Environmental Science and Policy 104 (2020) 88–97

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Perceived adaptive capacity within a multi-level governance setting: The role of bonding, bridging, and linking social capital

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ARTICLE INFO

Keywords:
Adaptive capacity
Multi-level governance
Social capital
Social trust
Social-ecological system
Social learning

ABSTRACT

In 2012 Sweden implemented a collaborative governance regime for managing moose (*Alces alces*). This was guided by the awareness that decentralization and stakeholder participation can help to reduce conflicts, foster systematic learning, and handle complexity. However, previous research has highlighted that there are no blueprint approaches to the governance and management of natural resources. In this case, diverse multi-use landscapes, ever-changing ungulate populations, and other external stressors (e.g. climate change, wildlife diseases) can create challenges for collaborative institutions. Adaptive capacity is therefore needed as it allows a system and the actors involved to react successfully to social-ecological changes and to develop even in times of no imminent change or risk. Using Swedish moose management as an example of a multi-level governance system, this research assesses the critical determinants of adaptive capacity across levels. We developed and applied a psychometric approach to measure actors' perceived adaptive capacity on two levels in the management system. A web-based survey was sent to Moose Management Groups (n = 765, response rate = 81 %) and Moose Management Units (n = 1,380, response rate = 71 %). Using structural equation modelling, we assessed the relative importance of governance aspects, different types of social capital, as well as human and financial capital on actors' perceived adaptive capacity. Linking and bridging social capital in the system had significant impacts on both levels. Actors felt more prepared to handle future challenges in moose management when they perceived benefits through collaborations with levels below and expressed social trust in authorities and the management level above. Besides those similarities between the two levels, fairness was a more important determinant of actors' perceived adaptive capacity on the lower management level. These results can contribute to a future improvement of the collaborative governance setting by finessing strategic interventions on different levels. Furthermore, our results illustrate the importance of scale when assessing the adaptive capacity of a system.

1. Introduction

Natural resources are part of complex social-ecological systems which are prone to constant change. Acknowledging this source of uncertainty and applying a holistic perspective on the linkages between the social and ecological components of a system have led to the emergence of a new view on natural resource governance (Berkes, 2009; Nelson et al., 2007; Pahl-Wostl, 2009). More adaptive governance regimes aim for public-private partnerships and institutions that can adjust to changes and local circumstances (Berkes, 2009; Dietz et al., 2003). Power sharing and a focus on systematic learning that provides information on ecological processes on a more local scale can also contribute to policy refinements (Berkes, 2009; Nelson et al., 2007; Pahl-Wostl, 2009): a social system can co-evolve with an ecological system so as to avoid a problem of fit and panacea traps (Brock and Carpenter, 2007; Ostrom et al., 2007).

Climate change research promotes adaptive capacity as one way of dealing with increased uncertainty (Engle, 2011). According to Gallopín (2006) the adaptive capacity of social-ecological systems (SESs) involves "two different components, namely (1) the capacity of the SES to cope with environmental contingencies (to be able to maintain or even improve its condition in the face of changes in its environment(s)) and (2) the capacity to improve its condition in relation to its environment(s), even if the latter does not change, or to extend the range of environments to which it is adapted" (p. 300). Thus, the concept contains both a reactive and a proactive component. The

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https://doi.org/10.1016/j.envsci.2019.11.011
Received 6 September 2019; Received in revised form 23 November 2019; Accepted 26 November 2019
Available online 09 December 2019

innate capacity of a system and its involved actors to respond to change of all kinds is critical for its long-term success (Engle and Lemos, 2010), while the proactive learning component could contribute to the local and institutional fit of a system (Pahl-Wostl, 2009).

Previous research has shown that adaptive co-management and similar participatory approaches can increase the adaptive capacity of a SES and its actors (Armitage, 2005; Berkes, 2017; Folke et al., 2002; Morrison et al., 2017; Pahl-Wostl, 2009). However, no blueprints for the design of such management approaches exist, and any governance system has to be adjusted to highly specific social and ecological circumstances. The governance, institutional, and socio-economic aspects of a system can significantly influence its adaptive capacity for better or worse (Adger, 2001; Engle and Lemos, 2010; Morrison et al., 2017). Consequently, these aspects should be considered when designing natural resource management structures.

Adaptive behaviours must exist across multiple scales, from individual actors to local collective actions and up to national governments taking action on behalf of society (Adger, 2003; Nelson et al., 2007). Therefore, adaptive capacity should be viewed as a systemic property in which the institutional context can facilitate or constrain the adaptability of individual actors (Eakin and Lemos, 2010; Robinson and Berkes, 2011; Vincent, 2007). Adaptive capacity has to be understood at the level at which adaptive actions have to occur (Adger et al., 2005). In multi-level governance settings, single-level evaluations of adaptive capacity will overlook the scale-dependent variations (Juhola and Westerhoff, 2011). High adaptive capacity on one level will not necessarily lead to overall high adaptive capacity of the whole system (Goldman and Riosmena, 2013). Vertical and horizontal linkages in the governance system are needed for creating and/or improving overall adaptive capacity (Robinson and Berkes, 2011). Upwards linkages can provide actors with access to additional resources and support, while downward linkages can help to achieve adaptations and changes at the local scale (Juhola and Westerhoff, 2011; Pelling and High, 2005). Thus, the existence of adaptive capacity across scale has high importance for the long-term success of a system.

While it is theoretically well established that adaptive capacity is scale dependent, empirical understanding is still limited. The development of research methods that can be applied across scales within the same system has proved to be challenging (Waters and Adger, 2017; Whitney et al.,2017; Vincent, 2007). In this study, we use the case of moose (*Alces alces*) management in Sweden as an example of a multi-level governance system, developing an instrument that quantitatively assesses adaptive capacity at different levels, thereby allowing for the study of scale dependency. We gain a better understanding of the dynamics between levels, help to identify policy gaps, and analyse which capitals should be strengthened at each level to increase overall adaptive capacity.

1.1. Swedish moose management

Sweden currently has one of the world's densest moose populations (Wallgren, 2016), but this was not always the case. As Fig. 1 shows, both the moose population and corresponding management approaches have changed considerably during the past century (Danell et al., 2016; Sandström et al., 2013). While in 1966 only 30.000 moose were harvested, less than 20 years later the population had grown exponentially, with a yearly harvest of roughly 180.000 (Liberg et al., 2010). During the last 10 years the yearly hunting quota has varied between 80.000 and 100.000 individuals per year, and the summer population is estimated at 300.000–400.000 animals (SAHWM, 2019).

