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Evaluating the outcomes of collaborative wildlife governance: The role of social-ecological system context and collaboration dynamics

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ABSTRACT

The acknowledgement of uncertainty and complexity in social-ecological systems has increased the implementation of collaborative governance regimes for environmental issues. The performance of these new regimes to deliver favourable social and ecological outcomes must therefore be evaluated. We focus on the case of Swedish wildlife governance, which has a tradition of using collaborative elements. In relation to moose (*Alces alces*), these collaborative aspects were recently formalized in an amended policy. We aim to assess some aspects of this new regime's performance with respect to intermediate ecological outcomes (i.e. quota fulfilment). We use path analysis to test the causal effects of system context and collaboration dynamics on governance outcomes. Collaboration dynamics were assessed using a web-based survey sent to all stakeholders in *Moose Management Groups* (response rate = 82 %). Our originally specified model yielded a good fit (SRMR of .030 and robust TLI of .996) and explained 20 % of the variation in outcomes. Context variables revealed significant direct effects on collaboration dynamics and outcomes. Larger *Moose Management Areas* and fluctuations in forage availability required more time investment from actors, while high land use diversity and density of other ungulate species negatively affected moose quota fulfilment. *Moose Management Groups* that invested more time and perceived to have a good knowledge base achieved better quota fulfilment. Collaboration dynamics thus had a positive direct effect on outcomes. From a policy perspective, our results raise questions regarding institutional fit because context factors had significant negative effects on collaboration dynamics and the outcomes of the collaborative process.

1. Introduction

In recent decades, collaborative forms of governance have become increasingly popular for addressing environmental issues (Armitage and Plummer, 2010; Bodin, 2017; Jager et al., 2019). This grew out of a general trend towards more collaborative governance regimes across all public policy domains (Newig and Fritsch, 2009), and the awareness that natural resources are components of complex social-ecological systems (SES) often associated with conflicts (Guerrero et al., 2015; Ostrom, 2009). One well-established framework for analysing these complex SES is Elinor Ostrom's social-ecological system framework (SESF; McGinnis and Ostrom, 2014; Ostrom, 2007), which shows how collective action and its outcomes are embedded into a complex context influenced by the governance system, actors, resource systems, and resource units (Ostrom, 2011). System analyses highlighted the complexity of SES, including change occurring at various spatial and temporal scales, which creates uncertainty and challenges for sustainable resource use (Armitage and Plummer, 2010; Berkes, 2017). There can be different types of uncertainties relating to environmental variation, monitoring, implementation and processes or structures (Milner-Gulland and Shea, 2017; Moa et al., 2017). To handle uncertainties and conflicts inherent to SES, more collaborative forms of governance are prescribed. They aim to include local knowledge, decentralize decision-making, create institutions that match ecological dynamics, and increase the adaptive capacity of the governance regime (Armitage and Plummer, 2010; Emerson and Gerlak, 2014). These collaborative gov-

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ernance regimes often operationalize adaptive management as a tool for systematic knowledge generation during the management process (Armitage et al., 2011; Berkes, 2017)[1] . Adaptive management that incorporates collaborative aspects has been termed adaptive co-management (Plummer, 2009).

The introduction of these collaborative governance and management approaches for environmental issues has been examined from diverse scientific perspectives (Ansell and Gash, 2008). Some research in this area has its origins in natural resource issues, as exemplified by the adaptive co-management literature (Plummer et al., 2012), whereas collaborative governance literature draws on existing frameworks and theories from broader fields such as public administration (see Ansell and Gash, 2008 or Emerson et al., 2011 for a detailed description). Reviews of collaborative governance and adaptive co-management case studies have presented implementation examples spanning a wide range of natural resources including forests, protected areas, wetlands, fisheries, and wildlife (Emerson et al., 2011; Plummer et al., 2017). However, examples relating to wildlife have mainly concerned aquatic creatures or species of conservation concern (Clement et al., 2019; Plummer et al., 2012; Redpath et al., 2017). There seems to be a lack of studies on collaborative governance and management of terrestrial wildlife such as ungulates that are managed for sustainable use, especially in a European context.

Independent of disciplinary roots and targeted resources, much of the existing research has focused on favourable preconditions for the implementation of collaborative governance regimes and the evaluation of their effectiveness (Emerson and Nabatchi, 2015b; Scott, 2015). More specifically, studies have sought to determine whether including collaborative aspects has led to improved social and ecological outcomes and thus greater sustainability. The focus of individual analyses in these studies has ranged from the local to the international level (Young, 2018). Existing evaluations have yielded varied but promising results, with collaborative forms of governance potentially improving conflict management while increasing social capital and the effectiveness of collective actions (Ansell and Gash, 2008; Emerson and Nabatchi, 2015b; Scott, 2015).

Previous studies have also highlighted the limitations and challenges of such evaluations and some remaining knowledge gaps (Emerson and Nabatchi, 2015b; Jager et al., 2019), such as a tendency to focus more on input and process aspects instead of outcome and impact measures and to treat social and ecological variables separately (Koontz et al., 2019; Thomas and Koontz, 2011). The implementation of collaborative governance regimes is often driven by complexity, interdependence, and uncertainties (Emerson et al., 2011). However, these drivers also make it difficult to monitor the right indicators over sufficient time periods and to account for complex interdependencies in order to obtain valid data for evaluation (Koontz and Thomas, 2006). Therefore, solid empirical evidence on the implications of specific ecosystem characteristics for the outcomes of collaborative governance regimes remains scarce (Bodin, 2017).

Here we aim to address these knowledge gaps using empirical evidence on Swedish wildlife governance. Our study examines a collaborative governance regime for moose whose implementation created a quasi-experimental set up of 149 cases across varied social-ecological contexts. Drawing on systematic ecological monitoring data and survey data on how the involved actors perceive the quality of the collaboration dynamics allows us to test a detailed theoretical model of collaborative governance. The cross-site study design enables us to evaluate the direct and indirect effects of the system context on collaboration dynamics and outcomes. Our study also contributes to the sparse literature on the implications of collaborative governance for sustainable use of terrestrial wildlife.

1.1. Swedish wildlife governance

Collaborative aspects and a focus on learning have a rather long tradition in Swedish wildlife governance. Moose, as the iconic species of the country, has partly driven the development of the wildlife management system (Danell et al., 2016). Starting from a total ban on all moose hunting at the beginning of the 20th century to recover the small remaining moose population, the regulations have undergone stepwise changes (Liberg et al., 2010). Local knowledge and collective action have been highly valued in the evolving management system (Danell et al., 2016). However, management strategies that worked well to increase the moose population faced challenges when exponential population growth led to strong negative impacts on forestry, an increased frequency of wildlife-related vehicle collisions during the 1980′s (Liberg et al., 2010), and increasing levels of conflict, particularly between forest owners and hunters (Sandström et al., 2013).

As part of its policymaking process, the Swedish government has conducted investigations to identify shortcomings of existing policies and guide future improvements. These investigations led to a change in moose management policy in 2012 (Bjärstig et al., 2014). The new policy modified the governance system to align it with an ecosystem approach based on the Malawi principles (CBD SBSTTA, 2000). It is thus designed to promote decentralized decision-making with extended inclusion of stakeholders in goal formulation while highlighting the ecosystem as a focal management level (Swedish Government Bill, 2009/10:239). The policy acknowledges that moose management is characterized by uncertainties, complexity, and change, and therefore prescribes adaptive management with a focus on monitoring and systematic learning.

