedom of action, by consistently expressing the value of independent management (8 out of 12 owners in article III). The results of previous cooperation experience initiated by external organisations suggested that the cooperation lacked true interaction between neighbouring forest owners (articles II and III). Just over one third of forest owners (34.9%) had discussed cooperative activities with neighbouring forest owners (article II). More than 47% of forest owners knew at least some of their neighbouring owners and more than 38% knew them all (article II, 9 out of 12 owners in article III). Simultaneously, neighbours were regarded openly, and relationships between neighbouring forest owners were reported as functioning and friendly (articles II and III). Only 13.8% of owners indicated that they did not know their neighbouring forest owners (article II).

Indeed, while cooperation was considered with careful consideration and sometimes with caution (articles II and III), most forest owners seemed to regard peer learning positively (articles II and III): The strong willingness of owners to cooperate (e.g. more than 75% of forest owners, article II) seemed to signal that forest owners were at least open to assistance and help from peer forest owners (article II). Practically all interviewed forest owners considered the number of participating forest owners rather irrelevant for the functioning of the cooperation activity (article III). In addition, forest owners appeared to value the practical and social support associated with cooperative activities (article III). Taken in tandem, the results in studies II and III suggest that the opportunity for cooperation had intrigued the owners. Most forest owners (57.5%) considered the opportunity for cooperation to increase their interest in management of lekking sites (article II), which highlighted the importance of peer support in achieving tangible habitat measures and knowledge exchange (article II). An awareness of others' participation could also establish a sense of commitment to realign their

own forestry methods (article II). Thus, a wider spread of game-oriented management methods would require the support and real-world examples provided by other forest owners (article I).

In the interviews, 9 out of 12 forest owners considered that the services provided by professionals have influenced their forestry decisions (article III, see also section 4.1). In article I, the forestry professionals and service providers were considered as change agents, who promoted the diffusion of game-oriented forest management methods within their work and services (article I). While channelling information to forest owners solely through professionals was considered as insufficient to increase the adoption of game-oriented methods (article I), there also appeared to be a noticeable lack of interaction between forest owners and professionals regarding game-oriented forest management information (article I). This assumption is supported by the low number of owners that received guidance on game-oriented management (5.3% of forest owners, see section 4.1, article I) and the low number of owners that were aware of related services (18.3% of forest owners, article I).

In contrast, the previous forestry-related cooperation, experienced by at least 45% of forest owners (article II, 7 out of 12 owners in article III) and initiated by external organisations, seems to have been considered successful, and 7 out of 12 forest owners indicated this clearly (article III). In both articles II and III, most owners also signalled a willingness to engage in cooperation in the future, which supports this conclusion. In this way, the results suggest that professionals may have important roles in the formulation of a normative atmosphere that would ease the adoption of a cooperative approach to management between forest owners (articles II and III). Indeed, the results infer that involvement of a leader may be needed to initiate the process of cooperative management, although cooperation also necessitates receptive and active forest owner participants (articles II and III). Together, these results seem to show that there are factors that both encourage and inhibit game-oriented forest management related communication between professionals and owners, and between peer owners in the context of cooperative approach to game-oriented forest management (Figure 6).

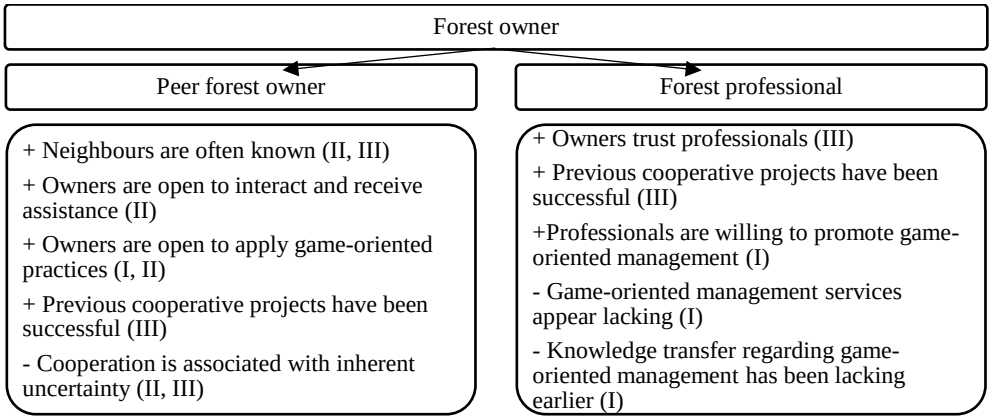

Figure 6. Communication-related factors that could encourage (+) and inhibit (-) cooperative action or communication in a game-oriented forest management context of forest owners with their peers or professionals. Roman numerals (I, II, III) in the figure indicate related article number.

5 DISCUSSION

5.1 Conditions based on current practices, readiness, and willingness to cooperate

As set in the conceptual framing of this research (components 1 and 2 in Figure 4), the results indicate that it is practically impossible to separate forest management history and related decision-making mechanisms from the readiness or willingness of forest owners to participate in cooperative management or to engage with game-oriented forest management methods (see Figure 4). This section contemplates the forest owner-origin conditions for cooperative forest management on lekking sites set against the needs, practices and norms of forest owners and their openness to cooperate for forest management. The forestry services, service adaptation and policy instruments in terms of institutional adaptation (Primmer 2010) to this cooperative management are discussed separately below, as is the knowledge exchange required for diffusion of the concept (see Figure 4).

If adjusted to Rogers' (1995) adopter categories, it seems that the early adopters and early majority adopters had adopted and approved game-oriented forest management (by 2017, article I) and cooperative activities (by 2019–2020, see articles II and III). The increasing acceptance of game-oriented methods, the indicated high willingness to engage in cooperative approach for lekking site management, and the overall curiosity raised by cooperative management seems favourable for the adoption of cooperative management by forest owners. The reliability of the results and the following discussion necessitates, however, that the subjectivity associated with the interview and survey responses be contemplated. Forest owners may have differences on how they understand the different concepts, which influences the inference and related argumentation of the research. Indeed, while perceiving the results as estimates of the degree of implementation and interest between forest owners, it should be noted that the results are based on subjective evaluations regarding the methods and their appliance.