Management has not always been able to keep up with the drastic changes in ungulate populations, which has resulted in damage to forestry and negative implications for biodiversity (Danell et al., 2016; Liberg et al., 2010). As a response to conflicts due to high browsing pressure, Swedish moose management underwent radical institutional changes in 2012 (Sandström et al., 2013). The new multi-level governance system then introduced is characterized by a focus on collaboration and ecosystem-based management (Regeringens Proposition, 2009/10:239; see Fig. 2 Following the Malawi principles of the ecosystem approach (CBD SBSTTA, 2000), relevant actors are involved in decision-making processes across all scales to find a balance between different societal interests while at the same time managing the ecosystem within its functional limits (i.e. the moose population).

On a national scale, the Swedish Environmental Protection Agency has the overarching responsibility for wildlife management while the Swedish Forest Agency is in charge of forest-related issues, including the monitoring of browsing damage. On the county level Wildlife Management Delegations (WMDs), which involve 15–19 representatives of different land use and public interest groups, provide general guidelines on wildlife management and regional population goals to the County Administrative Boards (CABs). CABs have the authoritative responsibility for moose management. To mimic the ecosystem level, so-called Moose Management Areas have been established (Fig. 1), which should comprise 80 % of a distinct moose population. Each of these areas is overseen by a Moose Management Group (MMG). MMGs consist of three landowner and three hunting representatives, while in the northernmost counties, one representative for reindeer husbandry replaces a hunting representative. MMGs play a central role as they establish adaptive management plans for the ecosystem level and coordinate with multiple Moose Management Units (MMUs). MMUs are voluntary collaborative groups of local landowners and hunting teams with varying organizational structures (no mandatory regulations exist for their governance). The chance to create their own management plans and a longer hunting period are used as incentives to motivate hunters and landowners to build MMUs. Collaboration between MMGs and their respective MMUs links the formalized management levels to local resource users and allows for local decision-making while still managing moose on an ecosystem level (Fig. 2). MMGs and MMUs need adaptive capacity to respond to changes while maintaining a functioning management system: both levels have to formulate goals, set up management plans, carry out management actions and monitoring, and evaluate and adapt their plans as circumstances change. Furthermore, these two levels need to be aligned in their management strategy to have a functioning system; this builds ultimately on good collaborative relationships among and between them.

In the context of Swedish moose management different social and ecological stressors have been identified, which will almost certainly require future adaptation of the actors and the system (Dressel et al., 2018; see Fig. 1): From an ecological perspective new co-occurrence of multiple ungulate species, the presence of large carnivores, and fluctuations in browsing resources will all call for adjustments to management strategies. Additionally, social factors such as variations in land ownership and land use patterns across the country require local adaptations (Dressel et al., 2018). Recent studies also indicate that climate change might affect habitat use and the condition of the Swedish moose population (Allen et al., 2016a, b) as well as the prevalence of disease and parasites (Malmsten et al., 2018), all of which adds further uncertainty to management. Adaptive capacity will be needed to reduce the probability of negative outcomes and to allow the system to adapt in line with any social-ecological changes that do occur. From a policy perspective, the following questions arise: (1) Does the new management regime enable adaptive capacity; (2) What are the critical determinants of it; and (3) How could adaptive capacity be enhanced.

1.2. Theoretical framework

In setting out our theoretical framework several general points can be made. Firstly, it should be noted that previous research has highlighted both the lack of conceptual clarity when it comes to adaptive capacity (Gallopín, 2006) and a multitude of components that have

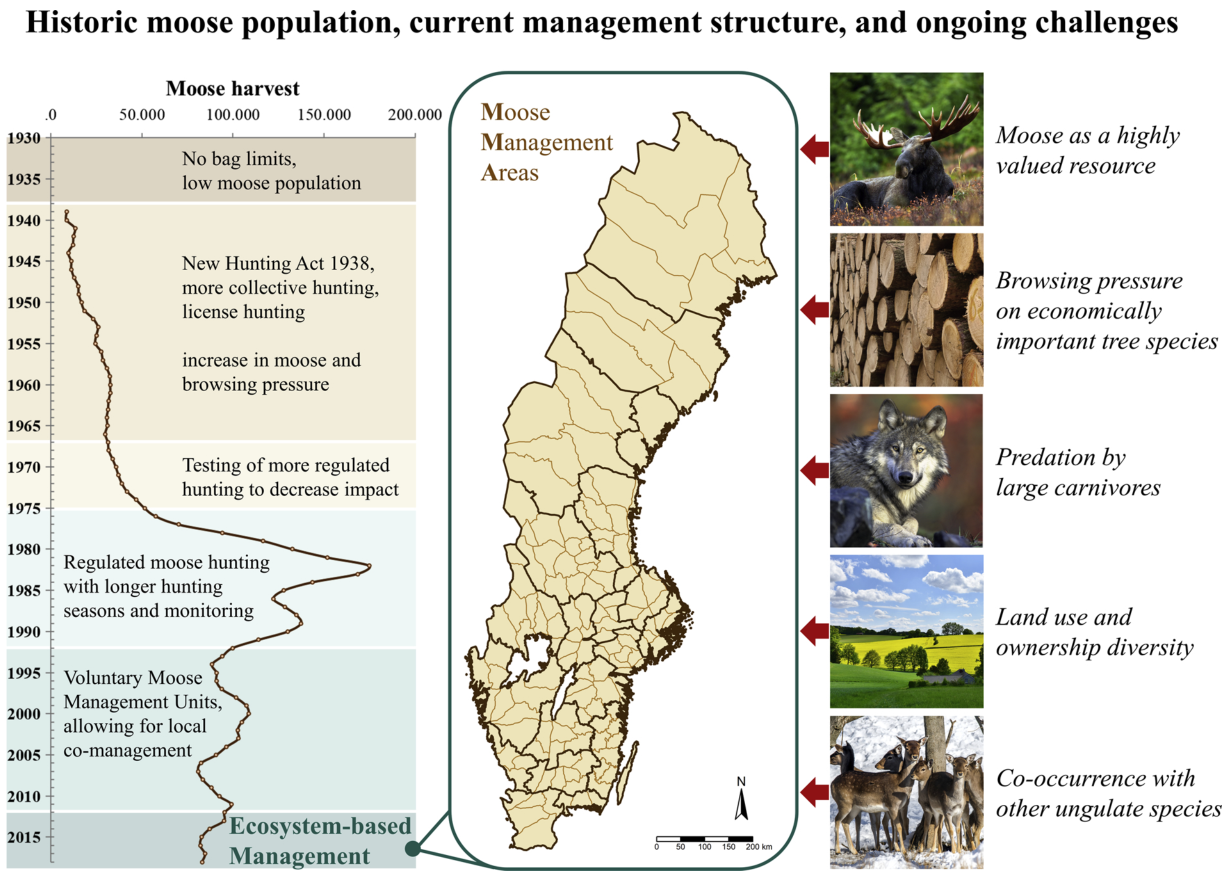

Fig. 1. Development of the Swedish moose population and different phases of its management up to the current ecosystem-based management approach. The map shows borders of Moose Management Areas (light brown) and the respective county borders (dark brown). Some of the challenges that have been identified for the current moose management system (see Dressel et al., 2018) are illustrated. Moose harvest data was extracted from https://rapport.viltdata.se/statistik/.

