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Research

Positive social relationships in hunting groups are related to compliance with the higher-level moose management

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ABSTRACT. Managing shared natural resources, such as moose (*Alces alces*) in Finland, is often challenging due to the involvement of multiple stakeholders with opposing views and the need for coordination across several spatial levels. A sustainable moose population is maintained through a carefully planned, multi-level system of adaptive management. However, ensuring that these plans are followed requires substantial support from the lowest level—the hunters. We investigated the decision-making and joint action of moose hunting groups, and how these are related to compliance with hunting recommendations. We conducted a country-wide questionnaire study with a sample of 4729 hunters in Finland. We applied the multidisciplinary social-ecological systems framework—rooted in systems thinking—alongside insights from evolutionary theory on cooperation. Our results showed that hunters who positively assessed social interactions and decision-making within their hunting group were more likely to be satisfied with and compliant toward natural resource management. To achieve long-term sustainability, we suggest that harvest regulations and recommendations should be accompanied by attention to the decision-making and group dynamics of those carrying out the harvest. We found that processes such as trust and frequent meetings that promoted social capital and communication within hunting groups, between groups, and between hunters and the national management level were crucial for sustainable local moose management. A balance between member commitment to the group and the regular acceptance of new members had a positive influence. Our results highlight that deeper understanding of local social dynamics can facilitate regional and national management of shared resources.

Key Words: *cooperation; environmental governance; multi-level governance; natural resource management; social-ecological systems; wildlife management*

INTRODUCTION

The management of common-pool natural resources is challenging due to the involvement of multiple stakeholders and the risk of overexploitation when users prioritize short-term gains over long-term sustainability (Hardin 1968, Acheson 2006). Therefore, many such resources are managed collaboratively by governments, resource users, and stakeholders (Acheson 2006). Moose (*Alces alces*) and other wildlife are common-pool resources because they are mobile and owned by nobody while alive (Fiorini et al. 2011). Wildlife management operates in a complex environment, solving conflicts between conservation goals and diverse societal needs (Apollonio et al. 2017). A deeper understanding of these systems can help avoid overexploitation and conflicts (Cox 2011, Dressel et al. 2018).

Lack of cooperation among resource users can undermine long-term management and ecological sustainability (Acheson 2006, Ostrom 2009a, Levin 2014). Robust management must address not only ecological concerns, but also social dimensions (Ostrom 2009b, Bodin 2017, Cumming et al. 2020). The social-ecological systems (SES) framework (Ostrom 2007, 2009a) emphasizes a system-thinking approach, which identifies key components that contribute to sustainability, including governance, specific properties of the resources, resource users (actors), and their interactions (Partelow 2018). While the SES framework has been widely applied in commons research, its use in wildlife management remains limited (Dressel et al. 2018, 2020a, Smith et al. 2019). In this study, we applied it to moose management in Finland and integrated it with evolutionary theory to explore cooperation among hunters (Rankin et al. 2007, Levin 2014). According to evolutionary theory, cooperation can evolve through several mechanisms, the most prominent being kinship and reciprocity (West et al. 2007). We assess whether such mechanisms, in combination with SES framework-based variables, are linked to sustainable moose management at the local level.

In Finland, ecological sustainability in moose hunting is defined as maintaining a viable population over time. Moose play a key ecological role in boreal forests (Apollonio et al. 2017), and are the most important wildlife species economically (Matala et al. 2021), but they also cause traffic accidents and damage to forestry and agriculture. As such, they are managed to meet often conflicting objectives (Fix and Harrington 2012). Finland's moose population has fluctuated historically, including periods of overexploitation (Nygrén 1987, Löyttyniemi and Lääperi 1988, Heikkilä and Aarnio 2001). Currently, the population is strictly regulated through hunting licenses, guided by adaptive, region-specific plans. Each region sets 3-year goals for population density, sex ratio, and age structure, which are informed by data from the Natural Resources Institute Finland (in Finnish "Luonnonvarakeskus/Luke"). The annual management plans, based on the goals, contain recommendations on suitable numbers of bulls, cows, and calves to harvest, and often also on which bulls to harvest (based on their antlers as indicators of age). Management plans are made through participatory planning involving representatives from hunting, traffic, forestry, and agriculture sectors (Tuominen et al. 2023).

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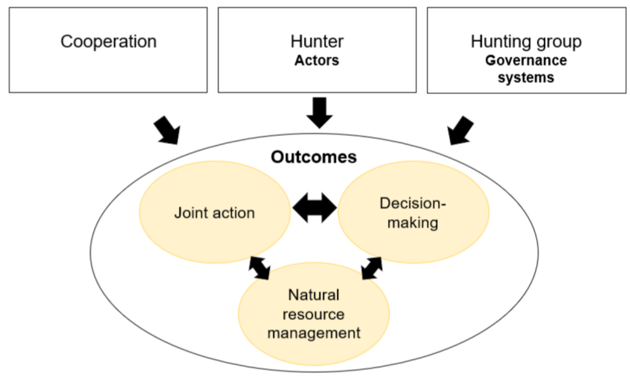
Previous studies have focused primarily on high-level decision-making in moose management (Dressel et al. 2018, 2020a). However, more attention is needed on how local-level dynamics among hunters contribute to sustainable outcomes (Gigliotti 2000, Di Minin et al. 2021). In Finland, moose hunting is a collective activity, requiring access to at least 1000 ha of land, typically through collaboration among multiple landowners (Heikkilä and Aarnio 2001). Hunting groups are either formally registered societies (82%) or informal, unregistered groups (17%) (Tuominen et al. 2023). Registered societies must hold biannual formal meetings where all members vote on leadership, membership, and other decisions. Hunters play a critical role in implementing regional management plans because they apply for and use hunting licenses based on annually communicated recommendations. Importantly, while licenses are enforced, recommendations (e.g., on which animals to harvest) are not. Thus, hunting groups may choose whether or not to follow them. There are signs of growing disagreement between hunters and Luke regarding population sizes and targets, which is raising the risk of non-compliance and conflicts between management levels. Effective wildlife management must consider hunters' support for management goals (Fix and Harrington 2012, Brinkman 2018). Additionally, not all hunters are equally satisfied with their groups or hunting experiences (Woods et al. 1996). Since hunting efforts are largely voluntary, hunter satisfaction is central to social sustainability. Hunter satisfaction depends on more than just harvest success; it is shaped by social interactions, communication, and shared experiences (Woods et al. 1996, Gigliotti 2000, Tuominen et al. 2023). Hunting also fulfills recreational, social, and skill-development needs (Hautaluoma and Brown 1978, Hammitt et al. 1990).

Given the multifaceted nature of partaking in hunting, we explore whether social aspects of hunting group dynamics are linked to satisfaction with and support for management recommendations. Specifically, we examine three latent outcomes within a structural equation model (SEM): group decision-making, joint action, and natural resource management (Fig. 1). These are assessed via a national electronic questionnaire. We define "decision-making" as non-tangible processes such as planning the hunt, inclusiveness, transparency, and satisfaction with the decision-making. "Joint action" reflects how the group functions in practice, including conflict levels, adherence to rules, and satisfaction with the participatory aspects. "Natural resource management" captures hunters' perceptions of sustainability and compliance with hunting recommendations within their group.

While the SES framework highlights the importance of local institutions (Ostrom 2007, 2009a), the interrelations between social and ecological outcomes remain unclear (Agrawal and Benson 2011). Our first research question asks to what extent decision-making and joint action are related to perceived (moose) management outcomes (Fig. 1). Although social performance is often linked to ecological performance measures in SES theory (Ostrom 2009b, Partelow 2018), compliance with recommendations may not always align with satisfaction or group cohesion. For example, a group may be internally cohesive but choose not to follow recommendations based on their own assessment of the local moose population and its sustainability, thereby increasing the risk of conflicts between management levels (Fix and Harrington 2012, Brinkman 2018). Since recommendations are

Fig. 1. A model for moose hunting, adapted from the social-ecological systems framework (Ostrom 2009a). We expect that the social outcomes (joint action and decision-making) within a hunting group's management are strongly correlated with each other and correlated, though less strongly, with the ecological outcome (natural resource management). Variations in cooperation within the group, individual hunters, and hunting group governance are expected to promote differences in the outcomes.



not enforced, such choices may reflect deeper disagreements and de-couple social dynamics from compliance with hunting recommendations. We therefore tested these associations explicitly (double-sided arrows in Fig. 1).

In the second part of our study, we examine three hypothesized drivers of these outcomes: individual hunters, group-level governance, and within-group cooperation (square boxes in Fig. 1). These composite factors are modeled in the SEM, drawing from the SES framework, hunting literature, and evolutionary theory.

First, we consider individual hunter attributes (actors), such as roles in the group, hunting experience, attitudes, values, and demographics, which may influence satisfaction, collective action, group dynamics, and compliance (Decker et al. 1980, Agrawal 2001, Béné et al. 2009, Gamborg and Jensen 2016, Schroeder et al. 2017, Brinkman 2018, Partelow 2018).

Second, we assess characteristics of the hunting group (governance), such as formal organization and group size, which may affect decision-making and joint action (Wagner et al. 2007, Béné et al. 2009, Ratner et al. 2013). Because moose traverse multiple hunting areas, inter-group collaboration is also important for shared knowledge, shared strategies, trust between groups, and reduced competition (Woods et al. 1996, Bodin et al. 2017, Hasbrouck et al. 2020). In addition, enforcement of social norms can lead to higher support for the recommendations (Woods et al. 1996, Rankin et al. 2007).

Third, we include cooperation-related aspects informed by game theory and evolutionary biology (Axelrod and Hamilton 1981, Rankin et al. 2007, West et al. 2007). We hypothesize that group stability, meeting frequency, and relatedness (Nowak 2006) foster cooperation and positively influence all three outcomes. Although the SES framework incorporates reciprocity, trust, and communication under subsystems actors, governance systems, or interactions (Dietz et al. 2003), we treat cooperation as a distinct subsystem situated between individual and group levels.

METHODS

Data collection

Data collection for this study was based on the SES framework (Ostrom 2007, 2009a) and evolutionary theory (Axelrod and Hamilton 1981, Nowak 2006, Rankin et al. 2007). We designed and administered a questionnaire to measure hunters' perceptions of group interaction and compliance with management recommendations, and to capture variables potentially associated with variation in these perceptions (Fig. A1.1). The SES framework provides an analytical list of relevant variables for specific systems, rather than prescribing the use of all variables. Therefore, we considered only those SES variables that were potentially relevant to moose management at the local hunter and hunting group level (Table A1.1). The questionnaire data were collected over 1 month (15 July–15 August 2021), prior to the hunting season. An electronic questionnaire (created using Webropol 2.0 online surveys) was distributed through The Finnish Wildlife Agency's online registry "*Oma riista*" to all moose and white-tailed deer (*Odocoileus virginianus*) hunters registered in Finland. In addition, various channels were used to advertise the survey, improve response rates, and address coverage errors. They included *Metsästäjä/Jägaren/Hunter* magazine, The Finnish Wildlife Agency and Finnish Hunters' Association websites, a member bulletin, and an e-mail sent to all 282 regional operations managers. Accordingly, we assumed that all active moose hunters in Finland were given the opportunity to respond to the survey.

In total, 4745 hunters answered the questionnaire, of which 4736 were included in the analyses. This represented approximately 3.9% of Finland's 123 000 cervid hunters, who were eligible to hunt deer or moose, having passed the required shooting test within the previous 3 years. Respondents represented 2768 different hunting groups, out of an estimated total of 5000 (55%). On average, each hunting group was represented by two respondents; however, in our analyses, responses were treated individually. While responses from the same hunting group cannot be considered entirely independent, the focus of this study was on individual hunters and their perceptions, rather than on group-level variance. Given the 3.9% individual response rate and 55% group-level coverage, we assessed potential non-response bias by examining the representativeness of the sample in terms of geographic area, gender, and age using background data obtained from The Finnish Wildlife Agency registry (received January 2022). Responses were distributed across all of Finland, covering all 15 wildlife agency regions and all but two game management association areas (Harjavalta and Sammatti) (n = 282), though not evenly (Table A1.2). With respect to gender, the sample was representative: most hunters in both the national population and the sample were male (94%); females represented 6%. For age groups, some deviations from the background data were observed (Table A1.3). All analyses were weighted to correct for area (wildlife agency regions) and age group distributions using the R package "survey" (Lumley 2004).

Hunting group management is operationalized through three latent variables: decision-making, joint action, and natural resource management, each measured by multiple items (Table 1). Variables that measured natural resource management were used to assess whether hunters perceived the local moose population as being in a sustainable state, and whether their group adhered to hunting recommendations. For decision-making, concepts from the literature on democratic leadership (Morlino 2004) and effective decision-making (Maruska 2004) were considered in conjunction with the context of Finnish hunting culture (Rannikko et al. 2011). Three main elements were assumed to characterize good decision-making within a hunting group. First, hunters should be satisfied with the decision-making process and perceive it as functional. Second, they should feel that everyone can contribute to decision-making (ensuring equality and inclusivity). Third, they should perceive the process as transparent, which allows for effective monitoring. In measuring joint action, we drew upon SES research (Ostrom 2009a, b), and focused particularly on rules, communication, and conflicts within the Finnish hunting context (Rannikko et al. 2011, Artell et al. 2020). Here, "rules" refer to both formal regulations and informal operational agreements (in Finnish: *pelisäännöt*) established collectively. Social aspects such as team spirit and participation are integral to moose hunting, alongside the catch itself, hunting opportunities, and hunts.