This policy can be viewed as another step towards formalization of the collaborative aspects of Swedish wildlife governance. County-level *Wildlife Management Delegations* consist of 15–19 representatives for various land use and public interest and formulate strategies and/or goals for regional wildlife management (Swedish Government Bill, 2008/09:, 2010). To enable the ecosystem-based moose management demanded by the policy and further decentralize decision-making, a new governance level was created in 2012: the *Moose Management Area* (MMA). Each MMA should extend over at least 80 % of the habitat of a distinct moose population, and is managed by a *Moose Management Group* (MMG, Table A.1). These groups have three members representing landowners' interests and three representing hunters, all of whom work collaboratively to set goals and formulate moose management plans for the respective MMA. Previously established voluntary *Moose Management Units* (MMU) were retained to set local goals. and formulate 3-year unit-level adaptive management plans. Alternatively, hunting can be carried out in *License Areas* that are granted quotas by the *County Administrative Board* in line with suggestions from the relevant MMG. Moose hunting is thus steered by goals set at multiple levels of the governance system, which necessitates collaboration and alignment between them (see Appendix A Table A.1 for a detailed overview of the governance system).

As part of the ongoing policy process, the system introduced in 2012 has undergone government-mandated evaluations since its implementation (Naturvårdsverket, 2015, 2018). These evaluations highlighted potential shortcomings in collaboration and goal fulfilment relating to moose harvest quotas and browsing damage. In response, the government issued an assignment (N2018/04160/FJR) requiring the Swedish University of Agricultural Sciences (SLU) to revise educational

[1] The concepts of governance and management have been defined in different and partly overlapping ways, and some scholars even use the terms interchangeably. Our understanding of collaborative governance is in line with the definition offered by Emerson, Nabatchi, and Balogh (2011): *"processes and structures of public policy decision making and management that engage people constructively across the boundaries of public agencies, levels of government, and/or the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished"*. We thus see management as an aspect within the broader governance regime and adaptive management as a specific management practice implemented to generate new knowledge (Hasselman, 2017).

material for relevant actors and identify collaborative aspects that contribute to goal fulfilment and better collaboration in moose management. Our research was embedded in this assignment: the authors have frequently been invited to present at stakeholder workshops and collected some of the data underpinning this study while working on the assignment (see section B in Appendix). Our quantitative evaluation of the system's effectiveness provides insight into the ways in which collaboration dynamics and social-ecological context can influence goal fulfilment, which in turn can help inform and improve policymaking and management performance.

1.2. Diagnostic framework

Our evaluation framework is inspired by the IFCG - Emerson, Nabatchi and Balogh's *Integrative Framework for Collaborative Governance* (Emerson et al., 2011). The IFCG was influenced by previous work on collaborative governance and includes elements from diverse empirical and theoretical frameworks. It has a nested structure in which the system's context influences the collaborative governance regime, where collaboration dynamics give rise to outputs that in turn lead to outcomes (Emerson et al., 2011). Our focus here is solely on the causal links between *system context*, *collaboration dynamics*, and *outcomes* (Fig. 1). Emerson et al. intentionally avoided rigorously specifying their integrative framework to ensure that it can be used by scholars from different disciplines, generalized to describe diverse forms of collaborative governance, and used as a basis for more rigorously specified theory testing and modelling (Emerson and Nabatchi, 2015a, p. 26). In keeping with this approach, we complemented the IFCG with elements from a revised version of the SESF to create a detailed diagnostic set-up for testing multiple theories on system context and its effects (McGinnis and Ostrom, 2014; Vogt et al., 2015). This framework has been used previously to analyse the social-ecological context of Swedish moose management (Dressel et al., 2018; Sandström et al., 2013). While this previous analysis highlighted critical variables and a potential "problem of fit" for moose management, this study takes the next step by investigating whether the identified context variables affect the governance regime's performance in terms of its collaboration dynamics and outcomes.

Evaluations of the performance of collaborative governance regimes can be multifaceted, focusing on processes and/or varying types of outcomes. Emerson and Nabatchi (2015b) illustrated this complexity by building a matrix of nine different productivity dimensions to which outcomes can relate. In this way, they highlighted the need to concretise what a study actually seeks to evaluate. Following their classification, we aim to evaluate productivity performance with a focus on the effectiveness of reaching desired outcomes or "results on the ground" by achieving target goals (i.e. meeting the hunting quotas).

Because we follow a logic model approach, it is important to distinguish between processes, output, outcomes, and the causal sequence we expect between these components (Emerson and Nabatchi, 2015b; Thomas and Koontz, 2011). We see management plans formulated by the MMGs as direct outputs of their collaboration dynamics (i.e. the process, Fig. 1). These plans set clear quantitative and qualitative goals and thereby specify what actions should be taken (i.e. how many moose should be harvested in a given season and the distribution of the quota among cows, bulls, and calves). Quota fulfilment is thus a measure of an intermediate ecological outcome because it directly links outcomes of actions (i.e. actual numbers of harvested animals) to an output (i.e. the goal agreed in the management plan). Reaching quotas is assumed to be necessary for achieving the overall desired ecological outcomes (i.e. goals in regard to quality and quantity of the moose population and acceptable levels of browsing damage). The framework of Emerson et al. (2011) identifies key variables of collaborative governance regimes. Below, we outline our empirical and/or theoretically based hypotheses about how the system context and collaboration dynamics interact and affect outcomes.

1.2.1. Hypothesis on the effect of collaboration dynamics on outcomes

Collaboration has been highlighted as a vital factor for improving goal-fulfilment in public policy and management (Bodin et al., 2017). It could also help reduce implementation uncertainty, a concept that relates to how practitioners in the field meet set quotas and comply with regulations (Moa et al., 2017). Within the IFCG, *collaboration dynamics* are characterized in terms of three interactive components: *principled engagement, shared motivation,* and *capacity for joint action,* which are all assumed to be beneficial for effective collaboration and the

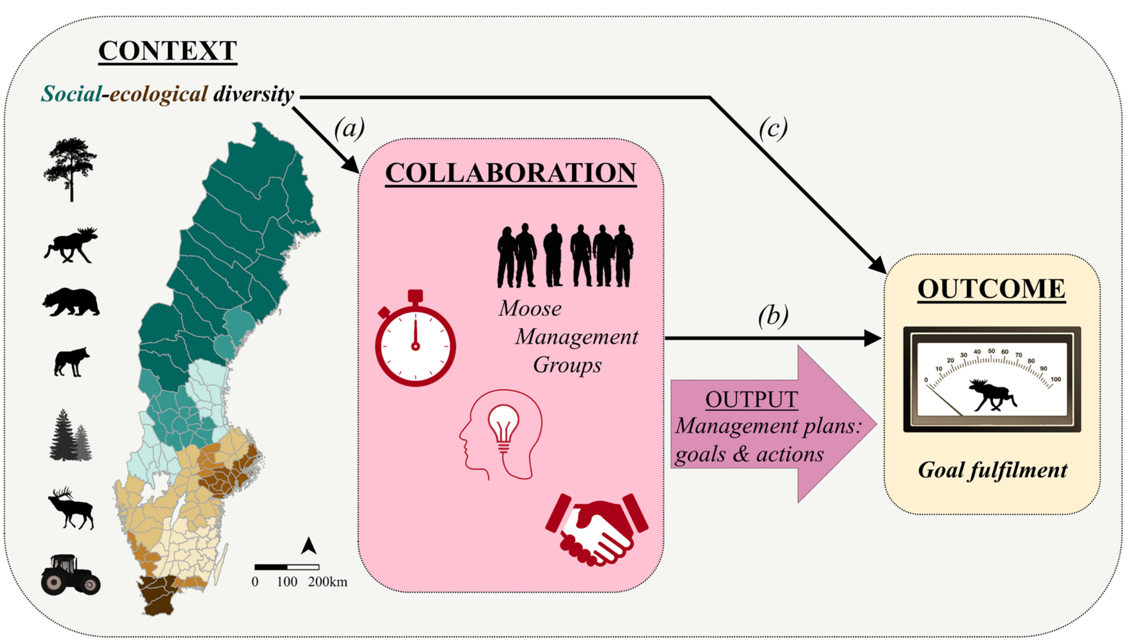

Fig. 1. Graphical illustration of the conceptual model showing (a) the assumed direct effects of the social-ecological system context on the collaboration dynamics, (b) the effects of collaboration on outcomes, and (c) the direct effects of context variables on outcomes. The map shows all 148 Moose Management Areas coloured according to the social-ecological context in which moose management has been implemented. The gradient ranges from social importance (green) to ecological diversity (brown); see Dressel et al. (2018) for more details.