In theory, forest owners who have already implemented game-oriented management methods or have participated in cooperation could be more open to cross-boundary management as defined here. Also, in practice, prior experiences related to cooperative agreements have been shown as positive factors to landowner participation (Belin et al. 2005; Vokoun et al. 2010). However, regardless of the acknowledged value of the capercaillie and the management of its habitat (articles II and III), the actual sensation of the *need* of forest owners to change their forestry approach accordingly is difficult to measure. The findings of multi-objectivity in forest owners (see also Karppinen et al. 2020) and the observed recent increase in the approval of game-oriented forest management signal that forest owners may feel the need to adapt their current forestry practices from the more traditional timber-emphasising practices. As hunting forest owners were not specifically highlighted in game-friendly forest management actions (article II), habitat management is not placed solely under the scope of improving recreation but also under a wider biodiversity management scope. The habit to value multiple objectives in forestry is also in line with the wider Finnish forest owner research, which also suggests that a high proportion of owners is categorised as multi-objective (Karppinen et al. 2020). These aspects, together with the results presented here, lead to infer that the current and future forest owners may wish to make management choices that are optimal or advantageous in a multi-objective manner, such as game-oriented management on capercaillie habitats located on commercial forests.

However, the change in the objectives of forest owners over the last ten years has been somewhat unexpected. The importance of financial and economic values related to forest ownership has increased, and the importance of immaterial goods has decreased (Karppinen et al. 2020). Here, the results also indicate a perception that forest owners' decisions to accept game-oriented forest management methods and cooperative management are at least partly guided by the potential changes caused to forest use and timber-related incomes (articles II and III). However, the observed consensus on the motives to participate in cooperative management (i.e. habitat wellbeing and joint action on economic features of management) may be better aligned with research in other countries that has shown that cooperation can be also driven by shared concerns (e.g. Fischer et al. 2019), and that the owners that respond positively to landscape-level management often have other ownership goals than purely financial gains (Belin et al. 2005). However, it should be noted that little research around cooperative forestry activities have been carried out in Finland to date, and there is no basis for comparison for how forest owners regard the compensability of other types of cooperative management.

Indeed, the similarity of prevailing beliefs and responses obtained from both the qualitative and quantitative surveys outlined here demonstrate a wider consensus on the motives to participate. Such consensus can advance the sense of group identity and reflect the ability of owners to internalise group standards as their own (Bouas and Komorita 1996; Swaab et al. 2007). Conceptually, this impression of reciprocal thinking, shared thoughts, and social identity that seems to decrease the "transaction costs of working together" visualise social capital (Pretty 2003), which is considered a key element in collective action (see article II, Figures 3 and 7) and in diffusion of novel concepts (Boland 2020). These considerations, together with the results that indicate the openness of the forest owners to peer actions, show that the decisions to participate in cooperative activities are also influenced by different considerations of associated social aspects (Meadows et al. 2013; article II). Cooperation and related decision-making are social processes after all.

Naturally, the forest owners should consider the concept of cooperative management to be useful and to be sufficiently practical for them to participate in it. The forest owners' perceptions of the easiness and effectiveness of cooperative management indicate that, in terms of theory, the *advantageousness*, *complexity*, or *compatibility* of cooperative management may favour the spread of the concept between forest owners. Indeed, while forest owners prefer easily workable game-oriented practices on their individual properties (see article II), the efforts required to independently manage a wide and complex habitat, such as a lekking site, may not be realisable. Thus, the considered practicality of cooperative lekking site management seems to relate in many ways to the ecological benefits and social benefits (as already described above) as help, knowledge transfer, and joint action associated with cooperative activities, which also likely account for the generally positive impressions of cooperative management (see Fischer et al. 2019).

However, positive predispositions do not necessarily lead to the adoption of the concept (Rogers 1995) or predict behaviour change (Ajzen 2020). Indeed, many of the results presented here show central phenomena that can either inhibit the shift of cooperative management to practice or prevent it entirely. The results showed that there are also a cohort of owners who do not see cooperative activities in a positive light, do not want to participate in cooperative management or management of lekking sites, and are sceptical of game-oriented methods. It is likely that these owners will not adopt these cross-boundary measures, or they will require intensive outreach as later adopters in terms of DoI (see Rogers 1995). These differences or mismatches in views and attitudes (i.e. modes of thinking), together with

scepticism to cooperation, decrease the readiness and willingness of forest owners to participate in cooperative forest management. In practice, they could also decrease the potential to engage in cooperation with peer owners or shift the management principles into practice, as shared perceptions of the management implications may be missing or difficult to formulate.

In particular, the uncertainties associated with cooperative (lekking site) management and the required commitments by the forest owners may undermine the wider spread of the concept. This observed carefulness could result from forest owners who consider that their needs as already fulfilled with their current management system (Kittredge 2005), as in practice, forest owners own different types of properties and may consider their forests suitable for cooperative or game-oriented methods to different extents. In wider research, the scepticism towards cooperative or ecosystem management alternatives has often been linked with the concerns of losing or weakening the independency and freedom of choice associated with the prevailing management (Brunson et al. 1996; Fischer and Bliss 2009; Meadows et al. 2013). The results of this research also seem to indicate that forest owners truly value their decision-making power. Forest owners may express positive attitudes towards cooperation and regard the methods with optimism (as in articles II and III), but it is likely they might find it more difficult to substantially engage in the activities.