Next, we outlined the variables hypothesized to promote variation in management, categorized into three subsystems: actors, governance systems, and cooperation (Table 1). The actors subsystem included variables such as age, gender, education, hunting experience, distance from residence to hunting grounds, role within the hunting group, the social and livelihood importance of hunting, land ownership, knowledge about the resource, and trust in population estimates. The rationale for selecting these variables and expectations regarding their influence on decision-making, joint action, and natural resource management are provided in Table A1.5.

The governance systems subsystem included variables such as collaboration and license-sharing between hunting groups, conflicts between actors in the area, the organizational structure of the hunting group, group size, and the proportion of landowners within the group. The rationale and expected influences of these variables are detailed in Table A1.5.

Finally, the cooperation subsystem included variables such as frequency of meetings during and outside the hunting season, relatedness among group members, consistency of members, inclusion of new members, and participation of guests. The selection rationale and expectations for these variables are presented in Table A1.5.

Statistical analysis

First, we used confirmatory factor analysis (CFA) to investigate hunters' perceptions of decision-making, joint action, and natural resource management within their hunting groups (Brown and Moore 2012). CFA constructs a measurement model for these three latent variables and tests whether the data fit the hypothesized construct (Fig. 1). Each latent variable was measured by a set of reflective indicators, statements evaluated by respondents (Brown and Moore 2012) (Table 1). Decision-making was measured by five indicators: satisfaction with

Table 1. Variables selected for the study. For the variables that measured decision-making, joint action, and natural resource management, respondents indicated their level of agreement with each statement on a scale from 0 (completely disagree) to 10 (completely agree). Variables that described actors, governance systems, and cooperation included binomial, categorical, and continuous types. Descriptive statistics and detailed values for each variable are provided in Table A1.4.

Social-ecological systems (SES) variable name	Variable name	Explanation
Social outcomes (self-perceived) O1		
	Decision-making	
	Satisfaction	Is the hunter satisfied with decision-making?
	Functionality	Is decision-making functional?
	Equality	Is decision-making equal?
	Inclusiveness	Is decision-making inclusive?
	Transparency	Is decision-making transparent?
	Joint action	
	Team spirit	Is team spirit good?
	Rules	Do members follow the group's rules?
	Ground rules	Do members follow jointly agreed upon ground rules?
	No conflicts	Are there any conflicts within the group?
	Communication	Does communication function?
	Participation	Do all members participate in shared work?
	Catch sharing (S)	Is the hunter satisfied (S) with how catch is shared in the group?
	Hunting opportunities (S)	Is the hunter satisfied (S) with hunting opportunities in the group?
	Hunt organizing (S)	Is the hunter satisfied (S) with how hunting is organized in the group?
Ecological outcomes (self-perceived) O2		
	Natural resource management	
	Sustainable population	Is the moose population sustainable in the area?
	License recommendation	Does the group follow recommendations set for applying licenses?
	Calf recommendation	Does the group follow recommendations set for calves?
	Bull recommendation	Does the group follow recommendations set for bulls?
	Cow recommendation	Does the group follow recommendations set for cows?
	Antler recommendation	Does the group follow recommendations set for antlers?
Actors A		
Socioeconomic attributes of users A2	Age	Hunter's age
	Gender	Hunter's gender
	Education	Hunter's highest completed degree
	Landowning	Does the hunter own land in the group's hunting area?
History or past experiences A3	Experience	Membership duration in the group (number of years)
Location A4	Distance	Distance from the hunter's residence to the hunting grounds
Leadership/entrepreneurship A5	Role	Hunter's role (chair, board member, member, guest, occasional guest) in the hunting group
Norms/social capital A6	Social importance	Is moose hunting an important social event for the hunter?
Knowledge of SES/mental models A7	Knowledge	Hunter's knowledge of the factors affecting the size of the moose population in the area
	Trust	Hunter's trust that the moose population estimates made by Natural Resources Institute Finland (Luke) correspond to the real population
Importance of resource A8	Livelihood importance	Is moose catch an essential addition to hunter's livelihood?
Governance systems GS		
Network structure GS1	Collaboration	Has the group taken part in a shared license between other hunting groups in the area during the past 5 years?
	License sharing	Does the group collaborate with other hunting groups in the area?
	Conflicts	Does the group have conflicts with other actors in the area?
Management strategy GS3.2	Organization	Is the group a registered (seura) or non-registered (seurue) hunting society?
Property rights system GS4	Landowner members	How large a proportion of the members own land in the groups' hunting area?
Number of relevant actors A1	Group size	Number of active group members in the hunting group, in the SES framework, placed in the **Actors** subsystem
Cooperation (not part of the SES framework)		
Repetition of interactions	Meetings during the season	Frequency of meeting other group members during the hunting season
	Meetings outside the season	Frequency of meeting other group members outside the hunting season
Relatedness	Relatedness	Share of the hunter's relatives in their hunting group
Stability of groups	Same members	Have active members remained largely the same for the past 5 years?
	New members	How often the group accepts new members
	Guests	How often people who do not belong to the group take part in the hunts

decision-making (used as the marker variable set to scale the latent variable), and perceptions of its functionality, equality, inclusiveness, and transparency. Joint action was measured by nine indicators: team spirit (marker), compliance with rules, compliance with ground rules, amount of internal conflict, communication, participation in shared tasks, and satisfaction with how the catch is shared, how the hunts are organized, and the hunting opportunities. Natural resource management was measured by six indicators: perception of a sustainable moose population (marker), and whether the group follows recommendations regarding licenses, bulls, cows, calves, and antlers.

Reflective indicator correlations met expectations (Table A1.6, A1.7, and A1.8) (Grewal et al. 2004). Some indicators for joint action and natural resource management were only moderately correlated, which potentially increased unexplained variance. As expected, most indicators were left-skewed, since most respondents stated high values for the variables, and did not follow normal distribution. Logarithmic transformations were tested (Pek et al. 2018), but because they did not improve model fit, the original variables were retained. We used a maximum likelihood estimator with robust standard errors (MLR) to account for non-normality. By default, the unexplained variance of the reflective indicators is not allowed to correlate within a latent variable (Muthén and Muthén 1998). However, we allowed correlations between the following indicator pairs due to conceptual overlap: equality and inclusiveness; team spirit and no conflicts; hunting opportunities and catch shared; and hunting opportunities and hunting organized. We report fully standardized parameter estimates (values vary between -1 and 1) to assess the strength of each indicator. Factor loading is a number that indicates the degree to which the reflective indicator correlates to a latent variable. The global fit for the model was evaluated using the root mean square error of approximation (RMSEA < 0.05), comparative fit index (CFI > 0.90), and standardized root mean squared residual (SRMR < 0.05) (Hu and Bentler 1999). Due to the large sample size, the Chi-square test was not used because it often indicates poor fit regardless of actual model quality (Hooper et al. 2008). A maximum of 50 iterations was allowed, in line with model convergence guidelines (Gignac 2006).

Next, we used structural equation modeling to test whether variables that described hunters, hunting groups, and cooperation were associated with the three latent variables: decision-making, joint action, and natural resource management. We created three composite factors, actors, governance systems, and cooperation, as weighted combinations of observed variables (Bollen and Bauldry 2011) (Fig. 1, Table 1). These composite factors are fully defined by their indicators and contain no measurement error (Kline 2015).

Some survey questions were optional, and "I don't know" responses were treated as missing (Table A1.4). Missing values in SEM indicators were imputed using multiple imputation (Asparouhov and Muthén 2010). Multiple imputed datasets were created by substituting missing values, then analyses were performed for each dataset, and results were combined. We generated 10 imputed datasets, because no variable exceeded 10% missing values, to ensure result reliability (Graham et al. 2007). Missing values in reflective indicators were handled in Mplus automatically via full information maximum likelihood.

Because respondents were distributed across regions with differing ecological and management contexts, we assumed some regional non-independence. Intra-class correlation values for wildlife agency areas (n = 15) as a cluster variable were generally quite low (< 0.05), suggesting minimal between-area variance when compared to within-area differences (Table A1.9) (Koo and Li 2016). Nonetheless, all models included wildlife agency area as a cluster variable, correcting standard errors, significance of variables, and Chi-square test of model fit in the presence of clustering (Muthén and Muthén 1998, McNeish et al. 2017). Data weights were applied to account for area and age group representation, using a weighted log-likelihood function. We used MLR estimator throughout, and incorporated non-normality, data weights, and multiple imputations. Seven cases with missing values in all response variables were excluded, which resulted in a final sample of 4729 respondents. Analyses were conducted using Mplus (Version 8.6). Model scripts are provided in Appendix 1 (Fig. A1.2, A1.3, and A1.4).

RESULTS

When hunters positively assess their group's decision-making and joint action, they also tend to follow hunting recommendations

Measurement of the three outcomes using hunter-evaluated statements

The three latent variables in the CFA model were significantly measured by all their reflective indicators ($p < 0.001$) (Fig. 2, Table 2). The global fit of the CFA model to the data was acceptable (X^2 = 1485.097, df = 162, RMSEA = 0.042, RMSEA 90% C.I. = 0.040-0.044, CFI = 0.966, SRMR = 0.035, $p < 0.001$). Better-functioning decision-making was measured, in order of importance based on the standardized factor loadings, by higher satisfaction with decision-making and higher values stated for functionality, equality, inclusiveness, and transparency. Better-functioning joint action was measured, in order of importance, by higher values stated for team spirit, functioning communication, compliance with formal rules and ground rules, higher satisfaction with how hunting is organized in the group, absence of conflicts within the group, higher satisfaction with how the catch is shared and with hunting opportunities, and members participating in shared work. Better natural resource management was measured, in order of importance, by higher values stated for the group following recommendations regarding bulls, cows, calves, and antlers; the local moose population being at a sustainable level; and the group following recommendations on licenses.

Associations among the three outcomes

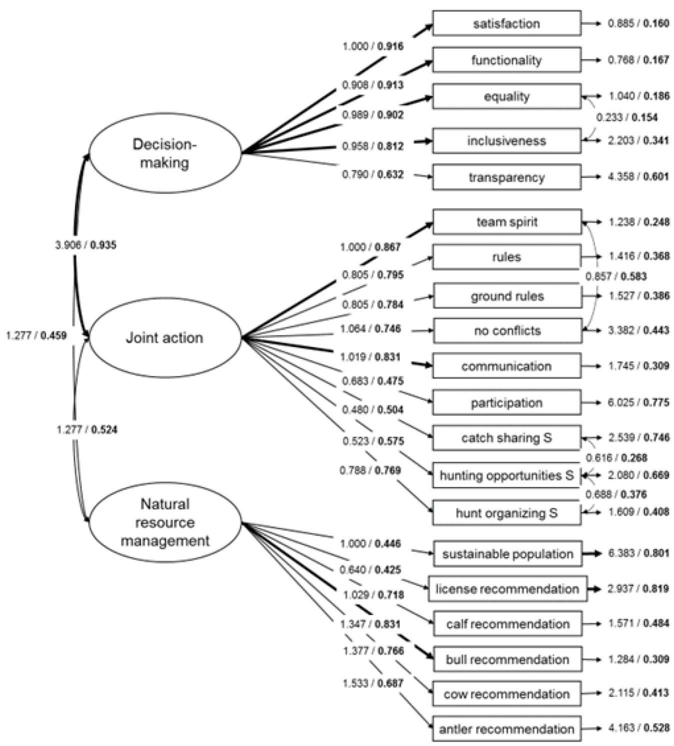
The latent variables were significantly positively correlated with each other. The high correlation between decision-making and joint action (0.935) indicated that they could be statistically considered almost the same. However, we considered them conceptually separate, while acknowledging that very similar drivers likely influenced both in hunting groups. Natural resource management was moderately positively associated with decision-making (0.459) and joint action (0.524). Therefore, when hunters positively assessed decision-making and social relationships in their group, they also tended to follow hunting recommendations, and vice versa.

Hunters, hunting group governance, and cooperation are associated with decision-making, joint action, and natural resource management in Finnish hunting groups

Associations between the three outcomes and the three composite factors

Latent variables of decision-making, joint action, and natural resource management were significantly associated with the composite factors of actors, governance systems, and cooperation (Fig. 3, Table 3). The global fit indices for the SEM were acceptable (number of free parameters = 97, Chi-square test of model fit not calculated for imputed datasets, df = 593, RMSEA = 0.034, CFI = 0.929, SRMR = 0.038). The model converged for all 10 imputed datasets, as required for trustable results.

Fig. 2. Confirmatory factor analysis model for decision-making, joint action, and natural resource management in Finnish hunting societies. Non-standardized values are presented first; standardized values are presented second in bold. On the right, the error term and its standardized value for each reflective indicator, as well as correlations between the set indicators, are shown. Arrows for factor loadings, error terms, and correlations with values over 0.8 are bolded. Values over 0.8 indicate a very high factor loading or correlation.