Table 1
List of variables included in the path analysis, including their sample size (n), mean value (M), standard deviation (SD) and range (Min-Max) and information on which component and variable they represent according to the SESF and IFCG.

Component	SESF / IFCG	Variable	Unit	n	M	SD	Min	Max
Context	RS3	Area size	1000 ha	149	271.80	413.23	20.78	2,781.41
	GS3	Sub-units per MMA	count	149	29.30	39.56	1	235
	RS1	Land use diversity	H index	149	1.04	0.20	0.62	1.53
	RS7	Fluctuation in forage availability	proportion	149	0.30	0.25	0.04	1.59
	RU3c	Predation by wolves & bears	1000 ha^{-1}	148	0.45	0.69	0	3.64
	RU3b	Density of other ungulates	1000 ha^{-1}	149	12.24	11.83	0	64.47
	RU5b	Moose density	1000 ha^{-1}	149	2.49	0.83	0.10	4.25
	I4	Browsing damage	proportion	146	0.16	0.10	0.02	0.56
Collaboration	capacity for joint action	Time investment	–	147	98.19	49.75	7	254.67
	capacity for joint action	Knowledge base	–	147	3.59	4.06	−8.88	13.35
	shared motivation	Bonding social capital	–	147	8.25	4.21	−10.28	14.04
Outcome		Quota fulfilment	proportion	146	0.88	0.12	0.25	1.28

performance of the governance regime (Emerson et al., 2011). *Principled engagement* describes the stages of discovery, definition, deliberation, and determination that occur among actors. The policy and established guidelines for management plans structure this process within MMGs quite detailed. Therefore, we focus in this study on elements of *shared motivation* and *capacity for joint action* (Table 1), as these two components focus more on the relational and functional qualities of collaboration dynamics (Emerson and Nabatchi, 2015a).

Capacity for joined action relates to the functional components of collaboration dynamics including procedural and institutional arrangement, leadership, resources, and knowledge (Emerson et al., 2011). Within this study, we focus on *resources* and *knowledge* as enabling elements for joint action and achieving preferred outcomes (Table 1). Because financial resources within the governance system are limited, representatives serving on MMGs receive only a small reimbursement each year. Their labour is thus either contributed voluntarily or paid for by their employer if their participation in the MMG is classified as one of their working duties. We decided to focus on the time that MMG members invest in the collaborative process, which was assumed to be an essential resource for good performance of the regime. Frequent communication between actors has shown positive effects in collaborative governance by helping to develop trust, acceptance of outputs, and rule compliance (Dietz et al., 2003; Jager et al., 2019). This supports two of our hypotheses. First, *we hypothesize that increased time investment in collaboration between levels will increase quota fulfilment* by promoting alignment of goals between different management levels. Second, we assume that increasing the time invested in the collaborative process will increase the actors' social capital. Similar effects were observed in a case study where an increase in meeting frequency was found to support the development of trust within wildlife management associations (Wagner et al., 2007). However, higher levels of social capital are also assumed to reduce transaction costs (i.e. time investment) (Ostrom, 2009) and increase knowledge generation (Berkes, 2009; Emerson et al., 2011), and common knowledge within a user group can also reduce transaction costs (Ostrom, 2009). In line with these complex interdependencies, the IFCG assumes that the three components of collaboration dynamics are synergistically interrelated, reinforcing one-another and ultimately boosting collaborative action (Emerson and Nabatchi, 2015b). Thus, *we hypothesize that there is a relationship between bonding social capital, knowledge and time investment but we do not want to specify a cause-and-effect association among them.*

The adaptive co-management philosophy assumes that knowledge is important for the development and use of better management practices (Berkes, 2017; Plummer, 2009). Goals and action plans are formulated based on current knowledge, monitoring regimes are established to systematically collect knowledge and new knowledge is co-produced with the aim of maximizing the utilization of already existing knowledge that is dispersed among different actors and management levels (Armitage et al., 2011; Berkes, 2009). Additionally, it is assumed that higher levels of relevant environmental knowledge will lead to collaborative outputs of greater environmental quality (Jager et al., 2019; Newig et al., 2018). In our case, an increase in the environmental quality of the output (i.e. management plans) would take the form of goals that are better-adjusted to the ecological circumstances (e.g. moose density and potential predation) or improved planning of actions (e.g. more efficient spatial distribution of quotas over sub-units). Thus, *we hypothesize that a higher knowledge level of MMGs will lead to improved quota fulfilment.*

Shared motivation is the interpersonal and relational component of the collaboration dynamics. It encompasses trust, mutual understanding, internal legitimacy, and commitment (Emerson and Nabatchi, 2015a), and therefore mirrors many dimensions of *social capital*. Social capital can be defined as the networks of social relationships that nurture trust through norms of reciprocity (Pelling and High, 2005). A lack of social capital has previously been identified as a barrier to successful ecosystem-based management (Yaffee, 2011). Social capital has also proven vital to the performance of collaborative governance regimes (Berkes, 2009; Cheng et al., 2015; Jager et al., 2019), and effective commons governance (Dietz et al., 2003). A recent meta-analysis showed that a good communication climate contributes to trust and shared norms, which can lead to higher acceptance of governance outputs and increase the likelihood of their implementation (Jager et al., 2019). Social capital can also help actors to improve their utilization of other resources, such as human capital (i.e. knowledge and expertise) or financial capital (Agnitsch et al., 2006; Cinner et al., 2018). In times of crisis, trust and community cohesion can increase the adaptive capacity of actors individually and collectively. Communities with high social capital are thus more likely to act collectively towards preferred goals (Adger, 2003; Cinner et al., 2018). Different types of social capital have been distinguished by research, namely linking, bridging, and bonding social capital (Agnitsch et al., 2006; Pelling and High, 2005). Bonding social capital arises from relationships within homogenous groups, while bridging and linking social capital arise from relationships between groups and towards organizations on larger scales, respectively. A balance between these different kinds of social capital has proven to be essential for collective action and successful natural resource management because they play different roles within the governance regime (Agnitsch et al., 2006; Grafton, 2005). However, since our unit of analysis in this work is MMAs, we focus on bonding social capital within MMGs. Based on the arguments above, *we hypothesize a positive effect of bonding social capital on outcomes* (i.e. quota fulfilment).

1.2.2. Hypothesis on the effects of the social-ecological system context on collaboration dynamics and outcomes

The system context can create barriers to collaboration dynamics and productivity performance of collaborative governance regimes (Ansell and Gash, 2008; Emerson and Nabatchi, 2015a). Fifteen SES context variables were previously identified as potential challenges for the implemented system because they exhibit considerable spatial variation and could lead to an emerging ‘problem of fit’ between created institutions and the ecological system (Dressel et al., 2018). Stakeholders confirmed that several of these variables present challenges for quota fulfilment during a workshop led by two of the authors (see section B in Appendix A for more details). Due to restrictions on data availability, only eight of these context variables could be included in this study. According to the adapted SESF of Vogt et al. (2015), they were first-, second-, and third-tier variables. Variables relating to the resource system were *sector (RS1), size (RS3),* and *predictability of system dynamics (RS7)*. Variables relating to the resource units (i.e. moose) were *competition between species (RU3b), predation (RU3c)*, and *the absolute number of units (Ru5b).* Additionally, the *network structure of the governance system (GS3)* and *conflicts (I4)* were included (Table 1).