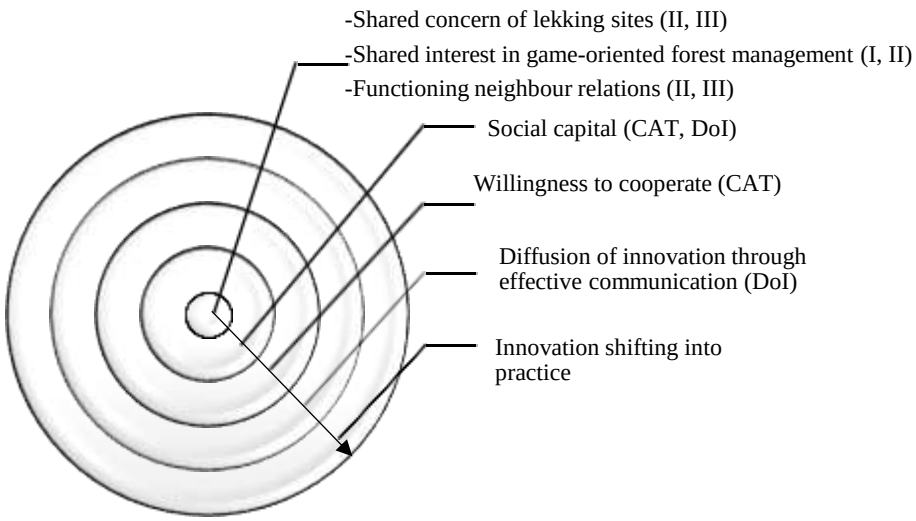

Figure 7. An illustration as to how forest owners' shared concern of lekking sites, increased interest in game-oriented practices and functioning relationships (articles I–III) can represent the social capital required for willingness to cooperate (as in Collective Action Theory CAT, Ostrom 1992) and effective communication (as in DoI, e.g. Boland 2020, see also Rogers 1995). The arrow represents how the innovation can diffuse from shared concern and interest through willingness to cooperate and communication to practice. Roman numerals (I, II, III) in the figure indicate related article number.

Indeed, forestry-related decision-making has often been influenced by traditions and common culture-bound ways to manage forests (Puettmann et al. 2015; O'Hara et al. 2018, Mason et al. 2022), as also shown in this research. Since Finnish management has tended to be self-sufficient (articles II and III), traditions may be seen as one social mechanism that indirectly supports the norm of independent management in a local forestry context. For example, in south-eastern USA, independent decision-making related to private properties has influenced the intensity of efforts in the cooperative timber market (Sample 1994; Jacobson 2002). Here, the independent spirit may also be an inherent characteristic of the owners, as properties are often inherited, and ownership has sometimes been associated with obligations that the forests should be managed similarly to the way that previous generations managed them (Lähdesmäki and Matilainen 2014; see also article III).

In general, Finnish forest owners born during 1945–1950 will pass on their forest properties to the next generation by 2025 (Karppinen and Tiainen 2010, see also Karppinen 2012). Aging and associated decline of physical abilities were indicated as reasons to withdraw from cooperative management (see also Meadows et al. 2013; article III), although the ongoing and forthcoming land transfer to the next generation may explain the observed hesitance of aged forest owners to immediately start changing their practices. At the same time, the transfer to younger generations could also ease the adoption of cooperative management alternatives. Earlier adopters tend to be younger (Rogers 1995; Henderson et al. 2014; Joshi et al. 2015; Bertsch et al. 2016; Khanal et al. 2019), and studies have demonstrated that younger owners are more likely engaged in wildlife management (Golden et al. 2012) or are interested in or have positive attitudes towards joint management (Jacobson 2002). However, less clear or opposing results as to the influence of age on participation also exist (Stevens et al. 1999; Stallman and James 2015).

In addition, studies that involve human participants and sensitive issues (such as forestry) show that stated intentions may be biased in a socially desirable direction (see Ajzen 2020). Responses tend to be biased especially when the behaviour under interest is considered abstract rather than requiring substantial engagement. Studies of willingness to accept (WTA) and willingness to pay (WTP), for instance, are often associated with this hypothetical bias (Nape et al. 2003). The respondents may address a willingness to pay more than they truly spend in field experiments (Sauer and Fischer 2010; Loomis 2011) or seem willing to accept contract details of hypothetical programs but hesitate, or be unwilling to participate, when confronted with real contracts (Håbesland et al. 2016). The forest owners here may have also experienced pressure to answer questions related to cooperation in ways that exhibit politeness to neighbouring forest owners or consent to their assumed values. For example, Lähdesmäki and Matilainen (2014) found that a proportion of forest owners in their study permitted hunting and the construction of nature trails on their lands out of fear that their refusal would have resulted in social sanctions. In this case, the local community limited the decision-making right of the forest owners to a certain extent, which again highlights the value Finnish forest owners place on their decision-making status.

Thus, it should be noted that the observed willingness to cooperate and the stated importance of managing lekking sites (articles II and III) might not reflect a shared commitment or a substantial urge to take steps towards adopting cooperative management. Rather, the results could be seen to reflect a decent starting point for the development of wider awareness of game-oriented forest management and cross-boundary management measures. The perceptions of the forest owners with regard to future cooperation may also be confused by their previous experiences, which may have been very different to the cooperation required for lekking site management. Forestry cooperation that includes

interaction and communication between forest owners has not been utilised in Finnish circumstances, other than in communally owned land (jointly-owned forests), which is also rather rare (Lähdesmäki et al. 2016). Thus, there is a risk that forest owners have understood the definition and content of cooperative management in different ways, which also differ from the definition intended here. This type of research around landscape-based approach to management can be fraught to misinterpretation, as habitats and ecosystems are ill-defined (Jacobson 2002; Belin et al. 2005), and their cooperative management implications likely vague to owners and professionals (Belin et al. 2005, article II), even in areas where such approaches have received more research. In Finland, where the implications of cooperative management are unclear and related discussion has been modest to date, the risk of bias is increased. More research is needed to ensure that the willingness and readiness indicated towards cooperative measures truly match the actions intended here.