According to the model, the governance systems composite had the highest factor loadings on all latent variables. This indicates that differences in the hunting groups and their governance particularly influenced how hunters assessed the group's decision-making ($p < 0.001$), joint action ($p < 0.001$), and natural resource management ($p < 0.001$). Negative associations indicate that the variables formed a type of governance that negatively influenced hunters' assessment. The actors composite indicates that differences among hunters influenced how they assessed decision-making ($p < 0.001$), joint action ($p < 0.001$), and natural resource management ($p = 0.001$). The cooperation composite indicates that differences in cooperation within the group particularly influenced assessments of decision-making ($p < 0.001$) and joint action ($p < 0.001$), and to lesser extent, natural resource management ($p = 0.014$). The variance explained for each latent variable in the SEM was relatively good: 35.6% for decision-making ($R^2 = 0.356$) and 42.5% for joint action ($R^2 = 0.425$), and was modest for natural resource management (20.1%, $R^2 = 0.201$).

Key variables forming composite factors that influenced outcomes

Governance systems appeared to be the most important composite for all latent variables. Most of its variables, excluding the share of landowners in the group, had significant importance (Fig. 3, Table 3). A higher score for governance systems was associated primarily with less collaboration with other hunting groups in the area and more conflicts with other actors in the area. This suggests that collaboration and conflict with other groups are highly relevant for both social and ecological outcomes of local moose hunting.

Almost all variables, except for gender and education, had significant importance for the composite variable actors (Fig. 3, Table 3). A higher score for actors was associated particularly with higher social importance and trust. When hunters placed high social value on the activity and trust the population estimates made by the Natural Resources Institute, they perceived their group's management more positively.

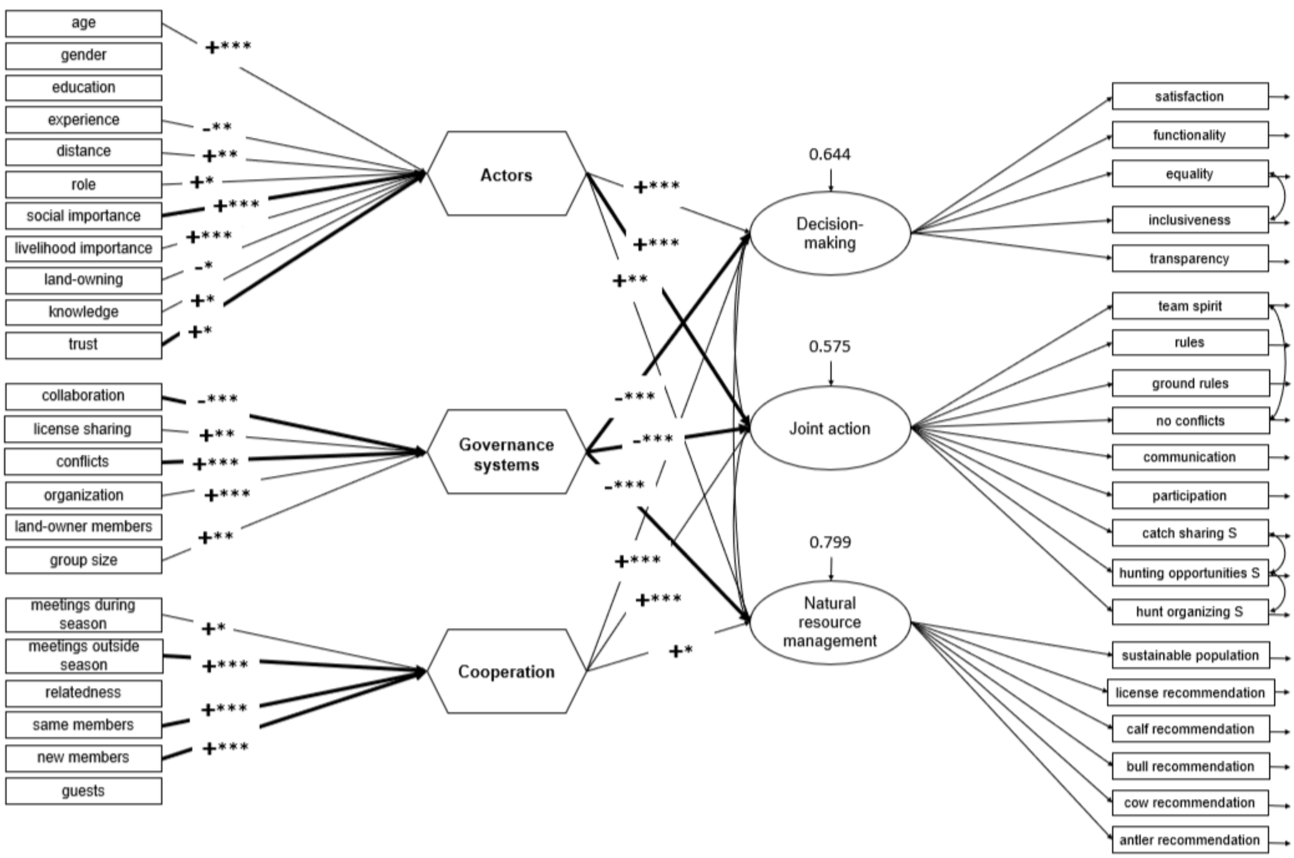
Four variables, excluding relatedness and guests, had significant importance for the composite variable cooperation (Fig. 3, Table 3). A higher score was particularly associated with more meetings outside the hunting season, more stable group membership, and a higher rate of accepting new members. This indicates that social interaction beyond hunting activities, along with a balance between long-standing and new members in the group, positively influenced how hunters assessed decision-making and joint action within the group.

All the variables for each composite were regarded in the model, even though some of them had non-significant associations. In addition, the covariances between all composite indicators were

Table 2. Results for the confirmatory factor analysis model (Fig. 2). Standardized factor loading estimates, their standard errors, and *p* values are presented for each reflective indicator measuring the latent variable. In addition, correlation estimates, their standard errors, and *p* values between latent variables and between allowed reflective indicators (marked "with") are presented. The letter "S" after a variable indicates that it describes hunters' satisfaction (e.g., with catch sharing). Standardized factor loadings or correlation estimates over 0.8 are shown in bold because they indicate the most important reflective indicators and associations.

Latent variable	Reflective indicators	Estimate	S.E.	*p*
Decision-making	**Satisfaction**	**0.916**	0.006	< 0.001
	Functionality	**0.913**	0.005	< 0.001
	Equality	**0.902**	0.006	< 0.001
	Inclusiveness	**0.812**	0.013	< 0.001
	Transparency	0.632	0.082	< 0.001
Joint action	**Team spirit**	**0.867**	0.009	< 0.001
	Rules	0.795	0.018	< 0.001
	Ground rules	0.784	0.017	< 0.001
	No conflicts	0.746	0.010	< 0.001
	Communication	**0.831**	0.009	< 0.001
	Participation	0.475	0.012	< 0.001
	Catch sharing S	0.504	0.019	< 0.001
	Hunting opportunities S	0.575	0.019	< 0.001
	Hunting organizing S	0.769	0.019	< 0.001
Natural resource management	Sustainable population	0.446	0.034	0.001
	License recommendation	0.425	0.029	< 0.001
	Calf recommendation	0.718	0.026	< 0.001
	Bull recommendation	**0.831**	0.011	< 0.001
	Cow recommendation	0.766	0.029	< 0.001
	Antler recommendation	0.687	0.021	< 0.001
Decision-making with	**Joint action**	**0.935**	0.005	< 0.001
Decision-making with	Natural resource management	0.459	0.024	< 0.001
Joint action with	Natural resource management	0.524	0.026	< 0.001
Inclusiveness with	Equality	0.154	0.035	< 0.001
Rules with	Ground rules	0.583	0.023	< 0.001
No conflicts with	Team spirit	0.340	0.027	< 0.001
Hunting opportunities S with	Catch sharing S	0.268	0.034	< 0.001
	Hunting organizing S	0.376	0.025	< 0.001

Fig. 3. Structural equation model results for the significant values in the model. Confirmatory factor analysis model values are presented in Fig. 2; therefore, they are not included here. For factor loadings on the composite variables and latent variables, it is indicated whether they had a positive or negative influence, and an asterisk denotes the significance level of the connection ($p < 0.001$ = ***, $p < 0.01$ = **, $p < 0.05$ = *). The error terms (variance not explained by the structural equation model) are marked for each latent variable. Arrows for factor loadings with values over 0.3 are bolded because they signify a high factor loading.



included in the model and were controlled by each other, even though none of the covariances were significant in the model (Tables A1.10, A1.11, and A1.12).

DISCUSSION

The hypothesized structural equation model that described the moose hunting social-ecological system in Finland (Fig. 1) was operationalized using a survey with questions designed to capture the variables. Our aim was to investigate whether decision-making and social interactions in hunting groups are related to compliance with moose management. All the 123 000 Finnish hunters with the right to hunt moose were informed about the survey, and approximately 4% responded, which covered the entire country. We found that the management of a hunting group is undoubtedly a diverse concept, measured by several indicators. Latent variables that modeled the groups' decision-making and joint action, as assessed by the hunters, are very strongly connected and, statistically, appear to measure the same issue: the social dynamics within the hunting groups. In addition, we found that natural resource management, mainly the hunters' evaluation of compliance with hunting recommendations in the group, is associated with these social dynamics. Therefore, group decision-making, joint action, and hunters' satisfaction with them contribute to higher-level moose management. Further analyses of composite variables that affected these outcomes showed that especially variables that described hunting groups, but also individual hunters (actors) and cooperation within the group, promote alignment of social aspects of group management with natural resource management by influencing all these outcomes in a parallel direction.

Our results show that in Finnish moose hunting, the social and ecological outcomes of natural resource management are connected (Agrawal and Benson 2011). Hunters and hunting groups tend to follow hunting recommendations more often when hunters are satisfied with decision-making and other group dynamics, and vice versa. Statistically, the correlation (0.52) is of medium strength. Nevertheless, this finding suggests that national management cannot rely solely on regulations to ensure ecologically sustainable outcomes; it must also consider the social dynamics of hunting groups. When hunters follow the recommendations, they support higher-level management (Schroeder et al. 2014, 2017), which is essential for the long-term

Table 3. Standardized estimates for regression coefficients, their standard errors, and *p* values for the structural equation modeling (Fig. 3). The table first presents the connections from composite variables to the three different latent variables. Second, it presents the factor loadings from composite indicators to the composite variable they measure. Significant regression coefficients indicate meaningful predictive power of the indicator on the latent variable when considering all other indicators and their covariances in the model. Standardized regression coefficients over 0.3 are bolded because they indicate the most important connections.

Latent variable	Composite variable	Estimate	S.E.	*p*
Decision-making	Actors	0.256	0.040	< 0.001
	Governance systems	**-0.336**	0.021	< 0.001
	Cooperation	0.243	0.027	< 0.001
Joint action	**Actors**	**0.302**	0.027	< 0.001
	Governance systems	**-0.371**	0.017	<0.001
	Cooperation	0.235	0.016	< 0.001
Natural resource management	Actors	0.210	0.065	0.001
	Governance systems	**-0.300**	0.021	< 0.001
	Cooperation	0.091	0.037	0.014
Composite variable	Composite indicator			
Actors	Age	0.225	0.045	< 0.001
	Gender	-0.052	0.031	0.098
	Education	-0.020	0.043	0.650
	Experience	-0.256	0.077	0.001
	Distance	0.263	0.101	0.009
	Role	0.247	0.108	0.023
	Social importance	**0.679**	0.073	< 0.001
	Livelihood importance	0.163	0.041	< 0.001
	Landowning	-0.073	0.034	0.034
	Knowledge	0.203	0.087	0.020
	Trust	**0.344**	0.150	0.013
Governance systems	**Collaboration**	**-0.713**	0.038	< 0.001
	License sharing	0.147	0.037	< 0.001
	Conflicts	**0.459**	0.032	< 0.001
	Organization	0.253	0.060	< 0.001
	Landowner members	0.009	0.074	0.902
	Group size	0.195	0.065	0.003
Cooperation	Meetings during season	0.182	0.079	0.021
	Meetings outside season	**0.338**	0.036	< 0.001
	Relatedness	0.116	0.096	0.226
	Same members	**0.690**	0.097	< 0.001
	New members	**0.402**	0.073	< 0.001
	Guests	-0.052	0.069	0.450

functioning of the system. Our findings underline that hunting groups in which recommendations are not followed are also groups where decision-making and joint action are perceived as unsatisfactory or dysfunctional. Therefore, one way to maintain the sustainability of the moose management system is to ensure that the social side of group management is functioning well. This part of our SEM supports previous research that has shown that hunter satisfaction consists of multiple aspects (Hautaluoma and Brown 1978). Several indicators should be considered within hunting groups, such as satisfaction with decision-making, its functionality, equality, and inclusiveness, as well as the group's team spirit and communication. Our model explained approximately 20–40% of the variance in the latent variables, which is acceptable compared to other hunter satisfaction models (Hammitt et al. 1990, Schroeder et al. 2017). However, to increase explanatory power, it could be beneficial to evaluate specific experiences rather than hunting management in general, as we have done in this study (Hammitt et al. 1990, Woods et al. 1996). We did not include variables that described local ecological conditions, which belong to the SES subsystems resource and resource system (Ostrom 2009a). Even though differences between wildlife agency areas, which cover wider ecological variability, were not found to be significant, we acknowledge that individual hunting areas differ from one another, for example, in cervid species compositions. Such variation can either facilitate or complicate decision-making and population management (Dressel et al. 2018).