Because these context variables present challenges in management, we assume that they will necessitate more work (i.e. time investment) from involved actors. The size (RS3) and predictability (RS7) of the resource system are posited to influence the likelihood of collective action because greater effort is required to monitor larger systems with low predictability (Ostrom, 2009). Additionally, a large spatial extent and complex network structures (GS3) can reduce actors’ ability to build suitable institutions and act collectively (Ostrom, 1990). As the spatial extent of the area to be managed increases, ecological and social variability may also increase, resulting in the inclusion of multiple sectors (RS1) with diverging goals within the same management regime. These theoretical arguments align very well with the reality described by moose management stakeholders, in which social variability (i.e. landownership structures) and the relationships between different land use interests (i.e. forest and agricultural) necessitate additional collaborative effort and adversely affect goal fulfilment (Table B.1). The governance design created an interdependence between levels and made alignment of their goals essential (Table A.1). Time investment should be higher for MMAs consisting of many sub-units because of the need to coordinate and follow-up with each subunit. Diversity in land use sectors imposes different demands on the management because managers must account for all interests in these multi-use landscapes and align wildlife management objectives with them (Apollonio et al., 2017). Finally, the new policy goal seeks to establish “a moose population of high quality that is in balance with available forage resources”, whereby forage resources for moose are highly sensitive to forestry practices (Liberg et al., 2010; Wallgren et al., 2013). Despite dual objectives within Swedish forest policy, which have both environmental and social aspects, Swedish forests are primarily managed to meet production goals (Beland-Lindahl et al., 2017). The resource against which the moose population should be balanced is thus subject to a separate management and governance regime in addition to being a key component of moose management. Forage availability naturally changes as a forest progresses through the different successional stages, and different forest management actions can cause it to increase or decrease within a given MMA. Additionally natural disturbances such as fire or wind can cause drastic and unpredictable changes (Lidskog and Sjödin, 2016). We assume that a high fluctuation in forage resources creates environmental uncertainty, necessitating a more intense collaborative effort for effective monitoring and adaptation of harvesting rules. We therefore *hypothesize that time investment increases with the spatial extent of the MMA, the size of the network (i.e. its number of subunits), the diversity of land-use, and the magnitude of the fluctuations in forage availability*.

Uncertainty about ecological processes and the acknowledgement that decisions must be made on the basis of imperfect knowledge was one reason for the introduction of the new governance regime (Swedish Government Bill, 2009/10:239). As outlined above, the predictability of system dynamics (RS7) relating to forage availability is a source of environmental uncertainty that might limit actors’ relevant ecological knowledge. There is also monitoring uncertainty relating to the presence of other ungulate and carnivore species, which might lead to competition between species (RU3b) or predation (RU3c). Within our survey (see methods section), members of all but one of the MMGs (138) stated that they require additional knowledge to support the management process. Of the respondents who specified more precisely what kind of knowledge they needed, members of 73 MMGs mentioned questions regarding forage availability and browsing pressure. Respondents also expressed a need for more knowledge about local moose populations (60 MMGs), the presence of other ungulates and their interactions with moose (39 MMGs), and predation by large carnivores (34 MMGs). Therefore, *we hypothesize that high numbers of other ungulate species, predation by large carnivores, and fluctuations in forage availability adversely affect the knowledge base of MMGs*.

Conflicts can impose strain on collaboration dynamics and should be considered within the system context (Emerson et al., 2011). Therefore, we assume that some ecological context variables have negative effects on the bonding social capital of MMGs. Conflicts in ungulate management are often caused by high ungulate densities and their negative impact on otherwise valuable resources such as agricultural crops or commercially harvested trees (Apollonio et al., 2010; Apollonio et al., 2017). Scots pine (*Pinus sylvestris*) is a common forage resource for moose but also a significant commercial tree species in Sweden. Therefore, moose foraging creates conflicts among stakeholders (Liberg et al., 2010; Månsson et al., 2007; Wallgren et al., 2013). Browsing damage to Scots pine is surveyed by the Forest agency and can be seen as an indicator of potential conflict (I4). The wish for high moose densities from hunting interests is commonly portrayed as a contributing factor to this conflict (Liberg et al., 2010; Månsson et al., 2007). We therefore see high numbers of moose (Ru5b) as a possible constraint on collaboration within MMGs. In areas with high densities of other ungulate species, there might be competition (RU3b) between species for available forage resources, which could lead to increased browsing damages to scots pine (Kalén, 2005; Pfeffer et al., 2020). Furthermore, other ungulate species such as fallow deer (*Dama dama*) and wild boar (*Sus scrofa*) commonly cause damage to agricultural crop fields (Official Report of the Swedish government, 2014:54). Such damage may create additional tensions between landowner and hunter representatives who must work together within MMGs. Based on this, *we hypothesize that high levels of browsing damage to scots pine and high densities of moose and other ungulate species will adversely affect the bonding social capital of MMGs.*

As discussed above, there are several ways by which the social-ecological context could indirectly affect the performance of the collaborative governance regime via its influence on collaboration dynamics (Paths *a* and *b* in Fig. 1). However, it could also have direct effects on hunters’ likelihood of fulfilling harvest quotas. Previous studies investigated this implementation uncertainty and discovered critical attributes of wildlife, habitat and hunters (Bischof et al., 2012; Lebel et al., 2012). High wildlife densities had a positive effect on hunting success (Bischof et al., 2012; Schmidt et al., 2005). Therefore, *we hypothesize that a higher absolute number of moose (Ru5b) will make it easier to fill set quotas.* Different landscape characteristics such as the density of roads also influence harvesting success (Lebel et al., 2012; Schmidt et al., 2005), and fragmentation in multi-use landscapes can set limitations for common moose hunting practices such as the use of free roaming dogs (Hiedanpää and Pellikka, 2015). Based on this, *we hypothesize a negative effect of land use diversity on quota fulfilment.* Hunting effort (i.e. days spent hunting) has been associated with a higher likelihood of successful harvesting in Alaska’s moose population (Schmidt et al., 2005). A study conducted in 2005 showed that the average Swedish hunter spent yearly 11 days hunting moose and 17 days pursuing other game species, and that hunting effort contributed positively to the harvest of moose (Boman et al., 2011). Since then, the densities of the other ungulate species have changed drastically; for example, the wild boar harvest rose from 23,000 (hunting season 05/06) to 115,000 animals (hunting season 17/18)[2] . Given that the number of hunters has fallen slightly since 2005 (Eriksson et al., 2018) and that the time invested in hunting per person might not have changed dramatically, *we* hypothesise *that high densities of other ungulates might reduce effort invested into hunting moose and thus have a negative effect on quota fulfilment.*

2. Methods

We used path analysis to assess direct and indirect effects of the social-ecological context on the collaboration dynamics and outcomes. Fig. 2 shows hypothesized paths between the different variables. Below, each variable is described briefly and their assumed effects on the collaboration dynamics and/or outcomes are specified. Table 1 provides an overview of all included variables as well as their means, standard deviations, and ranges.

2.1. Outcome variable

We requested all moose management plans created between 2014 and 2018 via the respective county administrative boards. Management plans cover a three-year period and are structured according to a template; they specify how many moose should be harvested per season and describe the area's environmental conditions (e.g. the extent of predation by carnivores, frequency of moose-car collisions, and forest conditions). Because the system focuses on learning and adaption, managers can update plans frequently to accommodate environmental changes. We therefore used the newest version of the management plan for each area and worked backwards in time to recreate the goal for each hunting season. We reviewed 468 management plans for 149 MMAs. At the end of each hunting season, it is mandatory to report the moose harvest. This data is publicly available via www.älgdata.se,[3] from which we extracted the number of harvested moose per MMA for the hunting seasons 2014/15–2018/19. We then calculated the ratio of harvested moose to the quotas specified in the management plans. To get a more stable measure and account for unforeseen variation in individual single years (e.g. due to extreme climate conditions), we calculated mean values over three years (hunting season 15/16–17/18). This mean value constituted our dependent variable *Quota fulfilment*.

2.2. Collaboration variables

Information on the collaboration dynamics was collected via a questionnaire sent to representatives serving on MMGs. In 2016, we administered an online survey to all representatives in 139 of 140 MMGs (N = 765). After three personalized contacts, including the option of a paper survey, a response rate of 82 % (n = 624) was achieved. Response rates were similar across counties and interest groups. Nevertheless, a phone follow-up was conducted to test for non-response bias, which revealed no significant difference between respondents and non-respondents. The mean respondent age was 58 years (range 26–82) and 95 % were male. See Dressel, Johansson, Ericsson, and Sandström (2020) for a more detailed description of the data collection process.