Yet, the openness to cooperative activities and landscape-level management, and simultaneous careful consideration of participation, is a known phenomenon (see Brunson 1998). The opportunities and ease of management associated with cooperation and the objective of the management likely intrigue the potential participants (Fischer and Bliss 2009), while the commitments needed for cooperation to function may be considered to limit individual action (Brunson 1998). Studies in USA have shown that ecosystem management has been viewed positively by landowners (Brunson et al. 1996; Belin et al. 2005) as was noted in this research, or there is potential for increasing the interest of the owners in it (Creighton et al. 2002; Jacobson 2002). Practical experiments in ecosystem and landscape management on private lands have also been carried out there (e.g. watershed management, see Rickenbach and Reed 2002), mainly encouraged by the positive response from the pilot programs. This progress from positive landowner attitudes to successful field experiments and pilot studies in ecosystem management could also reflect the prospects for experimentation under Finnish conditions. However, this should be taken as very tentative discovery due to the observed uncertainty and hindrances to cooperation in a Finnish forestry context.

5.2 Conditions based on service and policy adaptation

It has been suggested that extensive research and planning are needed before on-the-ground projects of cooperative management are established (Fischer and Bliss 2009). The results here seem to suggest that forest owners' openness to cooperative management could be hampered by the traditions and age structure of the owners, and the considered threats to private decision-making and property rights that result from engaging in cooperative measures. Simultaneously, forest owners hold numerous management objectives, which can complicate forest management on at the landscape level (Campbell and Kittredge 1996). In Finland, there are no systematic policy tools or instruments to formulate cooperative management activities, which would successfully acknowledge all these aspects. Management and activity targeting have been suggested as answers to the difficulties in management caused by overlapping goals and as an important means to promote ecosystem level management or biodiversity conservation (e.g. Paloniemi et al. 2018).

Aside from the nebulous compensation claims, the policy implications of this research are similar to many other ecosystem management-focused studies, with regards to indications that the owners may regard cooperative management as most beneficial when based on voluntariness and involving equal participation (Rickenbach et al. 2004), local and legitimate

leadership (Gass et al. 2009; see also Raik et al. 2006), and strengthened by organisational support in different forms (Campbell and Kittredge 1996; Kittredge 2005). In this context, the voluntariness of game-oriented methods (article I) also suggests that the cooperative approach to their implementation should also be voluntary. In Finnish forest conservation schemes for individual properties, the voluntary approach has received approval and been considered successful by forest owners, as it profoundly acknowledges the forest owners' objectives, perceptions, and property rights in comparison to authoritative conservation schemes (Horne et al. 2009, Korhonen et al. 2013). Research suggests that encouraging forest owners to cooperate rather than creating compulsory participation methods would most likely yield greater participation (Brunson et al. 1996; Campbell and Kittredge 1996), i.e., trial or adoption of the concept.

Taken together, the results infer that a cooperative approach to game-oriented management necessitates some type of organisational support or initiation. The trust placed in forestry professionals (article III), their apparent role as change agents (article I), and the previous experience of organisation-led cooperation among forest owners (articles II and III), all speak in favour of external service-based administration and monitoring of cooperative management. Cooperatives have rarely developed entirely without government inspiration (Kittredge 2005; see also Sample 1994), and often participants positively regard shared expert knowledge and the support provided by agency interventions in dynamically complex ecosystem management practices (Bernacchi et al. 2015). In this way, the trust of Finnish forest owners placed in professionals or institutions may not be exceptional, although contradictory results have been obtained from examples elsewhere (e.g. Rickenbach et al. 2004; Fischer and Bliss 2009; Meadows et al. 2013). In some instances, cooperative management has been inhibited by a lack of backup by organisations or institutions. For example, the lack of support by estate conservation developers in Australia was considered as a primary institutional barrier for a type of cooperative management of conservation zones (Meadows et al. 2013).

In these type of cases (Finland and Australia), the government or organisations may have a role in supervising and securing the use of forests and creating circumstances that inspire the forest owners to take actions towards more sustainable management (Borrini-Feyerabend et al. 2007). The provision of forest owners with incentives for participation in cooperation, for example (Kittredge 2005), is a measure that has been used to encourage rather than force to action. The uncertainty that is sometimes associated with game-oriented forest management methods, and especially with cooperative management, show that information must be provided in different ways and through different channels in order to shift these approaches into practice. Information could be seen as an efficient starting point before the introduction of other measures. In Finnish research, monetary incentives or compensation have been contemplated and have been proposed to change forest management behaviour towards climate-smart activities (Husa and Kosenius 2012; Laakkonen et al. 2018) or to increase the carbon store in forests (Kärenlampi 2001). An extensive study of the uptake of continuous cover forestry across Europe, for example, pointed out that a greater uptake of the approach necessitates that it is financially attractive to forest owners (Mason et al. 2022).

Yet, the observed lack of compensation claims for participation in cooperative measures seems to show that there is no apparent need to compensate for participation under Finnish circumstances. However, different incentives could be used to alleviate the uncertainty related to the economics of cooperative management and to attract the attention of a wider forest owner audience in the long-term. Thus, monetary incentives may be worth discussing in more depth here. To date, land and forest owners have preferred different rent and payment

programs or ecosystems markets for the conservation or management of ecosystems (Fischer and Bliss 2009). The two most important Finnish financing systems for practical forestry and conservation are (1) the subsidies for sustainable forest management (in Finnish previously known as Kemera, will be changed to Metka), and (2) the voluntary conservation scheme that finances conservation or nature management projects with compensations equivalent to the value of timber at the sites (METSO programme). Both systems are based on management of individual properties. In Finland, there are no compensation systems for cooperative management, as have been discussed and evaluated, for example, in USA (Parkhurst et al. 2002; Goldman et al. 2007). This (agglomeration) bonus-system that is based on providing extra compensation for the cooperative creation of larger management units could have relevance in encouraging forest owners to manage wider habitats (Kline et al. 2000). In co-management terminology, these measures would refer to system adaptation and institution building; creation or evolvement of favourable policy environments for co-management (Berkes 2009).