Governance systems, consisting particularly of collaboration and conflicts between hunting groups, are most strongly linked to all three outcome variables. Thus, it is especially aspects of hunting groups that align the social outcomes with the natural resource management of the hunting group. We found that a hunting group's collaboration with other groups is the most important variable that positively influences hunters' assessment of the group's management, while the second most important variable, conflicts, has a negative influence. The positive effect of collaboration between stakeholders, especially when it is voluntary, is well supported by previous research (Woods et al. 1996, Ostrom 2009b, Dressel et al. 2020b). Collaboration between groups can create more accurate shared knowledge about the mobile resource (moose) and build trust toward other groups, thus enabling better hunting planning and shared strategies (Ostrom 2009a, Bodin et al. 2017). Collaboration between hunting groups creates social capital and reduces the negative influence of a "we" versus "them" mentality (Dressel et al. 2020b). In addition, social control is increased when hunting groups interact more frequently, which may lead to higher compliance with regulations—in this case, the recommendations (Woods et al. 1996, Rankin et al. 2007). The negative effect of conflicts is assumed to be due to opposite mechanisms. Conflicts reduce trust and social capital, can undermine shared strategies, and may increase selfish behavior due to a lack of social control (Hasbrouck et al. 2020). Clearly, a lack of collaboration can either lead to conflicts or result from them; these two aspects often go hand in hand. Therefore, a main finding of this work is that promoting collaboration and conflict resolution mechanisms between local hunting groups can greatly benefit moose management, as supported by previous SES research (Ostrom 2009b, Mitterling et al. 2021). The assessment of conflicts and their sources can help resolve issues; for example, annual monitoring of social indicators could provide information for management (Fix and Harrington 2012).

As predicted by the SES framework, we found the subsystem that described the hunter (actor) was important in promoting differences in management. The high social importance given to hunting is the most important variable associated with hunters. This finding aligns with hunting and SES research, which shows that strong social interactions and social capital are highly relevant for successful management (Wagner et al. 2007, Ostrom 2009b, Dressel et al. 2020b, Mitterling et al. 2021). A high social importance may increase hunters' investment in the activity, which in turn affects group management positively. The livelihood importance related to the catch and the meat is a major motivator in moose hunting (Brinkman 2018) and was significant in our study, though with considerably lower weight than social importance. However, both create commitment to the activity and the group, thus facilitating management (Acheson 2006, Ostrom 2009a). The second most important variable about the hunter is their trust in the population estimates made by the Natural

Resources Institute Finland ("Luke"). The allocation of licenses and recommendations is based on population estimates, which makes their validity and legitimacy an essential part of the system (Brinkman 2018). In a multilevel system, local hunters are strongly impacted by the information provided and decisions made at higher levels (Riley et al. 2018), and our results, supported by previous research (Schroeder et al. 2017, Brinkman 2018, Dressel et al. 2020b), suggest that stronger trust toward higher levels is crucial for a sustainable moose management system. Maintaining and increasing hunters' trust mitigates conflicts and can be fostered by open communication and transparency between management levels (Brinkman 2018, Riley et al. 2018, Dressel et al. 2020b). The ongoing debate and conflict between hunters' perceptions and Luke's population estimates highlight the importance of this finding. One possibility is to involve hunters in higher-level decision-making, for example, by allowing them to voice their opinions on the moose population before 3-year goals are set for the regions. However, the impact of different mechanisms on trust should be tested carefully. Quite surprisingly, demographic variables such as hunters' education, gender, or landownership status have only a minor influence. Therefore, our results underline that rather than who the hunters are, as found to be important in several other studies and systems (Decker et al. 1980, Ostrom 2009a, Gamborg and Jensen 2016, Schroeder et al. 2017), it is the social importance and trust created within the system that play a more prominent role in promoting collective action and hunters' satisfaction.

We investigated cooperation as a separate subsystem. We acknowledge that variables that describe cooperation can, depending on the study, be placed under the actors, governance systems, or interactions subsystems that are already part of the SES framework (McGinnis and Ostrom 2014). Our rationale for considering them separately was to specifically explore their contribution. We found that the cooperation subsystem mainly influenced the social side of group management but only weakly affected natural resource management. The most important variable for cooperation was stability, measured by the same members staying in the group. Stability is assumed to be connected to reciprocity and trust, which increase cooperation between the same individuals in the group, as found in other studies (Axelrod and Hamilton 1981, Nowak 2006, Dressel et al. 2021). Undoubtedly, hunters who are satisfied with the group remain in the same hunting group longer. In addition, they can have a positive influence on the group by possessing more knowledge about the resource (Agrawal and Chhatre 2006, MacNeil and Cinner 2013). Against our expectations based on the importance of stability, we found that accepting new members more often into the group also positively influenced hunters' assessment of management. This indicates that, in addition to committed members, the regular acceptance of new members is beneficial for a hunting group. It suggests a dynamic and active group, where new people, possibly bringing new ideas and enthusiasm, are welcomed and contribute positively (Tuominen et al. 2023). At the same time, it indicates that the group was perceived as attractive to potential new members. A third important variable that defined cooperation was frequent meetings outside the hunting season. While hunters naturally meet during the season, meetings outside the season may reflect higher commitment and stronger ties among group members. Face-to-face communication has repeatedly been emphasized as important for sustainable resource governance, leading to higher trust and shared norms, rules, and strategies (Wagner et al. 2007, Ostrom 2007, 2009b). Against our expectations (Nowak 2006, Rankin et al. 2007), we found that hunters with or without relatives in the group were equally satisfied with the group. Thus, relatedness between hunters neither facilitates cooperation nor leads to clear nepotism and any associated negative consequences. In the future, it would be beneficial to investigate the influence of other long-term social relationships in hunting groups, such as friendships and neighbor relations.

Moose management in Finland serves as a strong example of a multilevel system designed to manage commonly owned natural resources. It has been nationally sustainable over the past decades, avoiding both population crashes and overabundance. However, this system relies heavily on the support of resource users; i.e., the hunters at the lowest level of management, whose role has received limited attention in prior research (Gigliotti 2000, Dressel et al. 2020a, Di Minin et al. 2021). Moreover, previous studies have shown that hunting groups differ in their ability to maintain a stable long-term moose harvest (Tuominen et al. 2023). We found that applying the SES framework (Ostrom 2007, 2009a), together with insights from cooperation theory (Rankin et al. 2007, West et al. 2007), enables a thorough analysis of the resource system and offers new insights. Our results emphasize that when local resource users organize into groups, their internal decision-making, social dynamics, and satisfaction with these processes influence their compliance with and support for regulations within the broader multilevel system. The SEM method demonstrates the value of measuring outcomes using multiple variables to capture their multifaceted nature (Tuominen et al. 2022). A novel insight for the SES framework is that social dynamics, specifically those fostered by both committed long-term members and the regular inclusion of new members, positively contribute to group management. Based on our findings, and supported by previous research (Dressel et al. 2020b, 2021), we suggest that social dynamics that enhance social capital and facilitate communication across governance levels, among organized groups, and within groups, should be actively promoted. We conclude that local-level social dynamics are a foundational component of sustainable natural resource management.

Author Contributions:

L.T., M.W., H.H., P.K., L.R., T.V., and J.B. all made substantial contributions to the conceptualization and methodology of the work. L.T. performed formal analysis, investigation, and visualization of the study. L.T. and J.B. wrote the original draft, and all authors reviewed and edited the manuscript and validated the study. J.B. supervised the research activity.

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Data Availability:

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. The codes are included in Appendix 1.

LITERATURE CITED

Acheson, J. M. 2006. Institutional failure in resource management. Annual Review of Anthropology 35:117-134. https://doi.org/10.1146/annurev.anthro.35.081705.123238

Agrawal, A. 2001. Common property institutions and sustainable governance of resources. World Development 29:1649-1672. https://doi.org/10.1016/S0305-750X(01)00063-8

Agrawal, A., and C. S. Benson. 2011. Common property theory and resource governance institutions: strengthening explanations of multiple outcomes. Environmental Conservation 38:199-210. https://doi.org/10.1017/S0376892910000925

Agrawal, A., and A. Chhatre. 2006. Explaining success on the commons: community forest governance in the Indian Himalaya. World Development 34:149-166. https://doi.org/10.1016/j.worlddev.2005.07.013

Apollonio, M., V. V. Belkin, J. Borkowski, O. I. Borodin, T. Borowik, F. Cagnacci, A. A. Danilkin, P. I. Danilov, A. Faybich, and F. Ferretti. 2017. Challenges and science-based implications for modern management and conservation of European ungulate populations. Mammal Research 62:209-217. https://doi.org/10.1007/s13364-017-0321-5

Artell, J., T. Lankia, J. Pellikka, and J. Pusenius. 2020. Hirvenmetsästys: tavat ja arvot 2019-2020.

Asparouhov, T., and B. Muthén. 2010. Multiple imputation with Mplus. MPlus Web Notes.

Axelrod, R., and W. D. Hamilton. 1981. The evolution of cooperation. Science 211:1390-1396. https://doi.org/10.1126/science.7466396

Béné, C., E. Belal, M. O. Baba, S. Ovie, A. Raji, I. Malasha, F. Njaya, M. Na Andi, A. Russell, and A. Neiland. 2009. Power struggle, dispute and alliance over local resources: analyzing 'democratic' decentralization of natural resources through the lenses of Africa inland fisheries. World Development 37:1935-1950. https://doi.org/10.1016/j.worlddev.2009.05.003

Bodin, Ö. 2017. Collaborative environmental governance: achieving collective action in social-ecological systems. Science 357:1-20. https://doi.org/10.1126/science.aan1114

Bodin, Ö., A. Sandström, and B. Crona. 2017. Collaborative networks for effective ecosystem-based management: a set of working hypotheses. Policy Studies Journal 45:289-314. https://doi.org/10.1111/psj.12146

Bollen, K. A., and S. Bauldry. 2011. Three Cs in measurement models: causal indicators, composite indicators, and covariates. Psychological Methods 16:265. https://doi.org/10.1037/a0024448

Brinkman, T. J. 2018. Hunter acceptance of antlerless moose harvest in Alaska: importance of agency trust, proximity of hunter residence to hunting area, and hunting experience. Human Dimensions of Wildlife 23:129-145. https://doi.org/10.1080/10871209.2017.1399486

Brown, T. A., and M. T. Moore. 2012. Confirmatory factor analysis. Pages 361-379 in R. H. Hoyle, editor. Handbook of structural equation modeling. Guilford Publications, New York, New York, USA.

Cox, M. 2011. Advancing the diagnostic analysis of environmental problems. International Journal of the Commons 5(2):346-363. https://doi.org/10.18352/ijc.273

Cumming, G. S., G. Epstein, J. M. Anderies, C. I. Apetrei, J. Baggio, Ö. Bodin, S. Chawla, H. S. Clements, M. Cox, L. Egli, G. G. Gurney, M. Lubell, N. Magliocca, T. H. Morrison, B. Müller, R. Seppelt, M. Schlüter, H. Unnikrishnan, S. Villamayor-Tomas, and C. M. Weible. 2020. Advancing understanding of natural resource governance: a post-Ostrom research agenda. Current Opinion in Environmental Sustainability 44:26-34. https://doi.org/10.1016/j.cosust.2020.02.005

Decker, D. J., T. L. Brown, and R. J. Gutierrez. 1980. Further insights into the multiple-satisfactions approach for hunter management. Wildlife Society Bulletin 8:323-331.