been identified as beneficial for it (Engle and Lemos, 2010; Whitney et al., 2017). Secondly, the determinants of adaptive capacity have usually been framed in terms of human, financial, physical, social, and natural capital (Whitney et al., 2017). Finally, it should also be mentioned that with regard to natural resources, the adaptive capacity of forest management (Keskitalo, 2013) and fisheries management (Malakar et al., 2018; Seara et al., 2016; Whitney et al., 2017) has been assessed, but the subject has rarely been considered in the context of wildlife management (Wagner et al., 2007) – a notable research gap that clearly needs attention.

Adaptive capacity is commonly assessed via national indicators; however, this study focuses on actors' perceived adaptive capacity, as individuals' perception of their abilities and constraints will ultimately guide their adaptive behaviour (Grothmann and Patt, 2005; Seara et al., 2016). While national indicators might portray the theoretically available resources (e.g. technical or financial capital), perceived adaptive capacity takes into consideration an individual's view on the adequacy of these resources (Elrick-Barr et al., 2017; Seara et al., 2016; Whitney et al., 2017); and of course the perceptions and actions of individuals have cumulative effects on system and policy outcomes (Selm et al., 2018).

Our written description of the moose governance system (visually presented in Fig. 2) should convey the notable degree of collaboration on which the system depends, both within and across levels. Goals, management actions and monitoring have to be aligned from local to regional level. Institutional design and governance mechanisms have also been shown to influence a variety of adaptive capacity determinants (Engle and Lemos, 2010). Reviewing the relevant adaptive capacity literature and its theoretical underpinnings with these points in mind, we defined the operational measures that seemed most relevant for our case and link to the following concepts: social capital, human capital, financial capital, and governance aspects (Table 1).

Social capital is usually seen as a critical component of adaptive capacity (Adger, 2003; Armitage, 2005; Engle, 2011). According to social capital theory, communities in which individuals have good social relationships are more likely to mobilize their common resources and act collectively towards a preferred goal (Adger, 2003; Agnitsch et al., 2006; Cinner et al., 2018). High levels of social capital increase the extent and quality of social networks which are a resource in itself but also a possible limiting factor for the use of other capitals (Agnitsch et al., 2006; Pelling and High, 2005). Strong social relations can, for example, then create better access to knowledge or financial resources (Cinner et al., 2018).

Research into social capital has distinguished different types; inward oriented social relationships within a homogenous group have been defined as *bonding* social capital, whereas social relationships between heterogeneous groups are seen as *bridging* social capital, and relationships to organizations at larger scales have been described as *linking* social capital (Agnitsch et al., 2006; Cinner et al., 2018; Pelling and High, 2005). For collective action to succeed on a community level, all forms of social capital have to be present (Agnitsch et al., 2006; Pelling and High, 2005; Whitney et al., 2017). Within our case study the governance design created an interdependence of actors on different scales; thus we see their adaptive capacity as dependent on social relations within and across levels.

Trust has been rightly highlighted as a core aspect of social capital and a critical component for common pool resource use (Adger, 2003; Paldam, 2000; Wagner et al., 2007). Community cohesion is shaped by trust, communication, and cooperation among group members, and influences if they act collectively in times of crises (Cinner et al., 2018).

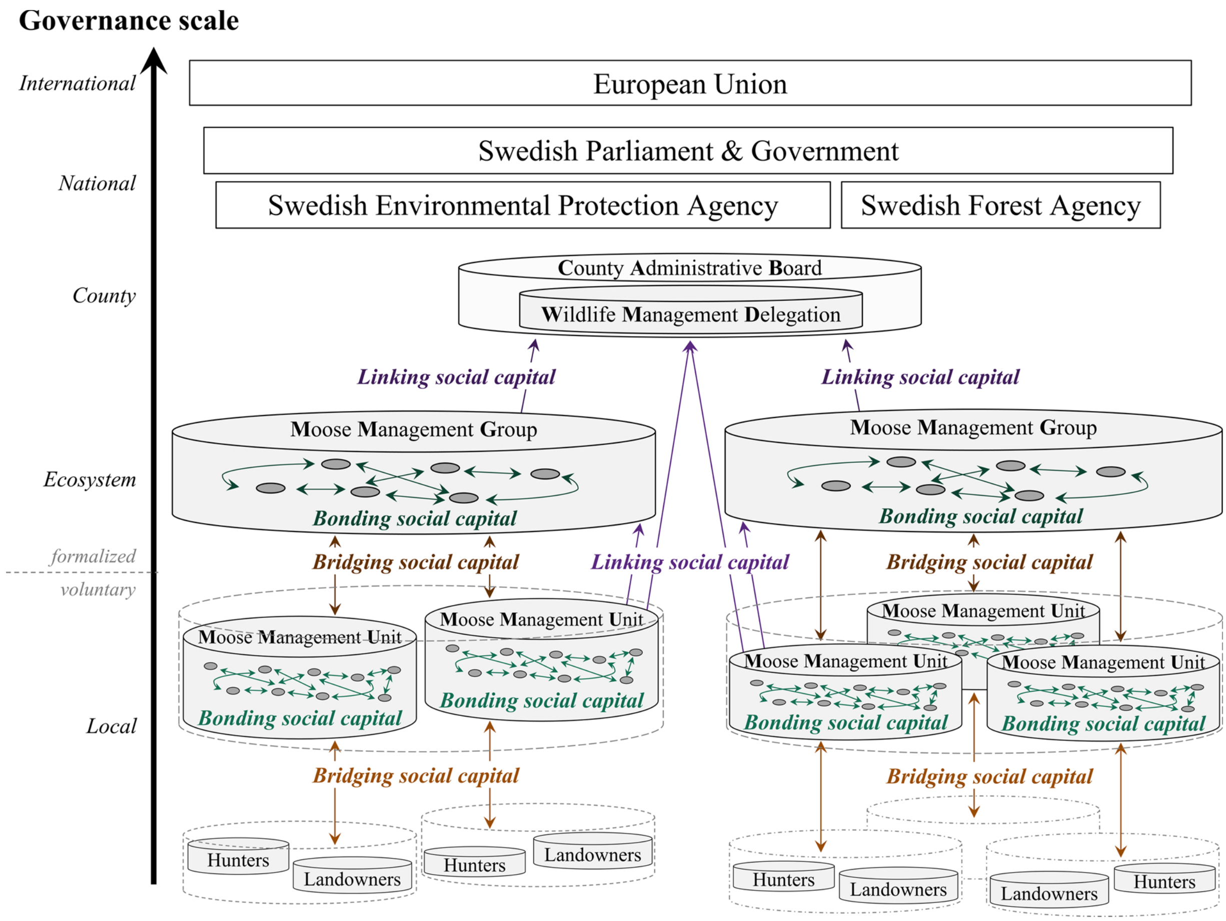

Fig. 2. Systematic view of levels in the Swedish moose management system, showing how linking social capital (purple), bonding social capital (green), and bridging social capital (brown) have been operationalized in the models for Moose Management Groups (darker colour palette) and Moose Management Units (lighter colour palette).