Three concepts were considered in this study: the time each group invests into collaboration dynamics, their self-assessed knowledge base, and the bonding social capital within the group. The exact wording of all used items together with their means and standard deviations are presented in Table C.1 in the Appendix. Because MMAs are the unit of analysis in this work, we calculated mean values per group; these were based on 4.5 respondents on average.

[2] Source: https://rapport.viltdata.se/statistik/ Public database on Swedish wildlife harvest data

[3] Hereafter we will refer to this database as ÄLGDATA.

2.2.1. Time investment

Respondents were asked to report how many hours they had spent on different tasks relating to moose management over the last 12 months. The questionnaire included 12 items covering activities relating to individual tasks (e.g. educating themselves or analysing data), collaboration tasks (e.g. talking to MMUs) and activities connected to establishing management plans (e.g. meetings within the group) (Table C.1). Five answer categories were offered: 0 h, 1 − 8 h, 9 − 20 h, 21 − 40 h, and > 40 h. We calculated a composite score across these 12 items for each participant, using the starting value of each category (i.e. 0, 1, 9, 21, 41) to define the minimum time investment per participant. Time investment values could thus theoretically range from zero hours to 492 h. We excluded respondents who had missing values for multiple items, giving a sample size of 614. The mean score for each group was calculated and formed the variable *Time investment*. We expected a positive effect of *Time investment* on *Quota fulfilment*.

2.2.2. Knowledge base

The questionnaire included 12 items asking respondents to assess their knowledge about different issues relevant to moose management (i.e. ungulate populations, forest conditions, predation, and adaptive management). These 12 items were previously used to represent *Knowledge base* (see Dressel et al., 2020), and have undergone testing for reliability as well as convergent and discriminant validity. Their standardized factor loadings from a previous Confirmatory Factor Analysis were used to calculate a composite score per participant (Table C.1). This allows us to account for measurement error because these items should represent the latent variable *Knowledge base*. Answers were given on a 5-point scale ranging from -2 = strongly disagree to +2 = strongly agree. Given the factor loadings, the composite score could take values between -16.54 to +16.54. Respondents with missing data were removed before calculating the mean value per group. We assume a positive effect of *Knowledge base* on *Quota fulfilment*.

2.2.3. Bonding social capital

Social capital is a multifaceted concept (Pelling and High, 2005). As in previous studies, we operationalized bonding social capital as a combination of communication, collaboration, and trust within the MMGs (Dressel et al., 2020). Four communication, three collaboration, and four trust items were weighted according to their standardized factor loadings (Table C.1) and summed according to their factor loading on an overall *Bonding social capital* composite score per person. Answers were given using the 5-point scale described above, and the theoretical range for the composite score was from -14.87 to +14.87. Respondents with missing data were removed before calculating the mean value per group. We assumed a positive effect of *Bonding social capital* on *Quota fulfilment*.

2.3. Context variables

2.3.1. Area size

We extracted the size (terrestrial area) of each MMA based on a MMA shapefile for the hunting season 2015/16 after excluding water bodies.[4] This spatial analysis was performed in ArcMap (Version 10.4.1.568, © 1999 − 2015 Esri. Inc.). We set the variable unit at 1000 ha to make the magnitudes of the mean values and variance for this variable similar to those for the others. We expect that bigger areas will require more collaborative effort from MMGs, resulting in a positive effect of *Area size* on *Time investment*.

2.3.2. Sub-units per MMA

Moose management units and license areas are required to report

[4] Waterbodies were available via the Geographic Swedish Data provided by The Swedish Land Survey (*Lantmäteriet*).

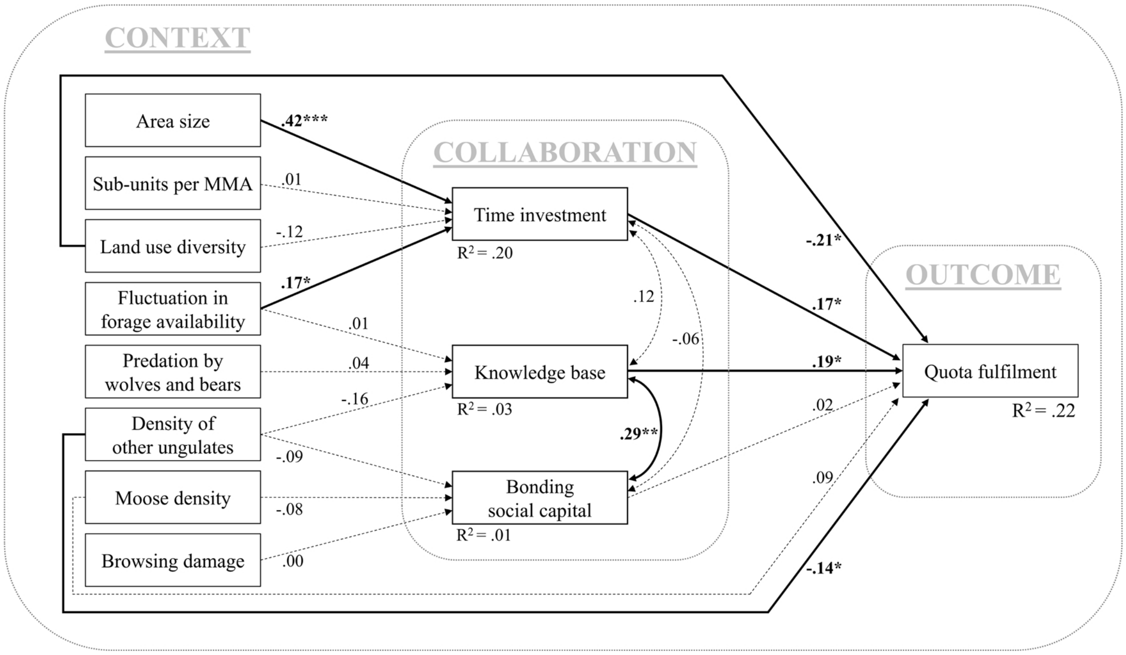

Fig. 2. Path analysis results. Straight arrows depict the hypothesized direct and indirect effects of context and collaboration variables on Quota fulfilment. Curved double-arrows visualize assumed covariance between the collaboration variables. Dashed arrows represent insignificant effects, while solid arrows are significant. Displayed values are standardized path coefficients with significance thresholds of *p < .05, **p < .01, ***p < .001.

their moose harvest in ÄLGDATA. We counted the number of sub-units (MMUs and license areas) per MMA for the hunting seasons 2014/15 and 2015/16 and calculated their mean value. We hypothesize that a high number of *Sub-units per MMA* will require more *Time investment* from MMGs, thus having a positive effect.

2.3.3. Land use diversity

Based on the National vegetation cover data[5] we extracted per MMA the proportion of six land use types: wetland, agriculture, artificial surface, water, forest, and other open land. In ecological research, diversity across sites is often compared using diversity indices (Magurran, 2013). Here, we used the Shannon diversity index (H) as a measure of *Land use diversity*. This index takes the area proportion (p_i) of each specific land use type i into account:

$$H = -\sum_{i} p_i \ln(p_i)$$

Areas with comparatively even distributions of land use types will have high H values while those with a more uniform dominance of one type will have lower values. We expected more diverse MMAs to require more effort from MMGs to collect information and collaborate with different land use interests. Furthermore, diverse land use might adversely affect hunting opportunities and effectiveness, making it harder to fulfil set quotas. We thus expected *Land use diversity* to have a positive effect on *Time investment* and a negative effect on *Quota fulfilment.*

2.3.4. Fluctuation in forage availability

We used official data on forage productive forest area for each MMA as reported annually by the Swedish Forest Agency, which uses satellite images to estimate of the total area of young forest stands between 1 and 6 m tall that are suitable for moose browsing (Kalén and Bergquist, 2004) and references therein). As an indicator of variability in forage availability, we calculated the sum of the proportional change (F) in the forage productive forest area (A) from one year (t) to the next ($t + 1$) over a 10-year period (2010–2020) for each MMA:

$$F = \sum_{t=2010}^{2020} \frac{|A_{t+1} - A_t|}{A_t}$$

While some areas showed a constant increase or decrease, others displayed variability in both directions during the considered period. We expected a high fluctuation to create multiple challenges for management. Firstly, it is a source of uncertainty that must be accounted for when collecting information on the area and setting management plans. Secondly, it might make it harder to set goals for a moose population that should be in balance with the available food resources to avoid unacceptable browsing damage. We therefore expect *Fluctuation in forage availability* to increase *Time investment* (positive effect) from MMGs while also reducing their *Knowledge base* (negative effect).