Dietz, T., E. Ostrom, and P. C. Stern. 2003. The struggle to govern the commons. Science 302:1907-1912. https://doi.org/10.1126/science.1091015

Di Minin, E., H. S. Clements, R. A. Correia, G. Cortés-Capano, C. Fink, A. Haukka, A. Hausmann, R. Kulkarni, and C. J. A. Bradshaw. 2021. Consequences of recreational hunting for biodiversity conservation and livelihoods. One Earth 4:238-253. https://doi.org/10.1016/j.oneear.2021.01.014

Dressel, S., G. Ericsson, M. Johansson, C. Kalén, S. E. Pfeffer, and C. Sandström. 2020a. Evaluating the outcomes of collaborative wildlife governance: the role of social-ecological system context and collaboration dynamics. Land Use Policy 99:105028. https://doi.org/10.1016/j.landusepol.2020.105028

Dressel, S., G. Ericsson, and C. Sandström. 2018. Mapping social-ecological systems to understand the challenges underlying wildlife management. Environmental Science & Policy 84:105-112. https://doi.org/10.1016/j.envsci.2018.03.007

Dressel, S., M. Johansson, G. Ericsson, and C. Sandström. 2020b. Perceived adaptive capacity within a multi-level governance setting: the role of bonding, bridging, and linking social capital. Environmental Science & Policy 104:88-97. https://doi.org/10.1016/j.envsci.2019.11.011

Dressel, S., A. Sjölander-Lindqvist, M. Johansson, G. Ericsson, and C. Sandström. 2021. Achieving social and ecological outcomes in collaborative environmental governance: good examples from Swedish moose management. Sustainability 13(4):2329. https://doi.org/10.3390/su13042329

Fiorini, S., S. Yearley, and N. Dandy. 2011. Wild deer, multivalence, and institutional adaptation: the "Deer Management Group" in Britain. Human Organization 70:179-188. https://doi.org/10.17730/humo.70.2.0107055588r8861h

Fix, P. J., and A. M. Harrington. 2012. Measuring motivations as a method of mitigating social values conflict. Human Dimensions of Wildlife 17(5):367-375. https://doi.org/10.1080/10871209.2012.682325

Gamborg, C., and F. S. Jensen. 2016. Wildlife value orientations among hunters, landowners, and the general public: a Danish comparative quantitative study. Human Dimensions of Wildlife 21:328-344. https://doi.org/10.1080/10871209.2016.1157906

Gigliotti, L. M. 2000. A classification scheme to better understand satisfaction of Black Hills deer hunters: the role of harvest success. Human Dimensions of Wildlife 5:32-51. https://doi.org/10.1080/10871200009359171

Gignac, G. E. 2006. Self-reported emotional intelligence and life satisfaction: testing incremental predictive validity hypotheses via structural equation modeling (SEM) in a small sample. Personality and Individual Differences 40:1569-1577. https://doi.org/10.1016/j.paid.2006.01.001

Graham, J. W., A. E. Olchowski, and T. D. Gilreath. 2007. How many imputations are really needed? Some practical clarifications of multiple imputation theory. Prevention Science 8:206-213. https://doi.org/10.1007/s11121-007-0070-9

Grewal, R., J. A. Cote, and H. Baumgartner. 2004. Multicollinearity and measurement error in structural equation models: implications for theory testing. Marketing Science 23:519-529. https://doi.org/10.1287/mksc.1040.0070

Hammitt, W. E., C. D. McDonald, and M. E. Patterson. 1990. Determinants of multiple satisfaction for deer hunting. Wildlife Society Bulletin 18:331-337.

Hardin, G. 1968. The tragedy of the commons: the population problem has no technical solution; it requires a fundamental extension in morality. Science 162:1243-1248. https://doi.org/10.1126/science.162.3859.1243

Hasbrouck, T. R., T. J. Brinkman, G. Stout, and K. Kielland. 2020. Assessing moose hunter distribution to explore hunter competition. Alces: A Journal Devoted to the Biology and Management of Moose 56:79-95.

Hautaluoma, J., and P. J. Brown. 1978. Attributes of the deer hunting experience: a cluster-analytic study. Journal of Leisure Research 10:271-287. https://doi.org/10.1080/00222216.1978.11969367

Heikkilä, R., and J. Aarnio. 2001. Forest owners as moose hunters in Finland. Alces: A Journal Devoted to the Biology and Management of Moose 37:89-95.

Hooper, D., J. Coughlan, and M. R. Mullen. 2008. Structural equation modelling: guidelines for determining model fit. Electronic Journal of Business Research Methods 6:53-60.

Hu, L. T., and P. M. Bentler. 1999. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Structural Equation Modeling: A Multidisciplinary Journal 6:1-55. https://doi.org/10.1080/10705519909540118

Kline, R. B. 2015. Principles and practice of structural equation modeling. Guilford Publications.

Koo, T. K., and M. Y. Li. 2016. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. Journal of Chiropractic Medicine 15:155-163. https://doi.org/10.1016/j.jcm.2016.02.012

Levin, S. A. 2014. Public goods in relation to competition, cooperation, and spite. Proceedings of the National Academy of Sciences of the United States of America 111:10838-10845. https://doi.org/10.1073/pnas.1400830111

Lumley, T. 2004. Analysis of complex survey samples. Journal of Statistical Software 9:1-19. https://doi.org/10.18637/jss.v009.i08

Löyttyniemi, K., and A. Lääperi. 1988. Moose in Finnish forestry. Reports-University of Helsinki, Department of Agricultural and Forest Zoology.

MacNeil, M. A., and J. E. Cinner. 2013. Hierarchical livelihood outcomes among co-managed fisheries. Global Environmental Change 23:1393-1401. https://doi.org/10.1016/j.gloenvcha.2013.04.003

Maruska, D. 2004. How great decisions get made: 10 easy steps for reaching agreement on even the toughest issues. AMACOM.

Matala, J., A. Nikula, J. Pellikkä, S. Aikio, J. Forsman, H. Henttonen, K. Holmala, O. Huitu, M. Jauni, I. Kojola, M. Melin, A. Paasivaara, and J. Pusenius. 2021 Hirvieläinten vaikutuksia yhteiskuntaan, elinkeinoihin ja ekosysteemiin.

McGinnis, M. D., and E. Ostrom. 2014. Social-ecological system framework: initial changes and continuing challenges. Ecology and Society 19(2):30. https://doi.org/10.5751/ES-06387-190230

McNeish, D., L. M. Stapleton, and R. D. Silverman. 2017. On the unnecessary ubiquity of hierarchical linear modeling. Psychological Methods 22:114-140. https://doi.org/10.1037/met0000078

Mitterling, A. M., B. A. Rudolph, and D. B. Kramer. 2021. The influence of private land deer management cooperatives on harvest outcomes and hunter satisfaction. Wildlife Society Bulletin 45:456-464. https://doi.org/10.1002/wsb.1209

Morlino, L. 2004. What is a 'good' democracy? Democratization 11:10-32.

Muthén, L. K., and B. O. Muthén. 1998. Mplus user's guide (Version 7). Los Angeles, California, USA.

Nowak, M. A. 2006. Five rules for the evolution of cooperation. Science 314:1560-1563. https://doi.org/10.1126/science.1133755

Nygrén, T. 1987. The history of moose in Finland. Swedish Wildlife Research (Sweden).

Ostrom, E. 2007. A diagnostic approach for going beyond panaceas. Proceedings of the National Academy of Sciences of the United States of America 104:15181-15187. https://doi.org/10.1073/pnas.0702288104

Ostrom, E. 2009a. A general framework for analyzing sustainability of social-ecological systems. Science 325:419-422. https://doi.org/10.1126/science.1172133

Ostrom, E. 2009b. Understanding institutional diversity. Princeton University Press.

Partelow, S. 2018. A review of the social-ecological systems framework: applications, methods, modifications, and challenges. Ecology and Society 23(4):36. https://doi.org/10.5751/ES-10594-230436

Pek, J., O. Wong, and A. C. Wong. 2018. How to address non-normality: a taxonomy of approaches, reviewed, and illustrated. Frontiers in Psychology 9:2104. https://doi.org/10.3389/fpsyg.2018.02104

Rankin, D. J., K. Bargum, and H. Kokko. 2007. The tragedy of the commons in evolutionary biology. Trends in Ecology & Evolution 22:643-651. https://doi.org/10.1016/j.tree.2007.07.009

Rannikko, P., J. Hiedanpää, J. Pellikkä, O. Ratamäki, S. Härkönen, and P. Salmi. 2011. Kohtaamisia metsässä-Eläinkiistoista yhteistoimintaan.

Ratner, B., R. Meinzen-Dick, C. May, and E. Haglund. 2013. Resource conflict, collective action, and resilience: an analytical framework. International Journal of the Commons 7:183-208. https://doi.org/10.18352/ijc.276

Riley, S. J., J. K. Ford, H. A. Triezenberg, and P. E. Lederle. 2018. Stakeholder trust in a state wildlife agency. Journal of Wildlife Management 82:1528-1535. https://doi.org/10.1002/jwmg.21501

Schroeder, S. A., L. Cornicelli, D. C. Fulton, and M. D. Grund. 2014. What predicts support for antler point restrictions? Human Dimensions of Wildlife 19:301-318. https://doi.org/10.1080/10871209.2014.915598

Schroeder, S. A., D. C. Fulton, J. S. Lawrence, and S. D. Cordts. 2017. How hunter perceptions of wildlife regulations, agency trust, and satisfaction affect attitudes about duck bag limits. Human Dimensions of Wildlife 22:454-475. https://doi.org/10.1080/10871209.2017.1345021

Smith, H., S. Marrocoli, A. Garcia Lozano, and X. Basurto. 2019. Hunting for common ground between wildlife governance and commons scholarship. Conservation Biology 33:9-21. https://doi.org/10.1111/cobi.13200

Tuominen, L. S., S. Helle, H. Helanterä, P. Karell, L. Rapeli, D. Richmond, T. Vuorisalo, and J. E. Brommer. 2022. Structural equation modeling reveals decoupling of ecological and self-perceived outcomes in a garden box social-ecological system. Scientific Reports 12:6425. https://doi.org/10.1038/s41598-022-10178-z

Tuominen, L. S., M. Wikström, H. Helanterä, P. Karell, J. Pusenius, L. Rapeli, L. Ruha, T. Vuorisalo, and J. E. Brommer. 2023. Factors promoting hunting groups' sustainable harvest of moose in a co-management system. Scientific Reports 13 (1):21076. https://doi.org/10.1038/s41598-023-48348-2

Wagner, M. W., U. P. Kreuter, R. A. Kaiser, and R. N. Wilkins. 2007. Collective action and social capital of wildlife management associations. Journal of Wildlife Management 71:1729-1738. https://doi.org/10.2193/2006-199

West, S. A., A. S. Griffin, and A. Gardner. 2007. Evolutionary explanations for cooperation. Current Biology 17:661-672. https://doi.org/10.1016/j.cub.2007.06.004

Woods, G. R., D. C. Guynn, W. E. Hammitt, and M. E. Patterson. 1996. Determinants of participant satisfaction with quality deer management. Wildlife Society Bulletin 318-324.

Appendix 1

Figure A1.1.
The questionnaire for Finnish hunters in 2021. It included questions about moose and white-tailed deer hunting. The questions related to white-tailed deer hunting are not presented here but were identical to those concerning moose. The question on the second page regarding the hunting area refers to the Wildlife Agency Area (n = 15) to which the respondent`s hunting group belongs. After selecting one of the 15 areas, respondents chose the specific Game Management Association area (n = 282) within their Wildlife Agency Area that their hunting group is part of. To keep the material concise, the Game Management Association areas are not shown here. The questionnaire was distributed only in Finnish and Swedish but is translated here into English.

SUOMEN
RIISTAKESKUS
FINLANDS VILTCENTRAL

Moose and white-tailed deer hunting

Tell us about deer management!

Mandatory questions are marked with a star (*)

Hunter, tell us how deer populations should be managed!
- Now you have a chance to make an impact

The success of moose and white-tailed deer population management is in the hands of hunting groups. They implement the management plans of the game management associations, which are based on the goals set for the moose management areas. The functioning of hunting groups has a great societal significance and therefore it is important to get more information about it.

Now all deer hunters in Finland have the opportunity to express their views by answering the survey. In the analyses, the answers are combined with group-specific catch statistics from previous years and open data from the association register. The answers are edited after combining the data so that the individual respondent cannot be identified.

The aim of the survey is to investigate the factors affecting the working prerequisites of deer hunters. The results will be used in the development of deer population management.

The survey is open on 15.7. – 15.8.2021. The survey was ordered by the Finnish Wildlife Agency and implemented by the University of Turku. It takes about 15 minutes to answer the survey.

Among the respondents, the Finnish Wildlife Agency will raffle five (5 pcs) transmitting and remote-controlled Uovision Glory 20MP 4G game cameras (Value: €395).

Welcome to answer!

Finnish Wildlife Agency

Background information *

The name of the hunting group where you belong as a member or a guest. If you are hunting in more than one, name the primary hunting group. [ ]

Estimate the hunting area size of your group (hectares) [ ]

In which area does your hunting group mainly hunt? *

- ○ Etelä-Häme
- ○ Etelä-Savo
- ○ Kaakkois-Suomi
- ○ Kainuu
- ○ Keski-Suomi
- ○ Lappi
- ○ Oulu
- ○ Pohjanmaa
- ○ Pohjois-Häme
- ○ Pohjois-Karjala
- ○ Pohjois-Savo
- ○ Rannikko-Pohjanmaa
- ○ Satakunta
- ○ Uusimaa
- ○ Varsinais-Suomi

Which deer does your hunting group hunt? *

- ☐ Moose
- ☐ White-tailed deer

Is your hunting group registered (seura) or non-registered (seurue) hunting society?

- ◯ registered (ry)
- ◯ non-registered (not ry)
- ◯ I don`t know

Are you the hunting group`s

- ◯ chair
- ◯ vice chair
- ◯ member of the board
- ◯ member
- ◯ regular guest
- ◯ occasional guest

Were you on the hunting season 2020/2021 in the moose hunting

- ◯ leader
- ◯ vice leader
- ◯ neither

In which year did you start deer hunting in your hunting group?

____

Do you own land in the area you hunt?