Table 1
Theoretical concepts, their operationalization, and the relevant management levels to which they refer in the Moose Management Group (MMG) and Moose Management Unit (MMU) survey respectively. County Administrative Boards (CABs) and Wildlife Management Delegations (WMDs) hold the authoritative responsibility for moose management at the county level.

Concept	Operationalization	MMG sample	MMU sample
Adaptive capacity	Perceived adaptive capacity		
Linking social capital	Social trust in authorities	CAB & WMD	CAB & WMD
	Social trust in level above	—	MMG
Bonding social capital	Communication within group	MMG	MMU
	Collaboration within group	MMG	MMU
	Social trust within group	MMG	MMU
Bridging social capital	Social trust in level below	MMU	Hunters & Landowners
	Benefits through collaborations with level below	MMU	Hunters & Landowners
Human capital	Knowledge base		
Financial capital	Operational resources		
Governance	Fairness		

We operationalized bonding social capital as three measurable constructs: social trust, good communication, and collaboration within MMGs and MMUs (Table 1 and Fig. 2). We see bridging social capital as the link towards lower levels in the management hierarchy, which provide knowledge and work force. While MMGs and MMUs coordinate monitoring and management actions, local hunting teams invest the actual time and resources, creating interdependent bonds between levels. Thus, we operationalized bridging social capital with two constructs; measuring social trust in the levels below, and the feeling of deriving benefits through collaborations with levels below that in turn will form a feeling of reciprocity (Fig. 2). In a multi-level setting linking social capital to higher levels can facilitate better access to resources, and also create possibilities for more input on management decisions (Pelling and High, 2005). In our case, the authoritative responsibility for moose management resides at the county level. Therefore, social trust in authorities at this level (i.e. the CAB and WMD) was used to operationalize linking social capital for MMGs and MMUs. For the latter, linking social capital includes also trust in their respective MMG, as they are responsible for planning at the higher level (Table 1 and Fig. 2).

Human capital (i.e. knowledge of actors) has also been identified as a critical determinant of adaptive capacity and behaviour (Keskitalo et al., 2011; Lockwood et al., 2015; Nelson et al., 2010). In essence, this means that sufficient knowledge among actors is needed to create risk awareness and plan strategic adaptations (Villamayor-Tomas and García-López, 2017). Given the ecological stressors to Swedish moose management, it is important that actors have not only sufficient knowledge on the state of the moose population, but also interactions with other ungulate species, the recent impacts of large carnivores, and the effects of moose on browsing resources - complex factors which vary geographically (Dressel et al., 2018).

The capacity to adapt also depends on access to financial capital (Keskitalo et al., 2011; Lockwood et al., 2015). In our case, it is critical that actors perceive that they have sufficient operational resources which involves money, but also time and support from their respective interest organizations. Most actors are part of moose management in an extra-occupational capacity, meaning that they receive only limited financial compensation for the time and effort they invest. In such circumstances, social support from the relevant organization might be seen as important balance to invested costs.

Finally, institutional design and governance aspects also influence adaptive capacity of systems and its actors (Engle and Lemos, 2010; Gupta et al., 2010; Lockwood et al., 2015). Before the current management system for moose had been implemented severe conflicts between forestry and hunting interests occurred (Sandström et al., 2013). Now actors representing different interests are included across multiple levels, but equity in terms of power sharing and a fair distribution of costs and benefits might still be perceived as limited. Perceived fairness in regard to procedures and outcomes of a governance system can affect an individual's willingness to respond and the scope of his/her adaptive behaviours (Adger et al., 2016). We apply this to individuals' perceptions of whether or not moose management benefits all interests equally, and if decision-making is just.

Our objectives with this study were twofold: from a methodological perspective we wanted to develop and test an instrument to assess adaptive capacity across scales, while from an empirical perspective we wanted to evaluate the scale dependency of adaptive capacity and its determinants in Swedish moose management. To our knowledge, this is one of the only studies to assess actors' perceived adaptive capacity quantitatively at multiple levels. Our goal was to analyse the relative importance of governance aspects, different types of social capital, as well as human and financial capital on the perceived adaptive capacity of actors at two levels in the management system. While we expected all of the concepts to contribute positively to actors' perceived adaptive capacity, we expected their relative importance to differ across scales. By identifying the critical determinants for each governance level, strategic policy interventions can be suggested to enhance adaptive capacity and thus prepare the system for future disturbances.

2. Material and methods

2.1. Data collection and samples

This study is based on questionnaire data collected over two consecutive years. A similar instrument was administered to two different sample groups in Swedish moose management. The resulting two datasets will hereafter be referred to as MMG and MMU sample, and the structural equation models as MMG and MMU model.

2.1.1. MMG sample

In 2016 we collected contact information for MMG representatives via the respective CABs. We reached 765 representatives, representing 139 of 140 MMGs.

We administered our survey sequential with two modes, first online then by paper. Online administration seemed to be suitable as respondents commonly report moose management data over the Internet. We offered paper surveys as an alternative for respondents requesting it and as a second mode to increase the response rate (Dillman et al., 2014). Three personalized contacts were made from April until May 2016. An individualized invitation and a reminder (five days after initial contact) were sent via e-mail (Limesurvey). Two weeks afterwards, we sent hand-written envelopes containing a paper survey, postage-paid return envelopes, and a cover letter.

The overall response rate was 82 % (n = 624) and was high across all counties (county response rates 73 %–94 %) and represented interests (hunter response rate = 82 %, landowner response rate = 81 %). Despite the high response rate, we carried out a non-response follow-up to check for possible bias. We contacted a random sample of 50 non-respondents via telephone and asked seven control questions from the questionnaire, including the dependent variable in this modelling process. Statistical analysis showed no significant difference between non-respondents and respondents for any item. Thus, non-response bias can be rejected and the results deemed representative.