2.3.5. Predation by wolves & bears

Predation by large carnivores is a source of natural mortality that must be considered when setting quotas for moose hunting. In Sweden, brown bears (*Ursus arctos*) and grey wolves (*Canis lupus*) are the species that commonly prey on moose (Tallian et al., 2017). We extracted estimated levels of predation by wolves and bears from the 468 collected moose management plans. Plans specify how many wolf packs and individual bears live in the MMA in question and then estimate how many moose they will prey upon in a given year. We summed the number of moose preyed upon per 1000 ha by both species and calculated the mean value for the hunting seasons 14/15 and 15/16. We hypothesize that *Predation by wolves & bears* is a source of uncertainty for management, which will negatively affect moose managers' *Knowledge base.*

2.3.6. Density of other ungulates

In the absence of systematic monitoring of other ungulate species, we used harvest data as a density indicator. Harvest numbers for red deer (*Cervus elaphus*), fallow deer (*Dama dama*), roe deer (*Capreolus capreolus*), mouflon (*Ovis orientalis*), and wild boar (*Sus scrofa*) are

[5] *Nationell marktäke data*; Raster data with a resolution of 10m, provided by the Swedish Environmental Protection Agency (available for download at https://www.naturvardsverket.se/Sa-mar-miljon/Kartor/Nationella-Marktackedata-NMD/Ladda-ned/)

commonly reported per hunting district.[6] Hunting district borders do not always directly overlap with MMA borders. We therefore assumed a homogenous distribution of harvest numbers across hunting districts to calculate harvest data per MMA based on the proportional overlap between hunting districts and MMAs according to shapefiles for the hunting season 2015/16. This spatial analysis was performed in ArcMap (Version 10.4.1.568, © 1999 – 2015 Esri. Inc.). For each species, we calculated a harvest rate per 1000 ha of land area for each MMA and accumulated harvest rates across species into an indicator for all "other ungulates". This calculation was done for the hunting seasons of 14/15 and 15/16. The mean value for these two hunting seasons constitutes our variable *Density of other ungulates*. We expect the presence of other ungulates to create uncertainty in the ecological dynamics of the ungulate community (leading to a negative effect on managers' *Knowledge base*). Furthermore, high densities of other ungulates might increase browsing damage and/or damage to agricultural landscapes, which can hamper collaboration between landowner and hunter representatives. This would mean a negative effect of *Density of other ungulates* on *Bonding social capital*. We predict that the presence of other ungulates will also have a direct negative effect on *Quota fulfilment* because the availability of these species may cause hunters to place a lesser focus on moose.

2.3.7. Moose density

There are various monitoring tools for estimating moose densities. The use and adequacy of individual methods differs across the country (Spitzer et al., 2019), but harvest statistics have performed well as spatiotemporal density indices for moose (Ueno et al., 2014). Based on this and in an attempt to keep *Moose density* similar to *Density of other ungulates*, we used harvest data as a density indicator. We extracted the number of harvested moose per 1000 ha for each MMA from ÄLGDATA and calculated its mean value for the hunting seasons 14/15 and 15/16. Because high moose densities may be associated with an increase in negative impacts (e.g. browsing damage or traffic accidents), we postulated that it might lead to more disagreement between different interest groups. We thus expect a negative effect of *Moose density* on *Bonding social capital*. At the same time, high moose densities are assumed to make it easier to reach set goals, and thereby positively affect *Quota fulfilment*.

2.3.8. Browsing damage

We used official data from the national inventory of moose browsing damage (Äbin) conducted by the Swedish Forest Agency. Among other variables, Äbin estimates the annual proportion of Scots pine (*Pinus sylvestris*) in young forest stands that is damaged by ungulates. In 2015 and 2016, inventories were conducted at the MMA level for the first time (they had previously been conducted at the county level). Each MMA is monitored every second year other than in the two northernmost counties, where MMAs are monitored annually. We used the proportion of damaged pine stems as an indicator of *Browsing damage*. If data for both calendar years were available, we calculated the mean value. We hypothesize that browsing damage, as a source of conflict, will negatively affect *Bonding social capital*.

2.4. Data analysis

We used confirmatory path analysis to test the effects of (a) context variables on collaboration dynamics, (b) collaboration variables on quota fulfilment, and (c) context variables on quota fulfilment (Fig. 1). Our unit of analysis was Moose Management Areas (n = 149). Path analysis assumes causal relationships between variables, and thus requires a clear temporal sequence of events (Hair et al., 2013). This means that if we assume one variable to cause another, the causing one must happen/exist before the other in time. In our study, most context variables were based on data for the hunting seasons 14/15 and 15/16. Information on collaboration dynamics was collected in 2016, but we assume that the responses represent the respondents' experiences over a longer period, as only 2 % of the respondents said they were new to their MMG, and 80 % had been in the group for at least two years. We therefore consider it reasonable to assume that our measure of the collaboration dynamics affected goal fulfilment over multiple years (15/16–17/18).

Some of the variables had up to 2 % missing data (Table 1). Listwise deletion was applied, which resulted in the use of 142 complete observations. Pearson's product moment correlations between variables were below .70 (see Appendix Table C.2) and the VIF values were < 3, therefore we deemed the degree of multicollinearity acceptable and applied no remedies.

Path analysis assumes a multivariate normal distribution. We calculated Mardia's multivariate skewness coefficient (1602.01, $p < .001$) and the multivariate kurtosis coefficient (15.75, $p < .001$), which indicated that multivariate normality could not be assumed. We therefore used a robust version of the maximum likelihood estimator for our path analysis. Given the characteristics of our sample and proposed model, we decided to use *lavaan*'s MLR estimator (Rosseel, 2012). MLR calculates robust 'Huber-White' standard errors based on the observed information matrix and a robust likelihood ratio test statistic, which is asymptotically equivalent to the Yuan-Bentler T_2^* test statistic (Maydeu-Olivares, 2017).

Quota fulfilment was the dependent variable in the model, while collaboration variables (i.e. *Time investment*, *Knowledge base* and *Bonding social capital*) acted as dependent and independent variables in the different paths of the model and were thus assumed to play a mediating role between the social-ecological context and quota fulfilment (path a + b in Fig. 1). We therefore calculated the indirect effects of context variables on outcomes and the total effect of the three context variables (i.e. *Land use diversity*, *Density of other ungulates*, and *Moose density*) that had indirect and direct paths to *Quota fulfilment*. Standard errors for indirect effects and total effects were calculated using the Delta method (Rosseel, 2012).

To determine whether our model represented the observed data well, we used absolute and relative goodness of fit measures with thresholds adjusted to our sample size and number of variables (Hair et al., 2013). For absolute fit, we inspected the Chi-square (χ^2) results for testing the exact fit hypothesis and aimed for a Standardized Root Mean Square Residual (SRMR) below .05. The Tucker-Lewis Index (TLI), a parsimony fit index, indicates good model fit when its value is $> .97$, and the Root Mean Square Error of Approximation (RMSEA) and its 90 % confidence interval should be below .08 (Hair et al., 2013). Since we used a robust version of the ML estimator to handle the non-normality of our data, robust versions of χ^2, TLI, and RMSEA were calculated. All statistical analyses were conducted in *R* (R Core Team, 2019) using the *lavaan* package (Rosseel, 2012), a covariance-structure analysis package. We treated all variables as continuous and used .05 as the cut-off for statistical significance. No modifications to the original model were made.