- ◯ Yes
- ◯ No

Gender *

- ◯ woman
- ◯ man
- ◯ other
- ◯ no answer

What is the highest level of education you have completed? *

- ◯ Elementary School
- ◯ 2nd level (upper secondary school)
- ◯ Bachelor`s degree
- ◯ Master`s degree

Year of birth *

Estimate how many active members there are in your hunting group taking part in moose hunting.

____

Do you have relatives in your hunting group?

- ◯ not at all
- ◯ few
- ◯ some
- ◯ many
- ◯ very many

Do guests who are not members of the hunting group take part in the deer hunts?

- ◯ never
- ◯ very rarely
- ◯ rarely
- ◯ regularly
- ◯ very often
- ◯ always

Does the hunting group accept paying hunting guests?

- ◯ Yes (e.g. guests paying a day card)
- ◯ No
- ◯ I don`t know

Does the hunting group sell moose meat?

- ◯ Yes
- ◯ No
- ◯ I don`t know

How big share of the hunting group members own land in the hunting area?

- ◯ nobody
- ◯ one
- ◯ less than half of the members
- ◯ about half of the members
- ◯ over half of the members
- ◯ almost all
- ◯ all
- ◯ I don`t know

Estimate how far you live from the hunting area where you most often hunt deer.

- ◯ I live in the hunting area
- ◯ less than 10 km
- ◯ 10-49 km
- ◯ 50-199 km
- ◯ 200 km or more

What do you think about the following statements regarding the moose population in your hunting area?
0 completely disagree - 10 completely agree

	0	1	2	3	4	5	6	7	8	9	10	I don`t know
I have excellent knowledge of the factors affecting the size of the moose population in our area.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
The group actively participates in monitoring the moose population.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
The moose population is at a sustainable level in our region.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
The group applies for moose permits in accordance with RHY's recommendations.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

	0	1	2	3	4	5	6	7	8	9	10	I don`t know
Typically, all moose permits received are used in my group.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Our group follows the recommendations regarding the share of calves of the catch.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Our group follows the recommendations regarding the share of bulls of the catch.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Our group follows the recommendations regarding the sparing of productive cows.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Our group follows the recommendations regarding the properties of antlers.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Which factors, in your opinion, can create challenges for your hunting group in the future? You can choose 1-4 options.

- ☐ reduction of deer populations
- ☐ increase of deer populations
- ☐ predators
- ☐ forest structure
- ☐ the presence of humans
- ☐ illegal hunting
- ☐ change of hunting area
- ☐ age structure of the group
- ☐ the low number of group members
- ☐ conflicts within the group
- ☐ the commercialization of hunting
- ☐ change in land ownership
- ☐ poor condition or lack of hunting infrastructure (e.g. slaughter shed)
- ☐ other, what? ____________
- ☐ no challenges

Does the hunting group carry out lure feeding of deer during the hunting season or support feeding during the winter?

- ☐ Yes, lure feeding
- ☐ Yes, support feeding
- ☐ No feeding at all
- ☐ I don`t know

Is the feeding of the deer carried out by individual members or according to the feeding plan of the hunting group?

- ☐ According to the feeding plan by individual members
- ☐ According to the feeding plan by hunting group
- ☐ No feeding plan, the feeding is random
- ☐ I don`t know

Those who apply to become a member of the hunting group are accepted as members.

- ○ never
- ○ very rarely
- ○ rarely
- ○ often
- ○ very often
- ○ always
- ○ I don`t know

Typically, new members of the group are

- ○ relatives
- ○ friends
- ○ landowners
- ○ other residents of the surrounding area
- ○ strangers
- ○ I don`t know

Who can join the hunting group?

- ☐ anyone with a hunting license
- ☐ must live in the area of the hunting group
- ☐ must own land in the hunting group`s area
- ☐ I don`t know
- ☐ other conditions, what? ____________

Has the hunting group participated in a joint license permit in the last 5 years?

- ◯ Yes
- ◯ No
- ◯ I don`t know

How many groups are typically involved in a joint license permit?

[ ]

The decisions made among the participants in the joint license permit are fair and functional.

completely disagree 0 — [0] — 10 completely agree

What do you think of the following statements regarding collaboration with other groups?
0 completely disagree - 10 completely agree

	0	1	2	3	4	5	6	7	8	9	10	I don`t know
We collaborate with other groups in the area.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
There would be more need for collaboration between groups than there is now.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
The group has conflicts with other actors in the area.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

What do you think about the following statements regarding decision-making in your group?
0 completely disagree - 10 completely agree

	0	1	2	3	4	5	6	7	8	9	10	I don`t know
Decision-making is transparent												
Decision-making is functional												
Decision-making is equal												
All stakeholders are included in decision-making												
Group has an excellent team spirit												
Members follow the shared decisions												
Previously agreed action rules are followed during the hunt												
There are no conflicts within the group												
Communication within the group functions well and everyone knows what is going on												
Active members have remained mostly the same for the past five years												
All members of the group participate equally in the shared work and work contributions												
All members have the opportunity to invite their own guests to the group's hunts												
I am satisfied with the group's internal decision-making												

What do you think about the following statements regarding moose hunting?
0 completely disagree - 10 completely agree

	0	1	2	3	4	5	6	7	8	9	10	I don`t know
Deer hunting is an important social event for me												
Moose catch is an essential addition to my livelihood												

How often do you meet other members of the group?

	never	very rarely	rarely	occasionally	often	very often
During the hunting season	◯	◯	◯	◯	◯	◯
Outside the hunting season	◯	◯	◯	◯	◯	◯

How is a decision usually made at your group's annual meetings (spring/autumn)?

◯ we all decide together

◯ the board decides

◯ the chair decides

◯ the leader of the hunt decides

◯ the largest landowner decides

◯ we don`t have a meeting

◯ I don`t know

◯ other, what? ______________________

What do you think about the following statements regarding moose hunting? 0 completely disagree - 10 completely disagree

	0	1	2	3	4	5	6	7	8	9	10	I don`t know
The assessment of the moose population made by the Finnish Natural Resources Agency seems to correspond to the real population.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
The number of moose licenses in the 2020/2021 hunting season is too low for our area in relation to the size of the population.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
The number of moose licenses in the 2020/2021 hunting season is too high for our area in relation to the size of the population.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
I am satisfied with the distribution of the moose catch among the members.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
I am satisfied with the moose-hunting opportunities in my group.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
I am satisfied with the distribution of moose licenses between local groups.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
I am satisfied with the way moose hunting is organized in my group.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Table A1.1
This table presents the subsystems of the Social-Ecological Systems (SES) framework and their second-tier variables. We indicate whether each variable was included in the data collection and provide either a brief justification for its exclusion or a short description of how it was operationalized in our study. Since the focus of the study was on the lowest level of decision making, namely, hunters, hunting groups, and local variation, we do not address broader social, economic, and political settings. Some variables in this study have been grouped under other a different subsystem than in the original SES framework.

variable name	included	information
Social, economic and political settings S		
S1 economic development	no	no variation is assumed when considering the outcomes across different hunting groups (-||-)
S2 demographic trends	no	-||-
S3 political stability	no	-||-
S4 other governance systems	no	-||-
S5 markets	no	-||-
S6 media organizations	no	-||-
S7 technology	no	-||-
Resource systems RS		
RS1 sector	no	-||-
RS2 clarity of the system boundaries	no	-||-
RS3 size of resource system	no	hunters` estimation of hunting groups` hunting area was not considered trustable
RS4 human-constructed facilities	no	-||-
RS5 productivity of system	no	this information was not available through a questionnaire
RS6 equilibrium properties	no	-||-
RS7 predictability of system dynamics	no	-||-
RS8 storage characteristics	no	-||-
RS9 location	yes	different wildlife agency areas (15 in total) were included in the models as a random effect
Resource units RU		
RU1 resource unit mobility	no	-||-
RU2 growth or replacement rate	no	-||-
RU3 interaction among resource units	no	-||-
RU4 economic value	no	-||-
RU5 number of units	no	sustainable population perceived as an outcome of the activity
RU6 distinctive characteristics	no	-||-
RU7 spatial and temporal distribution	no	this information was not available through a questionnaire
RU8 social and other values	no	-||-
Governance systems GS		
GS1 government organizations	no	-||-
GS2 nongovernment organizations	no	-||-
GS3.1 network structure	yes	1) collaboration 2) license sharing 3) conflicts with other actors
GS3.2 management strategy	yes	organization

GS4 property-rights system	yes	land-owner members
GS5 operational-choice rules	no	assessment of the decision-making perceived as an outcome of the activity
GS6 collective-choice rules	no	-||-
GS7 constitutional-choice rules	no	-||-
GS8 monitoring and sanctioning processes	no	-||-
Actors A		
A1.1 number of relevant actors	yes	group size, in this study, part of **Governance Systems** subsystem describing the group
A2 socioeconomic attributes of users	yes	1) age 2) gender 3) education 4) land-owning
A3 history or past experiences	yes	hunting experience
A4 location	yes	distance
A5 leadership / entrepreneurship	yes	role
A6 norms (trust-reciprocity) /social capital	yes	social importance
A7 knowledge of SES/mental models	yes	1) knowledge 2) trust in population estimates
A8 importance of resource	yes	livelihood importance
A9 technologies available	no	-||-
Interactions I		
I1 harvesting levels of diverse users	no	satisfaction in harvesting levels perceived as an outcome of the activity
I2 information sharing among users	no	communication perceived as an outcome of the activity
I3 deliberation processes	no	-||-
I4 conflicts	no	conflicts within the group perceived as an outcome of the activity and conflicts with other actors in the area part of the **Governance Systems** subsystem
I5 investment activities	no	-||-
I6 lobbying activities	no	-||-
I7 self-organizing activities	no	-||-
I8 networking activities	no	-||-
I9 monitoring activities	no	-||-
I10 evaluative activities	no	-||-
Outcomes O		
O1 social performance measures	yes	1) decision-making 2) joint action
O2 ecological performance measures	yes	3) natural resource management
O3 externalities to other SES	no	not studied
Related ecosystems ECO		
ECO1 climate patterns	no	-||-
ECO2 pollution patterns	no	-||-
ECO3 flows into and out of focal SES	no	-||-

Table A1.2

There were 4745 respondents (4736 acceptable for analyses), representing approximately 3.9% of the 123 000 hunters with hunting rights for cervids in Finland. Respondents came from all Wildlife Agency areas, with response rates ranging from 2.64% to 5.42% of hunters in each area. To improve representativeness, the data were weighted to better reflect the distribution of hunters across regions.

Wildlife agency area	Number of responses	Share of responses out of all questionnaire responses	Number of cervid hunters in Finland	Share of responses out of cervid hunters in Finland
Etelä-Häme	204	4.3 %	5134	3.97 %
Etelä-Savo	367	7.8 %	7098	5.17 %
Kaakkois-Suomi	235	5.0 %	6887	3.41 %
Kainuu	222	4.7 %	6642	3.34 %
Keski-Suomi	287	6.1 %	6809	4.22 %
Lappi	573	12.1 %	17921	3.20 %
Oulu	467	9.9 %	14257	3.28 %
Pohjanmaa	393	8.3 %	8860	4.44 %
Pohjois-Häme	211	4.5 %	5553	3.80 %
Pohjois-Karjala	296	6.3 %	6507	4.55 %
Pohjois-Savo	338	7.1 %	8414	4.02 %
Rannikko-Pohjanmaa	229	4.8 %	4224	5.42 %
Satakunta	322	6.8 %	7140	4.51 %
Uusimaa	296	6.3 %	11209	2.64 %
Varsinais-Suomi	296	6.3 %	6451	4.59 %
Total	**4736**	**100 %**	**123106**	**3.85 %**

Table A1.3
Age distribution of questionnaire respondents compared to background data for all cervid hunters in Finland. The questionnaire sample includes fewer young hunters (≤24 years) and older hunters (75-84 years), and a higher proportion of hunters aged 35-44 and 45-54, compared to the population data. The data were weighted to more accurately reflect the age distribution of the hunting population.

Data	**≤24 years**	**25-34 years**	**35-44 years**	**45-54 years**	**55-64 years**	**65-74 years**	**75-84 years**	**≥85 years**
Background data	7.5%	11.5%	16.4%	17.7%	20.8%	18.8%	6.7%	0.5%
Questionnaire data	2.9%	11.4%	20.8%	22.2%	22.5%	17.5%	2.7%	0.1%
Difference	-4.6%	-0.1%	4,4%	4.5%	1.7%	-1.3%	-4%	-0.4%

Table A1.4
Descriptive statistics for the outcome and predictor variables used in the Confirmatory Factor Analysis and Structural Equation Model. As the electronic questionnaire did not require responses to all questions, the number of missing values varies across variables (0-9.4%). Although some variables are marked as ordinal, all were treated as either continuous or binary in the analyses. Descriptions of each variable are provided in Table 1.