As cooperation can be seen to require external support, the professionals and organisations have a crucial role in spreading the novel forest management concepts to forest owners. As the forest sector is still adapting to game-oriented methods, and associated services have merged into other forestry services (article I), the cooperative approach to implementing game-oriented management might be a distant goal. Granted that the results seem to suggest that the sector and services have become more adapted to providing owners with a cooperative approach to forestry operations rather than providing owners with just game-oriented methods. Successful previous cooperative projects (article III) and a lack of interaction between owners and professionals with regard to game-oriented methods (article I) indicate that cooperative projects have been successfully promoted in comparison to the implementation of game-oriented forest management practices. This might relate to the business aspects of the two different concepts – game-oriented forest management might not provide extra income to the professionals or organisations, and changing the behaviour of forest owners may require more effort than would produce benefits for the professionals.

While cooperative forest improvement projects have also been supported with subsidies for sustainable forest management (under the Act on the Financing of Sustainable Forestry 34/2015, Kemera/Metka system), they are more likely profitable to the organisations that promote them. In this way, the promotion of these services may be regarded as more meaningful by the professionals. In the past, forest improvement projects have been arranged by public forest administration, forest owner organisations (commonly known as forest management associations in Finland), and different service providers (e.g. Markkola et al. 2008), which is also likely to remain the case now. Still, in many cases, forest management decisions are made in processes related to planning forestry practices or harvests with timber buyers. The latter could also benefit from wider client relationships and the larger management units provided by cross-boundary contracts (Meadows et al. 2013). Often the stumpage prizes (or price of standing timber) are linked to the size of the sales units (Buongiorno and Young 1984; Sydor and Mendell 2008; see also Haara et al. 2021), and in this way, cooperatively managed forests could also benefit forest owners economically.

The underuse of the competency and knowledge of forest professionals with regard to game-oriented practices (article I) may also signal that the different performance targets of the organisations have restricted the possibility to encourage forest owners to engage with game-oriented forest practices. In previous practice elsewhere, professionals have emphasised the importance of using technical and scientific knowledge as strategies to promote ecosystem management (Fischer and Bliss 2009, see also the discussion in

Puettmann et al. 2015). Here, the professionals seem to have specific knowledge of the methods (article I), which suggests that the systems-related reasons for the forest owners' modest use of game-oriented methods are to be found elsewhere. This is contrary to the results of Mason et al. (2022), who pointed out that the absence of relevant skills by foresters could be a major obstacle to change in the forest sector. However, both this research and the above-mentioned studies seem to come to similar conclusions, namely that without support for efforts to try novel approaches, the limited silvicultural innovations may not reach their full potential (Mason et al. 2022; see also Lawrence 2017).

5.3 Conditions based on communication and knowledge transfer

The results presented in this thesis identify various knowledge-related challenges around game-oriented forest management methods, which include lekking site management, in particular. These could potentially hamper the future adoption of these methods and their cooperative employment by forest owners. In the wider research arena related to the adoption of forestry practices and approaches, informational and educational issues have also been identified as major bottlenecks for uptake (Puettmann et al. 2015; Mason et al. 2022). For example, Puettmann et al. (2015) stated that scientific knowledge and information of alternative silvicultural approaches is critically lacking, especially when compared to more conventional forestry approaches. In addition to such issues of content or availability of information, knowledge needs may also relate to this absence of knowledge transfer as the knowledge may be possessed by different stakeholders. Under-utilisation of knowledge, insufficient resources, inexperience with data analysis, and incompatible IT systems for knowledge storage also hamper the flow of forest-related information (Pynnönen et al. 2019). In this way, the actors in the social systems may not become aware of the existing information, in which case potential adoption of new information may be left unrealised. In terms of DoI, the information flow within networks can be impeded by different physical, social or cultural barriers (Rogers 1995, Foxon and Pearson 2008; Khanal et al. 2019), such as the culture-bound forestry traditions described earlier.

The results presented here seem to infer high awareness and acceptance of game-oriented methods, which are not likely to restrict the wider adoption of the management practice in general. However, the uncertainties related to the adoption of a cooperative approach to management of lekking sites seem to be related to the knowledge needs of game-oriented practices itemised, especially, for lekking sites or cooperative management. This is likely the case, especially with the latter, as it is rarely employed in Finland and no ready pattern for it currently exists. As available information, guidelines and handbooks itemised for lekking site management are already available (e.g. Kaukonen et al. 2018), it may be that the knowledge needs of lekking site management are instead related to awareness or knowledge transfer issues. Indeed, one impression conveyed from the results is that forest owners would manage the lekking sites or find related information if they were aware of the lekking sites. This lends support to DoI, which suggests that the information that precedes adoption can be actively searched for only after the individual has become aware of the existence of the idea and the potential information sources (Rogers 1995).

The pathways for forest owners to become aware of lekking sites are likely scant if the lekking sites are not commonly known by the local forest owners, nature hobbyists or forest professionals, for example. At the same time, the results presented here picture an interesting and perhaps conflicting overall view of the forest owners' positions to wider interaction with

other forest owners. The creation of an interactive cooperative management scheme that forest owners would consider realisable (worth adopting and engaging with) is a complicated task, especially in circumstances where the owners regard peer support and cooperation as welcome, but are devoted to the maintenance of their privacy and independency in decision-making and practices. The possibilities to design measures to increase awareness of lekking sites between neighbouring forest owners may become narrow; how to provide forest owners with information of lekking sites without undermining the very privacy that forest owners wish for their properties and management? Previous practice from Finland and elsewhere, has also indicated that landowners and forest owners may not be willing to share detailed information of their properties with neighbours (Fischer and Bliss 2009; Hujala et al. 2010; Fischer and Charnley 2012).