The majority of respondents (67 %) have been in a MMG since the introduction of the new management system; 339 of them represented hunter interests and 284 represented landowner interests. Respondents' ages ranged from 26 to 82 years (M = 58 years) and 5 % were females.

2.1.2. MMU sample

In 2017, we collected contact information for MMU contact persons via the respective CABs in six counties (i.e. Norrbotten, Västerbotten, Kronoberg, Jämtland, Västernorrland, and Södermanland). We contacted 291 MMUs and requested names and email addresses for all members of their MMU steering committee or board. A reminder was sent after six days, and non-respondents were contacted via telephone in an attempt to retrieve the remaining contact information. In total, we retrieved 1.380 names and email addresses for members of 245 MMUs.

Similar to the MMG sample, we administered the survey online with three personalized contacts during June 2017. After the second reminder, we carried out an online search to supplement our sample frame with postal addresses for non-respondents. We sent 646 handwritten envelopes containing a paper survey, postage-paid return envelopes, and a cover letter.

The overall response rate was 71 % (n = 979) with a variation between 62 % in Södermanland county and 80 % in Västerbotten county. It was not possible to carry out a non-response follow-up as telephone numbers were not available for respondents.

Most respondents (65 %) were both landowners and hunters, 31 % were only hunters and 4 % solely landowners. When asked which interest they represented on the MMU board, the majority (73 %) said that they had a double mandate and represented hunter and landowner interests, while 24 % represented only hunting interests and 1 % said that they represented only themselves. Half of all respondents had been active on the MMU board since the introduction of the new management regime and another 23 % have been active for four to five years. Age and gender distribution were very similar to the MMG sample, with an average age of 57 years (range 24–85) and 2 % female respondents.

2.2. Instrument

Data was collected by a 16-page questionnaire (in Swedish) developed for the MMG sample. Following Robson and McCartan (2016) the questionnaire was piloted in multiple rounds among researchers and people acquainted with the topic (e.g. hunters and wildlife managers). The pilot-study resulted in the wording of the questionnaire being refined and more tailored to the context of moose management. We kept the visual design of the online and paper questionnaire identical, so as to minimize measurement differences (Dillman et al., 2014).

For the MMU sample, the instrument was kept as similar as possible to the initial MMG instrument, although the wording needed to be adjusted to ensure relevance for this management level. We piloted the revised instrument with representatives of different interest organizations, researchers, and wildlife managers. For both the paper and online survey the same layout as in the MMG sample was used.

In the MMG model 52 items (I) forming eight constructs are included (Fig. 3b); their precise wording can be found in Supplementary

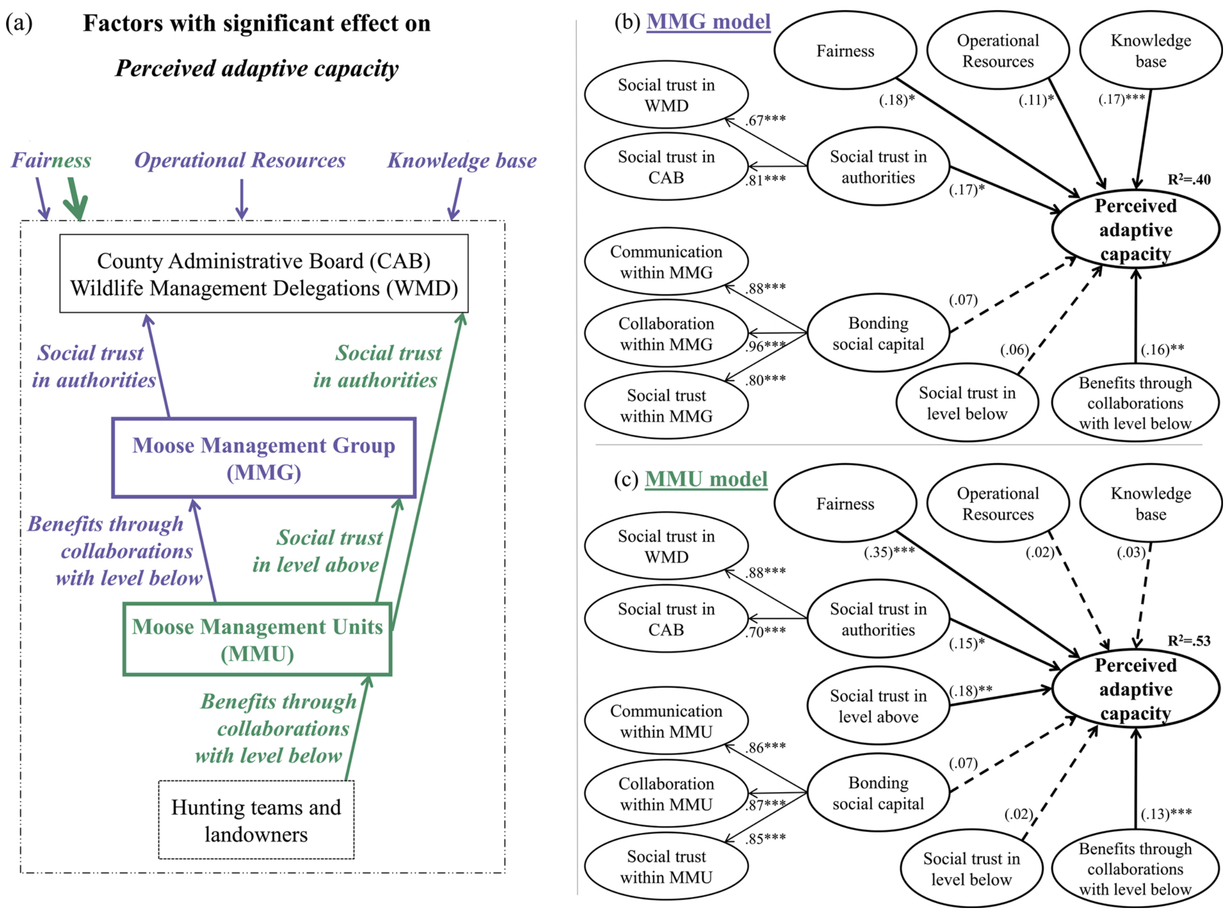

Fig. 3. (a) Determinants with significant effect on actors' perceived adaptive capacity summarized from both models. (b) Full structural model for Moose Management Group (MMG). (c) Full structural model for Moose Management Unit (MMU). Solid arrows in Figures (b) and (c) indicate significant effects (*p < .05, **p < .01; ***p < .001), while dashed lines imply non-significant effects.