Variable name	Mean	Min /Max	S.D.	% of missing	variable type	values
Decision-making						
satisfaction	7.91	0/10	2.41	1.7%	continuous	on a scale 0 (completely disagree) – 10 (completely agree) with a statement, I don`t know = NA
functionality	7.95	0/10	2.19	1.8%	continuous	0-10
equality	7.94	0/10	2.41	2.5%	continuous	0-10
inclusiveness	7.47	0/10	2.59	3.8%	continuous	0-10
transparency	7.62	0/10	2.69	5.0%	continuous	0-10
Join action						
team spirit	7.59	0/10	2.26	1.2%	continuous	0-10
rules	8.20	0/10	1.98	1.5%	continuous	0-10
ground rules	8.32	0/10	2.00	1.2%	continuous	0-10
no conflicts	6.85	0/10	2.81	3.5%	continuous	0-10
communication	7.50	0/10	2.43	1.4%	continuous	0-10
participation	5.08	0/10	2.78	2.5%	continuous	0-10
catch sharing S	8.88	0/10	1.84	4.8%	continuous	0-10
hunting opportunities S	8.90	0/10	1.82	2.6%	continuous	0-10
hunt organizing S	8.44	0/10	2.04	2.7%	continuous	0-10
Natural resource management						
sustainable population	7.33	0/10	2.74	2.5%	continuous	0-10
license recommendation	8.85	0/10	1.85	6.7%	continuous	0-10
calf recommendation	9.00	0/10	1.72	3.7%	continuous	0-10
bull recommendation	8.53	0/10	1.96	3.8%	continuous	0-10
cow recommendation	8.34	0/10	2.21	3.9%	continuous	0-10
antler recommendation	7.42	0/10	2.74	7.2%	continuous	0-10
Actors						
age	50.80	18/91	13.99	0%	continuous	years
gender	0.06	0/1	0.23	0.3%	binary	male = 0, female / other = 1
education	1.50	0/3	0.87	0%	ordinal	primary school = 0, upper secondary school = 1, bachelor's degree = 2, master`s degree = 3
experience	21.16	0/62	14.87	2.6%	continuous	years as a member

distance	1.52	0/4	1.33	0.1%	ordinal	lives in the hunting area = 0, <10 km = 1, 10-49 km = 2, 50-199 km = 3, 200 km or more = 4
role	3.41	1/5	0.75	1.2%	ordinal	occasional guest = 1, regular = guest = 2, member = 3, member of the board and / or vice chair = 4, chair = 5
social importance	8.49	0/10	2.13	2.4%	continuous	0-10
livelihood importance	2.98	0/10	3.15	2.6%	continuous	0-10
land-owning	0.51	0/1	0.50	0.5%	binary	no = 0, yes = 1
knowledge	7.85	0/10	1.86	2.5%	continuous	0-10
trust	5.97	0/10	2.62	9.4%	continuous	0-10
Governance Systems						
collaboration	7.47	0/10	2.24	3.4%	continuous	0-10
license sharing	0.73	0/1	0.45	0%	binary	no / I don`t know = 0, yes = 1
conflicts	3.44	0/10	3.09	8.0%	continuous	0-10
organization	0.85	0/1	0.36	1.8%	binary	non-registered = 0, registered = 1, I don`t know = NA
land-owner members	3.25	0/6	1.45	5.5%	ordinal	no one = 1, one = 1, less than half = 2, around half = 3, over half = 4, almost everyone = 5, everyone = 6, I don`t know = NA
group size	28.49	0/300	28.55	3.2%	continuous	number of active members (divided by 10 for analyses)
Cooperation						
meetings during season	3.95	0/5	0.91	0.4%	ordinal	never = 0, very rarely = 1, rarely = 2, now and then = 3, often = 4, very often = 5
meetings outside season	3.06	0/5	1.04	0.4%	ordinal	never = 0, very rarely = 1, rarely = 2, now and then = 3, often = 4, very often = 5
relatedness	0.87	0/4	0.85	0.5%	ordinal	relatives in the group: not at all = 0, few = 1, some = 2, many = 3, very many = 4
same members	8.87	0/10	1.48	2.5%	continuous	0-10
new members	3.35	0/5	0.98	4.4%	ordinal	never = 0, very rarely = 1, rarely = 2, often = 3, very often = 4, always = 5, I don`t know = NA
guests	1.63	0/5	1.05	0.4%	ordinal	never = 0, very rarely = 1, rarely = 2,

		regularly = 3, very often = 4, always = 5

Table A1.5

Selection of variables used to describe Actors, Governance, and Cooperation, along with predictions of their influence on Decision-making, Joint action, and Natural resource management. The literature referenced in the table can be found in Supplementary Text 1 below.

SES variable name	Variable name	Selection and predictions
Actors A		
socioeconomic attributes of users A2	age	Demographic variables are important in determining hunters` attitudes and values[1], and satisfaction in groups` collective action[2,3,4]. Age has been found to correlate negatively with support for management decisions[5,6] and hunter satisfaction[7], possibly due to higher expectations developed with time. However, it has been found that age can be positively associated with increased trust and stronger social relationships with other members[8,9].
	gender education	Demographic variables are important in determining hunters` attitudes and values[1], and satisfaction in groups` collective action[2,3,4].
	land-owning	Owning land in the hunting area can strengthen the ties to the local community developing shared norms and trust, which positively influence the management and satisfaction with it[10].
history or past experiences A3	experience	Hunting experience is important in determining hunters` attitudes and values[1], and satisfaction in groups` collective action[2,3,4]. Experience has been found to correlate negatively with support for management decisions[5,6] and hunter satisfaction[7], possibly due to higher expectations developed with time. It has been also found to be positively associated with increased trust and stronger social relationships with other members[8,9].
location A4	distance	Shorter distance to the hunting grounds is also assumed to be related to locality, which can lead to shared identity[11], higher knowledge about the resource[12], and importance of the activity[13].
leadership / entrepreneurship A5	role	When hunters have an important role in the group, they can be more satisfied due to higher decision power[14] and benefits[15].
norms / social capital A6	social importance	Social capital is a key variable in SES framework[2,16] and it is expected that higher social importance given to hunting positively influences management[8,9].
knowledge of SES / mental models A7	knowledge	Hunters` knowledge about the resource can lead to more realistic expectations of the hunt and well-planned management, leading to higher satisfaction and compliance with the management decisions[17,18].
	trust	Trust in population estimates is needed for hunters` compliance with the regulations[5] and acceptance of management[6,19,20].
importance of resource A8	livelihood importance	High livelihood importance, i.e. dependence on the resource, can make rule creation easier[21] and hunters more committed to the activity[2].
Governance systems GS		
network structure GS1	collaboration license sharing	Collaboration with other hunting groups can lead to social control and shared trust and strategies between the groups

		and create more accurate knowledge on the mobile moose population[22,23,24]. Therefore, it is expected that hunters in hunting groups, which collaborate and collaborate by license-sharing with other hunting groups in the area are more satisfied and comply with the recommendations.
	conflicts	Conversely, we expect the conflicts with other in the area to have a negative influence in the management[11].
management strategy GS3.2	organization (registered society / non-registered hunting group)	We expect that a more democratic society would lead to more satisfaction with the management due to wider involvement in decisions, and more equal benefits for all hunters[15,22].
property rights system GS4	land-owner members	It is expected that a lower share of hunters who are landowners can increase inequality in the group leading to dissatisfaction in management[11].
number of relevant actors A1	group size	It has been found that groups need to be large enough for effective management but a larger member group size is more demanding for decision agreement and can be associated with decreased trust and reciprocity[2,8]. Therefore, it is beneficial for the group size to be relatively small.
Cooperation (not part of the SES framework)		
When individuals interact with each other more often and the group members remain more or less the same (stable), reciprocity increases leading to higher benefits for cooperators[25,26].		
repetition of interactions	meetings during season	Face-to-face communication has been repeatedly found to positively influence sustainable resource management and decision-making[10,22], and increase trust[8,27].
	meetings outside season	
relatedness	relatedness	Relatedness between individuals can lead to more communication as well as higher number of cooperators in a group because the benefits are likely to be shared between family members[28]. In addition, relatedness between some members may increase benefits for them[29] (nepotism) and the hunters with more relatives in the group to be more satisfied with the management, whereas the opposite could be the case for those hunters who don`t have relatives as group members.
stability of groups	same members	Stability by intact management groups has been found to be positive for moose management through creation of commitment[12].
	new members	
	guests	

Bibliography for Table A1.5

1. Gamborg, C. & Jensen, F. S. Wildlife value orientations among hunters, landowners, and the general public: A Danish comparative quantitative study. *Human Dimensions of Wildlife* **21**, 328-344 (2016).
2. Ostrom, E. A general framework for analyzing sustainability of social-ecological systems. *Science* **325**, 419-422 (2009). https://doi.org:10.1126/science.1172133
3. Partelow, S. A review of the social-ecological systems framework: Applications, methods, modifications, and challenges. Ecology and Society 23 (2018). https://doi.org:10.5751/ES-10594-230436
4. Agrawal, A. Common Property Institutions and Sustainable Governance of Resources. *World Development* **29**, 1649-1672 (2001). https://doi.org:10.1016/S0305-750X(01)00063-8
5. Schroeder, S. A., Fulton, D. C., Lawrence, J. S. & Cordts, S. D. How hunter perceptions of wildlife regulations, agency trust, and satisfaction affect attitudes about duck bag limits. *Human Dimensions of Wildlife* **22**, 454-475 (2017).
6. Schroeder, S. A., Cornicelli, L., Fulton, D. C. & Grund, M. D. What predicts support for antler point restrictions? *Human Dimensions of Wildlife* **19**, 301-318 (2014).
7. Gigliotti, L. M. A classification scheme to better understand satisfaction of Black Hills deer hunters: the role of harvest success. *Human Dimensions of Wildlife* **5**, 32-51 (2000).
8. Wagner, M. W., Kreuter, U. P., Kaiser, R. A. & Wilkins, R. N. Collective action and social capital of wildlife management associations. *The Journal of wildlife management* **71**, 1729-1738 (2007).
9. Mitterling, A. M., Rudolph, B. A. & Kramer, D. B. The influence of private land deer management cooperatives on harvest outcomes and hunter satisfaction. *Wildlife Society Bulletin* **45**, 456-464 (2021).
10. Ostrom, E. A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences of the United States of America* **104**, 15181-15187 (2007). https://doi.org:10.1073/pnas.0702288104
11. Ratner, B., Meinzen-Dick, R., May, C. & Haglund, E. Resource conflict, collective action, and resilience: an analytical framework. *International Journal of the Commons* **7** (2013).
12. Dressel, S., Sjölander-Lindqvist, A., Johansson, M., Ericsson, G. & Sandström, C. Achieving social and ecological outcomes in collaborative environmental governance: Good examples from swedish moose management. *Sustainability (Switzerland)* **13**, 1-21 (2021). https://doi.org:10.3390/SU13042329
13. Chhatre, A. & Agrawal, A. Trade-offs and synergies between carbon storage and livelihood benefits from forest commons. *Proceedings of the national Academy of sciences* **106**, 17667-17670 (2009).
14. Sandström, C., Di Gasper, S. W. & Öhman, K. Conflict resolution through ecosystem-based management: the case of Swedish moose management. *International Journal of the Commons* **7** (2013).
15. Béné, C. *et al.* Power struggle, dispute and alliance over local resources: analyzing 'democratic'decentralization of natural resources through the lenses of Africa inland fisheries. *World Development* **37**, 1935-1950 (2009).
16. Ostrom, E., Ahn, T. K. & Kingdom, U. a Social Science Perspective on Social Capital. *Sociology The Journal Of The British Sociological Association*, 812-855 (2001).
17. Decker, D. J., Brown, T. L. & Gutierrez, R. J. Further insights into the multiple-satisfactions approach for hunter management. *Wildlife Society Bulletin*, 323-331 (1980).
18. Dressel, S. *et al.* Evaluating the outcomes of collaborative wildlife governance: The role of social-ecological system context and collaboration dynamics. *Land Use Policy* **99**, 105028-105028 (2020). https://doi.org:10.1016/J.LANDUSEPOL.2020.105028

19. Brinkman, T. J. Hunter acceptance of antlerless moose harvest in Alaska: importance of agency trust, proximity of hunter residence to hunting area, and hunting experience. *Human Dimensions of Wildlife* **23**, 129-145 (2018).
20. Riley, S. J., Ford, J. K., Triezenberg, H. A. & Lederle, P. E. Stakeholder trust in a state wildlife agency. *The Journal of Wildlife Management* **82**, 1528-1535 (2018).
21. Acheson, J. M. Institutional failure in resource management. *Annual Review of Anthropology* **35**, 117-134 (2006).
22. Ostrom, E. *Understanding institutional diversity*. (Princeton university press, 2009).
23. Woods, G. R., Guynn, D. C., Hammitt, W. E. & Patterson, M. E. Determinants of participant satisfaction with quality deer management. *Wildlife Society Bulletin*, 318-324 (1996).
24. Bodin, Ö., Sandström, A. & Crona, B. Collaborative networks for effective ecosystem-based management: A set of working hypotheses. *Policy Studies Journal* **45**, 289-314 (2017).
25. Axelrod, R. & Hamilton, W. D. The evolution of cooperation. *science* **211**, 1390-1396 (1981).
26. Nowak, M. A. Five rules for the evolution of cooperation. *science* **314**, 1560-1563 (2006).
27. Fiorini, S., Yearley, S. & Dandy, N. Wild Deer, Multivalence, and Institutional Adaptation: The" Deer Management Group" in Britain. *Human Organization* **70**, 179-188 (2011).
28. Queller, D. C. Expanded social fitness and Hamilton's rule for kin, kith, and kind. *Proceedings of the National Academy of Sciences of the United States of America* **108**, 10792-10799 (2011). https://doi.org:10.1073/pnas.1100298108
29. Bollig, M. Towards an Arid Eden? Boundary making, governance and benefit sharing and the political ecology of the "new commons" of Kunene Region, Northern Namibia. *International Journal of the Commons* **10** (2016).