As cooperative forestry practices seem to represent almost opposing-like values (joint action) to the learned habit or tradition-based management (independent action), a shift over time from inherent independent management to innovative cooperative management might necessitate intensive outreach. The importance of providing convincing peer learning and real-world examples to enhance awareness has been most accentuated among the later adopter groups (article I, see also Khanal et al. 2019). Yet, the utility of such an 'intensive outreach' in communication strategies in the early phase of introducing the cooperative approach is worthy of further discussion here. It seems clear that more knowledge would be needed of the practices that are suitable for lekking sites and the potential benefits that these practices could provide to both capercaillie and multi-objective forestry. Especially in this case, where the innovation is based on cooperative activity and involves a group of participants, the importance of shared learning experiences may be seen to be even more important (see also Schusler et al. 2003).

Yet, the few truly communicative cooperative activities to date may also suggest that there are currently few opportunities for forest owners to share their knowledge and information (of game-oriented methods) with each other (articles I, II and III). Although the peer communication channels were not defined and assessed for their effectiveness in this research, Hamunen et al. (2015b, see also Hamunen 2013) found that forestry-related communication with forest owners occurs solely within families and the immediate circle (article III). The importance of family members in forest management decision-making also seems to be highlighted in this research, in addition to the studies of Bieling (2004) and Korhonen et al. (2013). Simultaneously, the results show that neighbours rarely influence the forestry related decision-making process (article III).

Even though forest owners seem to seldom discuss forest management and cooperation with other forest owners, it is likely that they are aware of the management practices that occur on neighbouring properties (article II). However, this research seems to show no clear evidence that forest owners would plan their management by acknowledging the management decisions of others (article III). Such cross-parcel (or -boundary) externalities, that show the owners to acknowledge how their management decisions influence the neighbouring lands have been modelled and shown to exist (Vokoun et al. 2010). Thus, although the willingness to cooperate (articles II and III) and an understanding of local forest management and the objectives of other forest owners seem to provide a solid basis for cooperative forest management, critical communication between owners may be missing.

In addition, increased future awareness of lekking sites or a cooperative approach to management with the assistance of professionals and services does seem contradictory. On one hand, information of cooperative management alternatives has been shown here to have been successfully communicated to forest owners by professionals and forest improvement

companies as a part of their business, while on the other hand, the game-oriented forest management information transfer from professionals to owners has been somewhat weak, even if the interest in game-oriented forest management infers here that there may be demand for such advisory services. Pynnönen (2020), also, noted that forest management advisory and planning services have not sufficiently adapted to the changing forest management objectives of forest owners.

It may also be that forest owners lack information and knowledge of ecosystem-based management (Jacobson 2002) or ways to preserve biodiversity in forestry practices, and forest owners have not sought services that would provide related consultancy. Although the mere transfer of information from advisory services (also web-based) to owners is probably insufficient (it should be supported with examples and demonstrations), the role of professionals and services in communicating forestry innovations to forest owners is clear (for contemplation of the role of professionals, see also Korhonen et al. 2013; Mason et al. 2022). Finnish forest owners have relied on the advice provided by trusted consultants (article III, Hujala and Tikkanen 2008) and have utilised web-based opportunities to reach out to and communicate with forest professionals (e.g. Pynnönen 2020). Moreover, the interaction with professionals is highlighted here as, in most cases of timber management, the timber is harvested by service providers and industries rather than by the forest owners themselves.

At the same time, the curiosity of the forest owners with regard to horizontal knowledge transfer, avoidance of regulatory control in diversifying forest management, and efforts towards multi-objective forestry and game-oriented management seem to capture the simultaneous, wider and ongoing change of ownership and policies in Europe, where forestry advice and knowledge are transferred in more complex ways than just from professionals or extension officers to the owners (Lawrence et al. 2020). According to Lawrence et al. (2020), this shift refers to increasing participation of owners as information sources, and preference to using information and persuasion over a compulsory system (Horne 2006; Horne et al. 2009), in addition to increased emphasis on ecosystem services over timber (Karppinen et al. 2020, articles II and III), diversification of advice providers in the private sector, and the development of new (virtual) communication instruments (Lawrence et al. 2020). A wide body of literature has emphasised the need to diffuse forestry knowledge through more versatile interactive networks (Nybakk et al. 2009; Ma et al. 2012; Korhonen et al. 2013; Khanal et al. 2019), which this research lends its support to. However, the change of policies in Finland may be still ongoing, and few examples of interactive networks in the private forestry sector have been demonstrated to date, aside from the continuously developing web-based forest services (e.g. Metsään.fi, Finnish Forest Centre 2022c).

Indeed, increasing awareness and knowledge exchange methods are also policy mechanisms to change and develop forestry practices. The results of this research seem to suggest that a soft knowledge exchange model involving the voluntary peer forest owners and professionals could create ideal circumstances for cooperation and social learning in the case of management of a lekking site, which in any case might necessitate the actions of a group of neighbouring forest owners. In a practical sense, these considerations would refer to the need to trial and learn with the assistance of someone who brings together the forest owners and coordinates the cooperation effort before the commencement of on-ground projects. Pre-existing networks, local leadership and external resources are identified social conditions that foster future cooperation (Fischer et al. 2019, see also Raik et al. 2006). Brook et al. (2006) have also suggested that channelling information through social networks and increased collaboration, providing the means to ease the owners' economic concerns and offering institutional assurance for actions, would promote conservation of rare species. The

presence of a coordinator and systematic support for practical measures could also build up trust between participating forest owners and in the cooperative management process itself.

5.4 Reliability and limitations of the research approach

This research applied an approach that combined both quantitative and qualitative data and analytical methods. The limitations and methodological choices in articles I–III were described in the Methods section here. However, the combination of these methods and data necessitates a separate and thorough contemplation of the limitations and reliability of the overall research approach.