Table A.2. Respondents' *Knowledge base* was measured with 13 items, covering four different knowledge subdomains, namely ungulates (I1–I4), browsing pressure (I5–I8), large carnivores (I9–I11), and adaptive management (I12–I13). Respondents were asked, if they thought that there is enough knowledge on these aspects out of their interest group's needs. This was the only question for which respondents had to answer from the perspective of their interest group (all other items were focused on their own individual perceptions).

Operational resources items measured three different types of resources: time (I14), money (I15), and support from their interest organization (I16). Respondents were asked to evaluate if they have enough of these resources to conduct their work in moose management. Four items on *Fairness* were used to assess if the respondents consider the different interests to have equivalent prerequisites in moose management.

To assess *Social trust*, respondents answered if they perceive that the respective level: (a) has completely different values in moose management than they do; (b) supports their views on moose management; (c) thinks differently than they do about how different issues in moose management should be dealt with; and (d) if they trust that the respective level takes into account people who are part of moose management. The formulation of these items stems from previous studies on wildlife-related issues in Sweden and the U.S.A. (Johansson et al., 2012; Needham and Vaske, 2008), and is primarily built on salient value similarity. The four *Social trust* items were repeated four times in the survey to measure trust in different levels of the management system: twice for *Social trust in authorities* at the county level (I21–I24 for WMD and I25–I28 for CAB), once for *Social trust within MMG* (I36–I39), and once for *Social trust in level below* (MMU, I40–I43).

Communication within MMG was assessed with four items asking if respondents feel that they can convey their ideas in the group, even if not everyone shares their opinion, that communication works in general, and that the group is positively affected by having a diversity of opinions. Three items on *Collaboration within MMG* were used to assess if members collaborate by sharing ideas and information, act so that it benefits all parties, and try to solve problems when they arise within MMGs. Six items were used to measure if respondents perceive *Benefits through collaborations with level below,* such as a better achievement of their goals or a better understanding of how different factors affect moose management and local communities. Half of these items referred to collaboration with MMUs (I44–46) and the other half to local landowners (I47–49). *Perceived adaptive capacity*, which is the dependent variable in the analysis, was derived from three items covering the respondents' perception of how well the current moose management can handle different situations and future challenges, and can adapt to new circumstances.

The MMU model contains nine constructs (Fig. 3c) based on 56 items (see Supplementary Table A.3). The *Knowledge base, Operational resources*, and *Fairness* constructs are identical to the MMG model. *Social trust* items occurred five times to cover all management levels that are relevant for this target group: twice for *Social trust in authorities* at the county level (I21–I24 for WMD and I25–I28 for CAB)), once for *Social trust in level above* (MMG, I29–I32), once for *Social trust within MMU* (I40–I43), and once for *Social trust in level below* (hunters and landowners, I44–I47). *Communication within MMU* and *Collaboration within MMU* were measured with the same statements as used in the MMG sample. *Benefits through collaborations with level below* was measured with six items, of which half referred to hunters (I44–I46) and half to landowners (I47–I49) who are included in the respective MMU.

Throughout both surveys all responses were given on 5-point Likert scales from 1 = strongly disagree to 5 = strongly agree. *Fairness* and *Social trust* contained negatively formulated items for which the scale has been inversed (1 = strongly agree to 5 = strongly disagree) before analysis.

2.3. Data analysis

We used confirmatory structural equation modelling (SEM) to evaluate the relative importance of governance aspects, different types of social capital, as well as human and financial capital on *Perceived adaptive capacity*. SEM combines confirmatory factor analysis (CFA) with structural regression analysis and accounts for measurement errors. Thus, only the explained variance of indicators (i.e. the part that is explained by the common construct) is used during the structural analysis.

CFA is based on the assumption that the indicator variables follow a multivariate normal distribution. As multivariate normality was not the case for either of the datasets, we used a robust version of the maximum likelihood estimator with scaled test statistics (equal to Yuan-Bentler) and robust standard errors (Huber-White) in our modelling. In both datasets missing data was on average less than 2 % for all included indicators (range: 0.8–3.7 %) and appeared to be missing at random. Thus, we used full information maximum likelihood substitution within *lavaan* to replace missing data (Rosseel, 2012).

We started with the MMG sample and conducted the SEM in a two-stage process: first, the measurement model is tested via CFA and then the full structural model is fitted. The reason for this was twofold: the measurement model is often the reason for bad fit and we included scales that have not been tested before. As we theorized a higher-order structure in our latent factors (Fig. 3b and Supplementary Fig. A.1), we followed the recommendations for CFA-based higher-order factor analysis by Brown (2015) and initially fitted a first-order CFA to our MMG measurement model. We scaled latent factors on their first indicators to control the variance of the construct.

We evaluated model fit by robust root mean square error of approximation (RMSEA), robust comparative fit index (CFI), robust Tucker-Lewis index (TLI), and standardized root mean square residual (SRMR). RMSEA ≤ .08, CFI and TLI values ≥.90, and SRMR ≤ .05 suggest acceptable model fit (Brown, 2015). We examined construct reliability via Raykov's factor rho coefficients (Raykov, 2001), and construct validity via the average variance extracted (AVE) and inspection of standardized factor loadings. A common threshold for acceptable factor loadings is .40, while Raykov's coefficients as well as AVE should be above the recommended level of .50 (Stensland et al., 2013). We evaluated discriminant validity by comparing if a factor shared more variance with its indicators (AVE value) than with any other factor (squared correlation) (Stensland et al., 2013).

After identifying suitable measurement and structural models for the MMG sample, we directly fitted the same higher-order model structure to the MMU sample. All analyses were carried out using the program R (Team, 2017) and the packages *lavaan* (Rosseel, 2012) and *psych* (Revelle, 2017).

3. Results

3.1. MMG model

3.1.1. Measurement model

The initial first-order measurement model had poor model fit and was revised in several steps by inspecting standardized residuals and modification indices and adding residual correlations. Based on inspection of Pearson's product moment correlations between latent factors (Supplementary Table A.1), we added a higher-order structure in which *Communication within MMG*, *Collaboration within MMG*, and *Social trust within MMG* build the second-order factor *Bonding social capital* (F5), while *Social trust in WMD* and *Social trust in CAB*) build the second-order factor *Social trust in authorities* (F4). The steps that constitute this process are described in more detail in the Supplementary material.

The resulting second-order model showed good fit indices with robust RMSEA = .036 (90 % CI .034–.039), robust CFI = .950, robust TLI = .944, and SRMR = .048. As shown in SupplementaryTable A.2 all indicators had significant ($p < .001$) standardized factor loadings above .40, which is considered as the threshold for good convergent validity (Brown, 2015). The same applied to lower-order factors which had standardized factor loadings from .67 to .96 on their second-order factors *Bonding social capital* (F5) and *Social trust in authorities* (F4) (SupplementaryTable A.2). In summary, all factors showed acceptable reliability, convergent and discriminant validity; our measurement model built a sound basis for the full SEM.