Table A1.6

Correlation matrix for the Decision-making variables. Correlations greater than 0.5 are considered strong and are bolded.

Variable name	satisfaction	functionality	equality	inclusiveness	transparency
satisfaction	**1.000**				
functionality	**0.836**	**1.000**			
equality	**0.827**	**0.823**	**1.000**		
inclusiveness	**0.744**	**0.741**	**0.771**	**1.000**	
transparency	**0.579**	**0.577**	**0.570**	**0.513**	**1.000**

Table A1.7

Correlation matrix for the Joint action variables. Correlations greater than 0.5 are considered strong and are bolded.

Variable name	team spirit	rules	ground rules	no conflicts	commun-ication	partici-pation	catch sharing S	hunting opportu-nities S	hunt organizing S
team spirit	**1.000**								
rules	**0.690**	**1.000**							
ground rules	**0.680**	**0.843**	**1.000**						
no conflicts	**0.760**	**0.593**	**0.585**	**1.000**					
communication	**0.721**	**0.661**	**0.652**	**0.620**	**1.000**				
participation	0.412	0.377	0.372	0.354	0.394	**1.000**			
catch sharing S	0.437	0.401	0.395	0.376	0.419	0.239	**1.000**		
hunting opportunities S	0.499	0.457	0.451	0.429	0.478	0.273	0.479	**1.000**	
hunt organizing S	**0.667**	**0.612**	**0.603**	**0.574**	**0.639**	0.365	0.388	**0.639**	**1.000**

Table A1.8

Correlation matrix for the Natural resource management variables. Correlations greater than 0.5 are considered strong and are bolded.

Variable name	sustainable population	license recommendation	calf rec.	bull rec.	cow rec.	antler rec.
sustainable population	**1.000**					
license recommendation	0.190	**1.000**				
calf rec.	0.320	0.305	**1.000**			
bull rec.	0.370	0.353	**0.597**	**1.000**		
cow rec.	0.341	0.326	**0.550**	**0.637**	**1.000**	
antler rec.	0.306	0.292	0.493	**0.571**	**0.526**	**1.000**

Table A1.9

ICC values for variables under Wildlife Agency clusters. Values above 0.05 indicate that the clustering effect is significant. Therefore, variables such as bull recommendation, antler recommendation, group size, distance, livelihood importance, and relatedness are weakly influenced by different Wildlife Agency areas. Wildlife Agency area was included as a clustering variable in the models.

variable	**ICC**
satisfaction	0.016
working	0.019
equality	0.017
all included	0.015
transparency	0.008
team spirit	0.017
rules followed	0.015
working rules followed	0.009
no conflicts	0.021
communication	0.018
voluntary work	0.015
catch shared	0.017
hunting opportunities	0.012
hunting organized	0.013
sustainable population	0.048
license recommendation	0.007
bull recommendation	**0.052**
cow recommendation	0.030
antler recommendation	**0.066**
license sharing	0.027
collaboration	0.014
conflicts	0.016
registered / non-registered	0.029
member land-owning	0.015
group size	**0.141**
age	0.021
gender	0.004
education	0.019
experience	0.013
distance	**0.068**
role	0.015
social importance	0.011
livelihood importance	**0.070**
group meetings during season	0.007
group meetings outside season	0.011
relatedness	**0.062**
stability	0.014

Figure A1.2

Measurement model (Confirmatory Factor Analysis) script for decision-making, joint action, and natural resource management. Analysis performed in Mplus.

```
TITLE:     Measurement model for Finnish hunting group management (CFA);
DATA:      FILE IS moose_hunting.dat;
VARIABLE: NAMES ARE !all the variable names listed as they appear in the excel file
           number agency organi role experien landown educa
           age groupsiz relativ guests landowm distance knowledg
           monitor sustaina licereco liceuse calfreco bullreco cowreco antlreco
           newmem join licensha shareno sharedec collab collabmo conflict
           transpa function equal inclusi teamspir rules
           groundrul noconfl commun samemem partici guestpos satisfac sociimp
           liveimp meetduri meetout trust low high catch huntoppo
           licegro huntorga weight gender;
           USEVARIABLES ARE !the variables used in the analyses (only the ones for latents)
           agency sustaina licereco calfreco bullreco cowreco antlreco
           transpa function equal inclusi teamspir rules
           groundrul noconfl commun partici satisfac
           catch huntoppo huntorga weight;
           MISSING ARE ALL (-99);
           WEIGHT = weight;
           CLUSTER = agency;
ANALYSIS:  ESTIMATOR = MLR;
           ITERATIONS = 50; !max. number of iterations
           TYPE = COMPLEX;
MODEL:     decision BY satisfac@1 function equal
           inclusi transpa; !decision-making 5 statetments
           decision;
           joint BY teamspir@1 rules groundru
           noconfl commun partici
           catch huntoppo huntorga; ! joint action 9 statements
           joint;
           natural BY sustaina@1 licereco calfreco bullreco
           cowreco antlreco; ! natural resource management 6 statements
           natural;
           rules WITH groundru;
           noconfl WITH teamspir;
           huntoppo WITH huntorga;
           huntoppo WITH catch;
           equal WITH inclusi;
OUTPUT:    STANDARDIZED TECH1 TECH4 MODINDICES(ALL 0)
```

Figure A1.3
Multiple imputation for moose hunting data for predictive variables, i.e., composite indicators. Analysis performed in Mplus.

```
TITLE:      Multiple imputation for moose hunting data;
DATA:       FILE IS moose_hunting.dat;
VARIABLE: NAMES ARE !all the variable names listed in the order they appear in the excel
            number agency organi role experien landown educa
            age groupsiz relativ guests landowm distance knowledg
            monitor sustaina licereco liceuse calfreco bullreco cowreco antlreco
            newmem join licensha shareno sharedec collab collabmo conflict
            transpa function equal inclusi teamspir rules
            groundrul noconfl commun samemem partici guestpos satisfac sociimp
            liveimp meetduri meetout trust low high catch huntoppo
            licegro huntorga weight gender;
     USEVARIABLES ARE ! Variables used in the imputation. There are variables included in the code,
            ! which are used in the data imputation to improve the quality of the results,
            ! but are not used in the further analyses.
            organi role experien landown educa
            age groupsiz relativ guests landowm distance knowledg
            monitor sustaina licereco liceuse calfreco bullreco cowreco antlreco
            newmem join licensha shareno sharedec collab collabmo conflict
            transpa function equal inclusi teamspir rules
            groundrul noconfl commun samemem partici guestpos satisfac sociimp
            liveimp meetduri meetout trust low high catch huntoppo
            licegro huntorga gender;
          AUXILIARY = number agency weight;
          MISSING ARE ALL (-99); ! All the missing values are coded as -99 in the file
DATA IMPUTATION: !The predictor variables are imputed (IMPUTE command) in the datasets and all
                 !the variables (USEVARIABLES command) are used in
                 !the imputation as they can be predictive of missingness
          IMPUTE = rooli (c) kokemus maanomv (c) koulutus (c)
          age etaisyys (c) tiedot (c) social (c) toimeent (c)
          gender (c) seura (c) yhteisty (c) luke (c) maanomj (c)
          yhteislu (c) konflikt (c) ryhmakok
          samatjas (c) vieraat (c) meetkaus (c) ! Non-continuous variables marked with (c)
          meetulko (c) sukulai (c) uujasen (c);
           NDATASETS = 10; !10 imputed datasets created for the analyses
           SAVE = huntimp*.dat;
ANALYSIS:  TYPE = BASIC;
```

Figure A1.4

Structural Equation Model for hunting group management. Analysis performed in Mplus. The minor spatial non-independence is accounted for by including Wildlife Agency areas (n = 15) as a cluster variable and using the complex analysis method in Mplus. The complex analysis method applies a sandwich estimator to estimate standard errors, which more accurately accounts for the variability in the regression coefficients due to clustering (McNeish et al. 2017).

```
TITLE:     Structural Equation model;
DATA:      FILE IS huntimplist.dat;
           TYPE = IMPUTATION;
VARIABLE: NAMES ARE !all the variable names listed as they appear in the data file
           organi role experien landown educa
           age groupsiz relativ guests landowm distance knowledg
           monitor sustaina licereco liceuse calfreco bullreco cowreco antlreco
           newmem join licensha shareno sharedec collab collabmo conflict
           transpa function equal inclusi teamspir rules
           groundrul noconfl commun samemem partici guestpos satisfac sociimp
           liveimp meetduri meetout trust low high catch huntoppo
           licegro huntorga gender number agency weight;
           USEVARIABLES ARE !the variables used in the analyses
           agency huntorga catch huntoppo commun
           rules groundrul partici teamspir noconfl
           sustaina licereco calfreco bullreco cowreco antlreco
           function equal inclusi transpa satisfac
           organi role experien landown educa
           age groupsiz relativ guests landowm distance knowledg
           newmem licensha collab conflict
           samemem sociimp liveimp meetduri meetout
           trust gender weight;
           MISSING = *; !missing values marked with asterix in the data file
           WEIGHT = weight;
           CLUSTER = agency;
DEFINE:    groupsiz = groupsiz / 10; !the variable is divided with 10 to standardize the variances
ANALYSIS: ESTIMATOR = MLR;
           ITERATIONS = 1000; !max. number of iterations to converge
           TYPE = COMPLEX;
MODEL:     decision BY satisfac@1 function equal
           inclusi transpa; !decision-making 5 statetments
           decision;
           joint BY teamspir@1 rules groundru
           noconfl commun partici
           catch huntoppo huntorga; ! joint action 9 statements
           joint;
           natural BY sustaina@1 licereco calfreco bullreco
           cowreco antlreco; ! natural resource management 6 statements
           natural;
           actors BY;
           actors ON role@1 experien landown educa
           age gender distance knowledge sociimp liveimp gender trust;
           actors@0;
           decision joint natural ON actors;
           governan BY;
```

```
          governan ON organi@1 collab conflict licensha
          landowm groupsiz;
          governan@0;
          decision joint natural ON governan;
          coopera BY;
          coopera ON samemem@1 guests meetduri
          meetout relative newmem;
          coopera@0;
          decision join natural ON coopera;
          rules WITH groundru;
          noconfl WITH teamspir;
          huntoppo WITH huntorga;
          huntoppo WITH catch;
          equal WITH inclusi;
OUTPUT:   STANDARDIZED TECH1 TECH4 RESIDUAL
```

Table A1.10

Estimated correlations for the variables in the actors composite. Correlations over 0.5 are considered strong and are bolded.

Variable name	age	gender	educa-tion	experience	distance	role	social impor t-ance	liveli-hood impor t-ance	land-owning	know-ledge	trust
age	**1.000**										
gender	-0.143	**1.000**									
education	-0.059	0.054	**1.000**								
experience	**0.582**	-0.161	-0.113	**1.000**							
distance	-0.085	0.002	0.218	-0.145	**1.000**						
role	0.085	-0.098	-0.022	0.171	-0.133	**1.000**					
social importance	0.121	-0.045	-0.081	0.132	0.006	0.145	**1.000**				
livelihood importance	0.025	0.063	-0.092	0.049	-0.109	-0.013	0.079	**1.000**			
land-owning	0.164	-0.064	0.044	0.243	-0.226	0.109	0.034	0.031	**1.000**		
knowledge	0.128	-0.082	-0.057	0.213	-0.162	0.204	0.210	0.004	0.109	**1.000**	
trust	0.033	0.004	0.051	-0.037	0.065	0.003	0.119	0.032	-0.053	-0.041	**1.000**

Table A1.11

Estimated correlations for the variables in the governance systems composite. Correlations over 0.5 are considered strong and are bolded.

Variable name	collaboration	license sharing	conflicts	organization	land-owner members	group size
collaboration	**1.000**					
license sharing	0.165	**1.000**				
conflicts	-0.283	-0.010	**1.000**			
organization	0.043	0.048	0.052	**1.000**		
land-owner members	0.027	-0.003	0.014	0.113	**1.000**	
group size	0.011	-0.095	0.005	0.145	0.062	**1.000**

Table A1.12

Estimated correlations for the variables in the cooperation composite. Correlations over 0.5 are considered strong and are bolded.

Variable name	meetings during season	meetings outside season	relatedness	same members	new members	guests
meetings during season	**1.000**					
meetings outside season	**0.584**	**1.000**				
relatedness	0.092	0.107	**1.000**			
same members	0.104	0.064	0.046	**1.000**		
new members	0.089	0.087	0.064	0.012	**1.000**	
guests	0.059	0.029	-0.020	-0.032	-0.040	**1.000**