A variety of data collection techniques, data types, and design approaches can be applied together to contribute to methodological rigor of the research (Patton 2002). Quantitative data focuses on numerical information and strictly objective statistical approaches, whereas qualitative research is composed of non-numerical information and interpretation that are inseparably associated with human subjectivity and senses (Leung 2015, see Pynnönen 2020). When large-scale surveys provide quantitative information of patterns of responses, qualitative results can provide meanings for these patterns (Patton 2002) or help understand and interpret more profoundly the observed phenomena (see Rust et al. 2017). This was the premise underpinning the approach here. The way the obtained information was applied in this research, and the way that the formation of each study contributed to the overall quality of the research, are explained in the following sections. *Validity*, *reliability*, and *generalisability* are commonly used research criteria, applicable for the assessment of rigor in both qualitative and quantitative research (Leung 2015; for an example see Pynnönen 2020) and are considered here also for the overall quality of this research.

In qualitative studies, validity may refer to the application of suitable instruments, processes and materials (Leung 2015). Similarly in quantitative research, validity may be seen to be dependent on careful instrument construction within prescribed procedures (Patton 2002). The characteristics and skills (objectivity) of the researcher may influence the research validity (Patton 2002), and measurement validity deals with correct operationalisation of the concepts to ensure that the measurements truly capture what the researcher seeks to measure (Adcock and Collier 2002). Careful research designs, pre-testing of the survey forms and interview framework, and careful selection of terminology improved the validity and comparability of the studies presented in this thesis summary. In addition, the studies were carried out in collaboration with other researchers, which enabled the discussion and contemplation of the results from a wide range of perspectives, and decreased the risk of subjectivity in the interpretation of the results.

Nevertheless, it may be practically impossible to formulate a value-free inquiry. As described in section 5.1, the interviewees may also have had differences in their understanding of the introduced concepts, which may have influenced the validity of the results. The hypothetical bias (also mentioned in section 5.1) associated with the responses in each study may have also influenced the overall results and made them seem more positive than they truly were. Therefore, a substantial effort was expended in this thesis summary to also consider and evaluate the potential sources of bias in this research.

Reliability in qualitative research refers to consistency of the methods and processes (Leung 2015) and the “degree to which the finding is independent of accidental circumstances of the research” (Kirk and Miller 1986). In quantitative research, reliability stands for replicability of the research and results (Leung 2015). The qualitative study in

article III was exploratory and was based on a relatively small dataset. Both that article and this summary would have benefitted from a much large sample size and more repetitions in multiple study locations. However, the qualitative study did provide information for this research that was impossible to obtain with quantitative methods (see also Barclay et al. 2017), and the study setting can quite easily be repeated in the future. It should be noted, however, that different study locations could influence the results to some extent regardless of the otherwise similar study context. The survey studies in articles I–II produced representative results from studies that were highly replicable.

According to Patton (2002), purposeful sampling (here applied in article III) is not widely understood, for which the results obtained with such samples are often treated with disbelief and ignorance. Purposeful sampling can also be seen as criterion sampling (Suri 2011), in which the sample is based on cases with predetermined criteria. Although this approach enables the construction of a thorough understanding of the research topic, strict criteria often reduce the number of cases to be included in the sample (Suri 2011). So, while the method employed here is valid, this research acknowledges that a qualitative sample has its limits. Thus, as the themes of articles II and III naturally complemented each other, the results of both studies were also compared to ensure the validity of each result. In practice, this means that the studies that measured similar phenomena were seen to support each other, especially as the studies produced consistently very similar results (e.g. the willingness/readiness of the owners to cooperate, compensation claims, importance of capercaillie, etc.). The congruency of the results in articles II and III also supported and facilitated the overall interpretation of the research.

Nonetheless, it should be kept in mind that the sample groups in articles II and III differed so that it was not known if the forest owners in article II had lekking sites located on their properties. The overall positive atmosphere and strong willingness to engage in lekking site management (and cooperation) could indicate that forest owners regard lekking sites and their management as important, even if they did not have such habitats on their properties. On the other hand, if the survey respondents considered the lekking sites or their management to be abstract in nature, the risk of hypothetical bias in the results of article II must be acknowledged. Abstract survey or interview topics can increase the hypothetical bias associated with the data (Ajzen 2020; see section 5.1), which reduces the generalisability of the results.

Indeed, in quantitative research, generalisability is a measure of the applicability of the results to a wider population (Payne and Williams 2015). In qualitative research, generalisability, as such, is often not a goal (Hays and McKibben 2021), and thus it may refer to the ability to make pragmatic generalisations derived from experiences that can be transferred to varying settings (Payne and Williams 2005; see Pynnönen 2020). The decision not to translate the surveys, as well as the exclusion of Åland forest owners from the survey group, restricts the generalisability of the findings of studies I–II to the forest owners of mainland Finland. Moreover, the unexpectedly small response rate in study II draws attention to the sampling protocol and the survey form and raises the question whether something (sample size, design of questions) could have been done differently. Yet, the overall generalisability of this research was also upheld by having the opportunity to use both qualitative and quantitative data. While the survey studies I–II provided highly-generalisable and reliable evidence of the different phenomena around game-oriented forest management and cooperation, the interview study for article III increased the plausibility of these findings. Hays and McKibben (2021), for example, have highlighted the importance of simultaneous data collection/analysis, and the comparison of studies to rigorous qualitative research and

overall generalisability. The same findings that recur in both articles II and III also provide a strong basis for the evaluation of the results and discussion of this research. This combination of results, theories and literature can also be seen as triangulation, which improves the validity (Patton 2002), trustworthiness and generalisability of the research (Hays and McKibben 2021).