3.1.2. Structural model

The fit measures confirmed a good fit for the structural model, with robust RMSEA = .036 (90 % CI .034–.039), robust CFI = .950, robust TLI = .944, and SRMR = .048. The structural model with standardized coefficients is illustrated in Fig. 3b. *Knowledge base* (β = .17), *Operational resources* (β = .11), *Fairness* (β = .18), and *Benefits through collaborations with level below* (β = .16) had significant positive effects on *Perceived adaptive capacity*. The second-order factor *Social trust in authorities* also had a significant positive effect (β = .17). No significant relationship between *Perceived adaptive capacity* and *Bonding social capital* as well as *Social trust in level below* was found (Table 2). Except for *Operational resources*, which had a lower effect, all significant factors had nearly the same influence. The reported R^2 value (Table 2) indicated that the model explained 40 % of the variance in *Perceived adaptive capacity*.

3.2. MMU model

Given the satisfactory fit measure of the MMG measurement model, the same model structure was fitted to the MMU dataset with identical residual correlations for *Knowledge base* (F1), *Fairness* (F3), *Communication within MMU* (F6.1), *Benefits through collaborations with level below* (F8), and all *Social trust* factors (F4.1, F4.2, F5, F6.3, F7) (see Supplementary Fig. A.2). The same higher-order model structure was applied, with *Communication within MMU* (F6.1), *Collaboration within MMU* (F6.2), and *Social trust within MMU* (F6.3) building the second-order factor *Bonding social capital* (F6). Furthermore, *Social trust in WMD* (F4.1) and *Social trust in CAB* (F4.2) form the higher-order factor *Social trust in authorities* (F4) (Fig. 3b and Supplementary Fig. A.2).

Table 2
Fit measures and standardized coefficients of the structural models for Moose Management Group (MMG) and Moose Management Unit (MMU).

	MMG model	MMU model
Fit measures for structural model		
Robust Comparative Fit Index (CFI)	.950	.940
Robust Tucker-Lewis Index (TLI)	.944	.934
Robust RMSEA	.036	.038
SRMR	.048	.048
Determinants of *Perceived adaptive capacity*		
Knowledge base	**.17*****	.03
Operational resources	**.11***	.02
Fairness	**.18***	**.35*****
Social trust in authorities	**.17***	**.15***
Social trust in level above	—	**.18****
Bonding social capital	.07	.07
Social trust in level below	.06	.02
Benefits through collaborations with level below	**.16****	**.13*****
R^2	.40	.53

*p < .05, **p < .01; ***p < .001.

Completely standardized factor loadings (λ) and Cronbach's alpha, which provides a measure of internal consistency of scale reliability for the MMU model, can be found in SupplementaryTable A.3.

The resulting MMU model had similar good fit measures as the MMG model, with robust RMSEA = .038 (90 % CI .035–.039) and a SRMR below .05 (Table 2). The structural regression analysis revealed that – similar to the MMG model – *Bonding social capital* and *Social trust in level below* had no significant impact on *Perceived adaptive capacity*, while *Benefits through collaborations with level below* did (β = .13). *Social trust in authorities* (β = .15), and *Social trust in level above* (β = .18) had significant positive effects on MMUs' *Perceived adaptive capacity* (Table 2 and Fig. 3c). In contrast to the MMG model, *Knowledge base* and *Operational resources* were non-significant, while the positive effect of *Fairness* (β = .35) was twice as high as the other relevant factors (Fig. 3c). The MMU model explained 53 % of the variance in *Perceived adaptive capacity*.

4. Discussion

We successfully developed a psychometric approach to quantitatively assess actors' perceived adaptive capacity and some of its contributing determinants across two levels of a particular multi-level governance system. The developed scales and SEM models resulted in good fit, and advance our understanding of which concepts shape actors' perceptions of how well the system is prepared to handle future changes. Human and financial capital had significant effects only on the upper management level, while fairness was of greater importance to actors further down the hierarchy. The different types of social capital played varying roles, but showed the same general pattern across models (Fig. 3a).

Bonding social capital was not a significant explanatory variable in either model. We see this rather surprising result as a possible effect of quite high levels of bonding social capital. The mean responses for those factors in both models were well above a score of four, which indicates that most respondents find that these aspects are present. Within their groups, the communication climate is open and allows members to share even opposing ideas while they try to work together in a way that benefits all parties and solves problems when they arise. This might have been supported by the fact that many landowner representatives are also hunters and vice versa, which could create mutual understanding. Even though group members represent different interests, they trust each other and seem to have built well-functioning social relations. However, previous research has highlighted that a balance between the different social capitals is needed for robust adaptive capacity (Adger, 2003; Cinner et al., 2018). Indeed, an extremely high level of bonding social capital could be a negative force, if it creates a "we" versus "them" in-group/out-group mentality. Therefore, adequate bridging and linking social capital is needed to counteract this possibility and connect the different governance levels (Robinson and Berkes, 2011).

In line with this, both models showed linking social capital as an important factor determining actors' perceived adaptive capacity. Trust towards authorities is crucial, as decision-making power still formally lies with wildlife managers at the CAB, approving all management plans and carrying the responsibility for rule of law and economic aspects. For members of MMUs this even applies towards MMGs, as they oversee management plans proposed by MMUs. The importance of trust in wildlife agencies cannot be overstated; it has, for example, been shown to influence US hunters' perceived risk towards Chronic Wasting Disease (CWD) and their likelihood of supporting management actions (Needham and Vaske, 2008). CWD may become a hazard in Swedish moose management, as the first case of a positively tested moose occurred in March 2019 (SVA, 2019). Thus, trust towards higher management levels will be crucial in the event of a possible outbreak, to handle the issue collectively and efficiently. Of course, the same applies for other ecological or anthropogenic hazards and changes: in short, linking social capital towards decision-making levels will heavily influence actors' risk perception and adaptive behaviour.

Bridging social capital (i.e. seeing benefits in collaborating with local units) showed significant positive effects in both models. Respondents perceive that collaboration with local actors helps them to achieve their goals, and therefore if those relationships are in place they feel better prepared to meet future challenges. Bridging social capital can give actors access to additional resources and allow for acquisition of new knowledge and skills (Juhola and Westerhoff, 2011; Morrison et al., 2011). In our study system, hunters and landowners generate new knowledge on a local level by using an array of inventory methods. MMUs and MMGs have to accumulate and analyse these observations to adapt their management plans. This need for a sufficient knowledge base had significant effects on actors' perceived adaptive capacity at the MMG level. Poor knowledge about the presence of other ungulate species and their interactions with moose can act as a limiting factor. In both models, those knowledge aspects were rated as least sufficient (see Supplementary Tables A.2 and A.3). When the new management approach was implemented in 2012, science-based monitoring methods were introduced; however, most of them are tailored to moose, and recent evaluations have shown that, for example, pellet counts might introduce high levels of uncertainty when applied in multi-species systems (Spitzer et al., 2019). Thus, additional new techniques need to be developed to supply actors on all scales with adequate knowledge that allows them to detect ecological changes and adjust management accordingly.