3. Results

The path analysis explained 22 % of the variation in our dependent variable *Quota fulfilment*. The model was based on 142 observations (95 % of all areas) and we freely estimated 23 parameters (see Fig. 2). A robust χ^2 value of 20.353, (df = 19, p = .374) and a SRMR of .030 indicated a good absolute model fit. A robust RMSEA of .022 (90 % CI = .000–.076) and robust TLI of .996 confirmed the acceptable fit of our path analysis. Unstandardized estimates, standard errors, and results of significance testing for all estimated parameters are presented in the supplementary material (Table C.3.).

We found two significant direct effects of the social-ecological

[6] Swedish: *Jaktvårdskrets*

context on the collaboration dynamics. *Time investment* was significantly higher in big MMAs and if there was a high *Fluctuation in forage availability* (β = .17, p = .023), with the *Area size* (β = .42, p < .001) having twice the influence of forage fluctuations. Overall, we explained 20 % of the variation in *Time investment*. Contradicting our expectations, *Land use diversity* had a negative path coefficient for *Time investment*, but the result was non-significant (β = −.12, p = .097). Similarly, the *Density of other ungulates* had a negative effect of −.16 on *Knowledge base*, but with a p-value of .069 it was above the threshold of statistical significance. Thus, none of the context variables significantly affected the *Knowledge base* or *Bonding social capital* of MMGs.

As expected, collaboration variables were found to have positive effects on outcomes (Fig. 2). *Time investment* and *Knowledge base* had significant positive effects on *Quota fulfilment*, with standardized path coefficients of .17 (p = .023) and .19 (p = .014), respectively. This indicates that outcomes were better in areas where MMGs invested more time or felt they had a good knowledge base. Furthermore, we found a significant covariance of .29 (p = .001) between *Knowledge base* and *Bonding social capital,* indicating a positive link between these two collaboration variables.

Of the three context variables that we expected to have direct effects on outcomes, two yielded significant estimates. *Quota fulfilment* was lower in areas with high *Land use diversity* (β = −.21, p = .041) and areas with a high *Density of other ungulates* (β = −.14, p = .035). *Moose density* on the other hand had no significant effect (β = .09, p = .332) on *Quota fulfilment*.

When inspecting the indirect effects of context variables on *Quota fulfilment*, we discovered that *Area size* had a small but significant effect (β = .07, p = .044): bigger areas led to increased *Time investment* by MMGs. None of the other indirect effects were significant; estimates for them are presented in the Appendix in Table C.3. When accounting for its indirect and direct effect on *Quota fulfilment, Land use diversity* had a total effect of −.24 (p = .035). The *Density of other ungulates* had no significant indirect effect on *Quota fulfilment* via decreased knowledge or bonding social capital in MMGs but had a total effect of -.17 (p = .009). *Moose Density* had no significant overall effect (β = .09, p = .339) on *Quota fulfilment*.

4. Discussion

Our study provided a unique opportunity to connect the social-ecological context to stakeholders' personal experiences of collaboration dynamics, and to compare their set goals to outcomes. This is important given that the governance system of moose in Sweden relies heavily on voluntary efforts to handle the inherent conflict between forestry and hunting interests. Our results show that some social-ecological context variables have direct effects on the time investment required of participants and thus influenced collaboration dynamics. More reported time investment and a stronger perceived knowledge base led to higher quota fulfilment, while ecological contexts involving diverse land use and high densities of other ungulates challenged successful outcomes.

4.1. The influence of social-ecological context on collaboration dynamics

The only significant direct effects of social-ecological context variables on collaboration dynamics identified by our model were those relating to the amount of time MMGs had to invest. In line with our predictions, larger MMAs and pronounced fluctuations in forage availability necessitated greater time investment. While we assume that larger areas increase the time spent on analysing monitoring data and collaboration, there are other factors that could contribute to the observed effect. MMAs tend to be larger in the north of the country (Fig. 1), which is dominated by forestry and where moose occur in higher numbers than other ungulates. This might increase the relative importance of moose management and actors' willingness to invest time. Further research will be needed to understand the exact mechanisms and actors' motivations for investing time. Environmental uncertainty in the form of fluctuations in forage availability may increase the demand for monitoring or more frequent revision of existing management plans and strategies. Uncertainty was found to increase transaction costs in other studies on collaborative resource management (Adhikari and Lovett, 2006). Contrary to our expectations, the actual number of sub-units had no significant effect on time investment, and the coefficient for land use diversity was actually negative. Diverse landscapes offer a variety of ecosystem services, and land use diversity is known to overlap with the presence of other ungulate species (Fig. 1, brown area of the map). This might reduce the importance of moose hunting relative to other hunting and land use forms, prompting hunter and landowner representatives to spend less time dealing directly with moose.

The participants' perception of their own knowledge base was not influenced by high fluctuations in forage availability, the presence of large carnivores, or other ungulates. However, the latter variable had a noticeable negative path coefficient and was barely above the level of statistical significance. Based on our workshop and survey material, we concluded that stakeholders are displaying adaptive capacity towards these possible sources of uncertainty. In our survey, participants from 90 different MMGs reported that they had developed local monitoring methods for other ungulate species. Thus, while other ungulates might be a challenge, many groups had developed ways of collecting knowledge on these species. An additional explanation for the non-significant effects may be geographical variation in the presence of these factors. As described earlier, the presence of other ungulate species and large carnivores either follows a geographical gradient or is restricted to certain regions. Given that we used MMAs as unit of analysis, we could not test geographically separated models for northern and southern Sweden because the sample sizes would have been too small. It may thus be that some of these factors would have regionally significant effects on knowledge.

Geographic variation could also impact the effects of high densities of other ungulates, moose densities, and browsing damage on bonding social capital in MMGs. This may be why no significant effects on bonding social capital were observed, in contradiction to our hypothesis. On the other hand, this could be interpreted as a positive feature of the studied system. Bonding social capital was relatively high in many groups, with a mean value of 8.25 (SD = 4.21) on a scale ranging from −14.87 to 14.87. This may indicate that groups have built solid bonding ties that can withstand external stressors such as conflicts over browsing pressure. Instead, groups created a collaboration climate that is built on trust and allows for the discussion and handling of challenges.

4.2. The influence of collaboration dynamics on outcomes

Tests of the link between collaboration dynamics in terms of shared motivation (i.e. social capital) and capacity for joint action (i.e. resources and knowledge) to manage goal conflicts and outcomes revealed positive effects of time investment and a high knowledge base on quota fulfilment. Multiple components of time investment were considered, including time investment on individual tasks (e.g. group members educating themselves or analysing data), collaboration tasks (e.g. talking to MMUs and representatives of other interests), and activities connected to establishing management plans (e.g. meetings within the group). While our analysis shows a causal link between time investment and quota fulfilment, the direct mechanism is open to interpretation. Each component could contribute in a different way. On the one hand, investment in collaboration with MMUs and local landowner and hunter representatives could lead to better anchoring of the set goals and planned management actions among the involved actors. Local hunting teams are the ones who ultimately conduct harvesting based on the established quotas. Including these teams in the goal-setting process could increase the legitimacy of plans and the likelihood of actors working towards a common goal, leading to effective conflict management (Newig et al., 2018). This kind of investment can also create bridging social capital, which can foster rule compliance and be beneficial for the alignment of management actions across scales (Grafton, 2005). On the other hand, time investment in analysing data, preparing for, and actually attending meetings to set and revise plans should also be beneficial for quota fulfilment. More preparation and discussion of plans might lead to quotas that are better adjusted to social and ecological conditions, which could contribute not only to the fulfilment of local and regional goals but also national policy objectives as stated by the Swedish government and parliament. Further research will be needed to disentangle different types of time investment, the potential role of bridging social capital, and the mechanisms by which time investment improves quota fulfilment.