6 CONCLUSIONS

This research explored the conditions that exist prior to a potential shift in cooperative management in a Finnish forestry context. In the light of the results presented here, forest management cooperation with neighbouring forest owners may be one potential pathway to obtain landscape level benefits for capercaillie lekking sites in Finland. However, this potential is the sum of a range of forces and conditions that influence the various actors to different extents (Figure 8). The currently narrow opportunities for communication with other forest owners appear to limit the spread of knowledge about game-oriented forest management and hinders potential future interactive cooperative actions. While an absence of communication in forestry issues could influence the implementation of basic cooperative actions, such as forest planning and coordination of activities, it could also hamper the formulation of group identity among forest owners and opportunities for the enhancement of social capital among private forest owner systems. However, it is likely that cooperation would be fostered due to often friendly and open atmosphere that currently exists between neighbours, their similar perceptions as to the importance of managing lekking sites and game habitats, and especially by their openness to engage in cooperation, peer action and potential horizontal knowledge exchange.

It would certainly seem that both lekking sites and forest owners would benefit more if management was approached with cross-boundary measures. For forest owners, it might be easier to approach landscape-level problems cooperatively, which could also improve the likelihood of success both ecologically and economically. Yet, the atmosphere for true cooperative forest management activities is not quite optimal. In the next decades, when the forest owner base in Finland will undergo considerable structural change and the forest sector will likely experience a wider change in policies (e.g. increasing emphasis on horizontal knowledge exchange and ecosystem services), a shift in cooperative management principles to practice may be more convenient. A cooperative approach to management should be based on voluntariness, as with game-oriented forest management, and the right of forest owners to make their own decisions should be emphasised to reach the best solution in practice.

Supportive measures are needed at the institutional or organisational level to shift the cooperative approach into practice, as has been identified in research elsewhere. Monetary compensation systems could increase the interest of the forest owners to manage habitats or participate in ecosystem management. Yet, information, organisational support and leadership (as in previous cooperative projects) may be more important measures in this context. The increasing interest in game-oriented forest management methods among forest owners and the adaptation of institutions to this interest could result in an increase in the future supply of related services. The more efficient promotion of cooperative management services through currently available and trusted forest owner organisations, local offices of public forest administration (FFC) and service providers, would make cooperative management more easily available to forest owners and could provide the hoped-for external

administration for the cooperative actions. Simultaneously, these voluntary cooperative activities should be targeted at the most receptive owners with multiple forestry objectives and interest in cooperation. The promotion of communication among forest owners, the identification of local leadership, the production of management examples that forest owners can relate to, and the piloting of a cooperative approach to management are suggestions based on the theoretical assumptions that arise from horizontal knowledge exchange literature (e.g. DoI), but which would especially facilitate landscape-level management in practice in this cooperation-oriented case.

This research is by no means fully comprehensive so as to make holistic conclusions of the future potential for cooperative forest management activities, but is instead a profile of the conditions based on research results obtained between 2017 and 2020. Research that focuses on different forest owner typologies and their attitudes towards cooperation or game-oriented practices are clearly needed to increase knowledge of how best to target cooperative approaches to forest management in different areas. The motives of the forest owners, which include compensation claims for habitat management or cooperation, require further research. A recommended pilot study to explore the practical functioning of cooperation actions and the measures needed for wider participation is a necessity and would serve as a starting point for subsequent research. Critical information would include the location(s) and quality of lekking sites on private lands, and the means for increasing the awareness of forest owners without compromising the privacy and decision-making right of owners. In addition, in order to develop services related to game-oriented and cooperative management principles, it would be beneficial to research the form of the services, as well as the communication channels between forest owners and professionals (face-to-face, web-based).

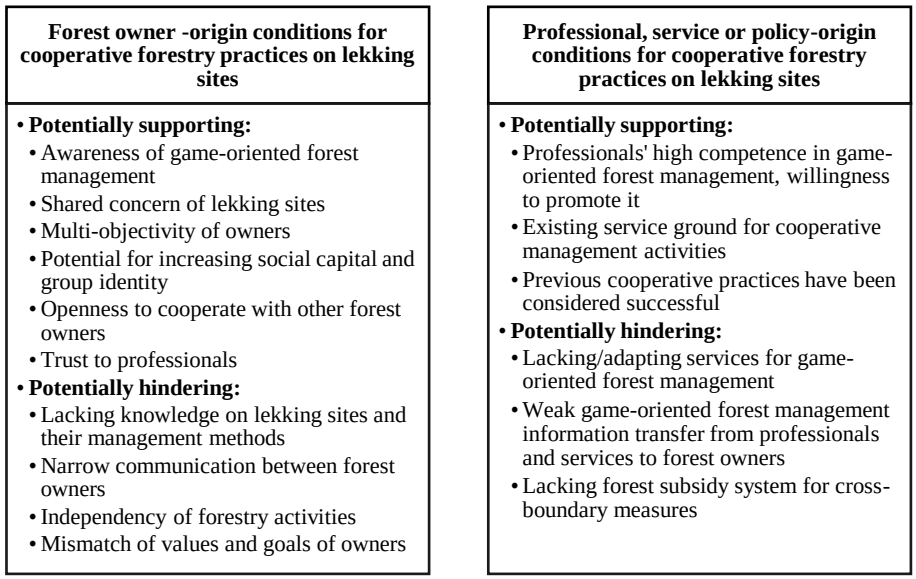

Figure 8. A schematic representation of the various forces that influence how a cooperative approach to game-oriented forest management could be put into practice, in a Finnish forestry context, pictured as owner-origin and service-origin conditions that also include the communication aspect related to the diffusion of novel management principles.

This thesis (and related articles) contributes to the research of forest owner decision-making mechanisms and advances our understanding of the potential for forest owner cooperative activities. This Finnish example may serve as an important reference for studies in countries with similar private forest ownership structure. Such a landscape-level approach could also inform how to solve other biodiversity-related challenges that will evidently have a larger emphasis in the future. For example, decreasing carbon sinks could be one challenge that could be approached with landscape-level measures.

This research brings value to understanding and advancing the development of forest management and provides a new approach to traditional forest management practices and to the field of forestry. This research also contributes to multidisciplinary research by employing a range of theoretical and conceptual premises and literature borrowed from the field of social sciences to describe the phenomena around forest owners' decision-making; a research theme arising from the field of forestry and natural sciences.

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