Our study confirmed the positive effect of perceived fairness on adaptive capacity across both models. However, the coefficient for fairness was nearly two times greater at the MMU level than at the MMG level. We hypothesize that these results might originate from the institutional design. At the MMG level representation is formalized with six representatives, drawn equally from the hunting and landowner interests. However, one of the landowner representatives will be appointed as chairperson, with a casting vote to resolve potential deadlocked situations. In the context of well-functioning MMGs with high bonding social capital use of a casting vote might not be necessary, as all members work together to resolve conflicts and find consensus, but its use in other, less functioning groups might create the feeling of unfair power distribution. MMUs, in contrast, are voluntary self-organized groups of local landowners and hunters with no formalized guidelines for representation of the different interests. Depending on landownership structures and varying prioritization of forestry or hunting-related revenues in neighbouring areas, there might be uneven distribution of power in decision-making. Additionally, MMUs are bottom-up formations, built on a bedrock of voluntarism as actors' decide to join forces and establish management plans for their units. Along with this collaboration come high transaction costs (e.g. for monitoring and organizing meetings among hunting teams). Actors might perceive an injustice if their locally made and hard-fought decisions are not then approved by the formalized levels above. The perception of scrupulous procedural fairness not only influences actors' perceived adaptive capacity - it can also have positive feedback effects on trust towards authorities and thereby improve linking social capital (Riley et al., 2018).

Overall, actors at both levels expressed moderate perceived adaptive capacity (MMG mean value: 3.8, MMU mean value: 3.5, scale ranging from 1 to 5). From a policy perspective our results stress the need to build upon and maintain the engagement of the actors, but also to prioritize interventions that can assist them with increasing social capital across governance levels (i.e. linking and bridging). We see considerable potential for social learning in the system by actors exchanging experiences and seeking advice from outside their established networks. As there are no official guidelines on how collaboration between different levels should be organized, there may exist huge diversity in communication strategies. For example, while some MMGs might have well-facilitated meetings attended by representatives of all included MMUs, others might rather apply somewhat one-way communication. Creating forums that standardize good communicative modes and encourage exchange between different county authorities, MMGs, and MMUs could help to identify best practice examples and open up opportunities for social learning across regions and decision-making levels. This kind of proactive learning could strengthen the bridging and linking social capital, and ultimately enhance the adaptive capacity of the system.

5. Conclusion

Our case study highlights a common challenge in multi-level systems: how to create an institutional environment that gives actors the perception of its genuine fairness, builds trust, and develops capacity to adapt across all levels. While effective multi-level participation can be fostered by formalized institutional arrangements (Robinson and Berkes, 2011), the system should still allow room for innovative collaboration. In our case, the creation of bridging and linking social capital has been shown as critical for actors' perceived adaptive capacity; this, might also be applicable to decentralization and stakeholder participation in other natural resource management settings. The 2012 policy intended to create a system that is "locally anchored and ecosystem-based" (Regeringens Proposition 2009/10:239, p. 20), which should allow for local adaptation and input while striving for a coordination of management on a larger ecological scale. Setting up a nested and multi-level system is one way of trying to accommodate these seemingly contradictory ideas, but this requires vertical alignment and trust between levels. This can be difficult to achieve because actors at different levels in the system have varying access to information and different power in decision-making processes. In our specific case, we investigated the intersection of the formalized part of the governance system (CAB, WMD, and MMG) and the voluntary level (MMU). While the system implemented clear incentives for horizontal collaborations (i.e. longer hunting times and higher quotas in return for forming MMUs), there is still a need to promote robust vertical alignments by creating appropriate incentives to collaborate across levels. This could, for example, include the development of techniques to supply actors with adequate knowledge, decision-support tools, and education. Allowing actors from one level to participate in processes on another level could strengthen social networks, help with knowledge transfer across levels, and contribute to perceived fairness of the decision making process.

Our results revealed differences in adaptive capacity and its determinants across scales. Besides their relevance for policy formulation, our results also highlight the empirical need to assess adaptive capacity across a system to understand scale-dependent variations. Measurements at a single level (e.g. use of national indicators) can lead to misinterpretations of the overall adaptive capacity of a system. Similar to other assessments of adaptive capacity, our approach is normative and shaped by our research group's particular perspectives and experience. Using a questionnaire to evaluate the actors' perceptions was useful, but admittedly limited the number of adaptive capacity determinants that we could capture. Given the decentralized decision-making in this multi-level system, governance-related aspects such as legitimacy, accountability, and leadership should be further investigated. While our assessment is a snapshot of actors' perceived adaptive capacity at one point in time, repeated measures can evaluate the longer-term effect of policy changes or targeted actions to foster adaptive capacity. Although more situated research (e.g. qualitative) could help to provide detailed guidance for enhancing adaptive capacity, we want to encourage the continued future application of psychometric approaches. While broad national indicators might well give an objective picture of the socio-economic or ecological setting and the theoretically available capitals, actors' capability to adapt and respond are based on their personal interpretation of the situation (Grothmann and Patt, 2005) - this can only be understood by individual-based measurements of their perceived adaptive capacity.

Funding

This work was supported by the Swedish Environmental Protection Agency's Wildlife Management Fund [*Naturvårdsverkets Viltvårdsfonden*, grant number 802-0161-15] and the Swedish Association for Hunting and Wildlife Management [*Svenska Jägareförbundet*, grant number 5871/2018].

CRediT authorship contribution statement

Sabrina Dressel: Conceptualization, Methodology, Formal analysis, Writing - original draft, Visualization. **Maria Johansson:** Conceptualization, Methodology, Writing - review & editing, Funding acquisition. **Göran Ericsson:** Conceptualization, Methodology, Writing - review & editing, Funding acquisition. **Camilla Sandström:** Conceptualization, Methodology, Writing - review & editing, Funding acquisition.

Declaration of Competing Interest

None.

Acknowledgements

We thank all of the participants who contributed valuable insights for our pilot-study, data collection, and interpretations. We would also like to thank participants at the 14th Nordic Environmental Social Science (NESS) Conference, Göran Spong, and one anonymous reviewer for their constructive comments on an earlier version of this manuscript.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.envsci.2019.11.011.

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