Better-adjusted plans could also be part of the positive effect of knowledge base on quota fulfilment, keeping in line with the hypothesis that a higher standard of outputs increases the likelihood of successful implementation (Newig et al., 2018). Groups that believe they possess sufficient knowledge about the current ungulate population, forage availability, predation, and local variation might feel more confident, leading to the formulation of more realistic quotas, which are thereby easier to reach. Adequate knowledge (particularly in relation to local variations in moose densities) could contribute to a better distribution of sub-quotas among MMUs and license areas. This is consistent with some of the obstacles discussed by stakeholders in our workshop on goal fulfilment, who reported that under certain distribution schemes, parts of the quota might be “locked-in” in areas where the moose density does not allow for the set target to be reached swiftly. This might be related to certain traditions of allocating quotas between sub-units or insufficient knowledge of seasonal and geographic variations in moose populations.

The perceived knowledge base also exhibited positive co-variance with bonding social capital. Higher perceived knowledge within MMGs could reduce the frequency of discussions or disagreements based on uncertainty, thereby helping to build bonding social capital and reduce conflicts. At the same time, high social capital in the group can benefit individual and group-level knowledge because it leads actors to trust one-another, strengthening communication and maximizing the utility of individual human capital by encouraging members to learn from each other (Grafton, 2005). Bonding social capital in itself had no direct effect on quota fulfilment, however. We assumed that better collaboration and trust between group members may result in the setting of goals that are considered more legitimate, leading to better outcomes. In statistical terms, it could be that having relatively high bonding social capital in most groups (as indicated by the high mean value), could not explain a significant amount of the variation in goal fulfilment. From a theoretical perspective, it may be that bridging and linking social capital, i.e. trust and positive collaboration between MMGs and their sub-units might be a more important factor for quota fulfilment. Further studies will be needed to explore this possible relationship and examine goal alignment between levels.

4.3. The influence of social-ecological context on outcomes

While collaboration aspects led to better outcomes, two context variables proved to be counterproductive for quota fulfilment: high land-use diversity and density of other ungulate species. While some MMAs in the North are clearly dominated by forests (which account for up to 85 % of their total area), MMAs elsewhere (especially in central and southern Sweden) can be comprised of a mixture of agriculture, forestry, wetlands, open areas and artificial surfaces. Those multifunctional landscapes provide diverse bundles of ecosystem services that are highly valued by different stakeholders (Queiroz et al., 2015). Thus, these multi-use landscapes increase the likelihood of frequent encounters between moose hunters and other stakeholders using the same landscape. The presence of urban and peri-urban areas in particular can have practical implications for moose hunting practices, such as limitations on the use of free-roaming hunting dogs, or the need for adaptive capacity in moose hunting strategies (Hiedanpää and Pellikka, 2015). Diverse land-use can thus reduce the success rates in the adaptive management process. Another possible explanation is the structure of landownership: the number of individual landowners per unit area in southern Sweden is more than twice that in the north. It is therefore possible that land use diversity partly reflects another north-south gradient that may directly affect quota fulfilment.

The presence of other ungulate species might create attractive alternative hunting opportunities that cause hunters to shift their focus away from moose. Red deer aside, no set quotas or management plans are required for other ungulates. These species thus offer hunters more individual freedom and require less transaction costs and collaborative efforts than being part of the moose management system. Hunters can individually decide how many individuals of the other ungulate species they want to shoot on their land during the hunting season. Although hunting seasons are defined separately for each ungulate species, most of them overlap during fall and winter times. Consequently, hunting activities are to some extent divided between several species, whereby the harvest ratio between other ungulates and moose can be as high as 50:1 in some MMAs. The current moose management system was designed on the basis of an ecosystem approach, but our results indicate possible limitations to this. While management decisions were decentralized and management areas were designed to cover distinct moose populations, multi-species management was not thoroughly incorporated into the management system. Current management plans account for the presence of large carnivores and forest conditions, but no systematic integration of other ungulate species is performed. Because our results show that high densities of other ungulates negatively influence moose quota fulfilment, this suggests that management performance could be improved by adapting strategies that allow for co-management of all species and balance efforts between species. This is also consistent with a recent call from leading wildlife biologists to adapt a more holistic perspective in European ungulate management (Apollonio et al., 2017).

Our study used a holistic approach based on a complex model to understand variation in quota fulfilment. This model explained 22 % of the variation, which could be considered low, but one should note that we aggregated and combined available data from different sources and collected over several years. We are aware of possible limitations in our variable selection. Our measure of quota fulfilment cannot account for rapid changes in the social-ecological context, which might influence annual performance. Workshop participants named factors such as climatic events (e.g. extreme snow or dry summers) and quick ecological changes leading to high natural mortality (e.g. a wolf pack suddenly entering the area or a disease outbreak). A social factor that some participants mentioned as creating barriers to quota fulfilment is land ownership structure (Appendix Table B.1). We are also aware that quota fulfilment inevitably depends on how and what goals are set. As noted previously, set goals can have detrimental effects on quota fulfilment if they are unrealistic or not co-created with sub-units. While knowledge and time investment might contribute to better-accepted and adjusted goals, more research on the quality of set goals is needed. Future studies should thus measure the local acceptance of set goals and their ecological feasibility. Furthermore, since quota fulfilment is an intermediate ecological outcome, further studies on desired final ecological outcomes (i.e. high quality moose populations and acceptable browsing damages) will be needed to properly evaluate the performance of the governance regime. Given the current data availability, this was unfortunately not possible.

5. Conclusions

This study offered an opportunity to compare the goals of a collaborative governance process to its outcomes while accounting for context and actors' perceptions. It thus represents a truly interdisciplinary effort to link social and ecological dynamics. Our approach shows how qualitative data and a close collaboration with practitioners and stakeholders can enrich quantitative modelling. We consider the use of actors' experiences of collaboration dynamics (as opposed to researcher-based assessments) to be a key advantage of our study. More research applying complementary qualitative and quantitative methods to triangulate causality and the underlying mechanisms is needed to obtain a situated understanding of success and failure in collaborative natural resource governance and enable systematic learning.

Nevertheless, some of the criticism that was raised towards other research evaluating collaborative governance regimes also applies to our study. Critics have argued that treatment and control set-ups are needed to really determine whether the collaborative process causes the observed changes in outcome variables or whether other confounding factors exist (Ferraro et al., 2019). Experimental setups of this type are rarely possible in real-world governance implementations. Nevertheless, we are confident that our cross-site study allowed us to disentangle the effects of collaboration process and context on outcomes. Furthermore, it is noteworthy that average quota fulfilment within the investigated period was 88 % (SD = 12.5 %) compared to reports of 54–58 % quota fulfilment prior to the policy change (Swedish Government Bill, 2009/10:239).

In future, it will be important to monitor additional performance measures to enable holistic evaluation of the governance regime (Emerson and Nabatchi, 2015b). In accordance with the stated goals of the new policy, ecological monitoring regimes are in place to evaluate qualitative aspects of the moose population (e.g. calf weights and recruitment rates) and impacts on the forest ecosystem (e.g. browsing damage and recruitment of certain tree species). However, monitoring of process performance and social outcomes are not embedded in the management structure, even though the changes to the policy were made with the goal of reducing conflicts between actors. Thus, repeated measurements of process aspects such as social capital, knowledge, leadership, legitimacy and commitment are relevant for both research and policy development. Ultimately, the system's sustainability will depend on both its social and its ecological performance. This is in line with a recent call from Waylen et al. (2019) for policy-driven monitoring and evaluation that lifts the focus from monitoring only management-related indicators to broader aspects of the governance regime.

Lastly, from a policy perspective our results raise the question of institutional fit in diverse landscapes with many other ungulate species: landscape diversity and an abundance of other ungulates both had negative effects on the performance of the moose policy. It thus seems that there is a need for adaptation to create institutions that better match the challenges of local contexts in order to secure positive social and ecological outcomes.

Data availability statement

All data necessary to replicate the findings of this study are available within the paper and its Appendix files.

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Declaration of Competing Interest

The authors report no declarations of interest.

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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.landusepol.2020.105028.

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