Reassembling transboundary natural resource governance: Case studies of posthuman wild food systems in Eeyou Istchee

Nathan A. Badry
Department of Natural Resource Sciences
Faculty of Agricultural and Environmental Sciences
McGill University, Montréal
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LIST OF ABBREVIATIONS

ANT	Actor-network theory
AFR	Adapted Forestry Regime
CNG	Cree Nation Government
CTA	Cree Trappers' Association
FCM	Fuzzy cognitive mapping
HSI	Habitat suitability index
ILA	Integrated landscape approaches
ILK	Indigenous and local knowledge
IPBES	The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
JBNQA	James Bay and Northern Quebec Agreement
LEK	Local ecological knowledge
MHQ	Moose Habitat Quality in Eeyou Istchee Under the Adaptive Forestry Regime
SES	Social-ecological system
SSHRC	Social Sciences and Humanities Research Council
TEK	Traditional ecological knowledge

ABSTRACT

The governance of natural resources is often characterised by ecological, social, and jurisdictional complexity. One dimension of this complexity is epistemological and ontological pluralism, wherein governance structures and processes must contend with multiple knowledge systems and worldviews. In Canada, for example, pluralistic natural resource governance often includes Indigenous Peoples, in addition to government, non-governmental, and industry actors. Even in cases where these diverse governance actors share broadly agreed-upon conservation and sustainable development goals, pluralism can have significant implications for collective action, as well as epistemic justice and reconciliation. While different knowledge systems and worldviews can enhance understanding, inclusion, and innovation, they can also create frictions and controversies. Indigenous knowledge systems are frequently incommensurable with the dominant scientific and bureaucratic knowledge systems of natural resource governance. This is particularly evident in cases involving the social roles of nonhuman actors, which often play active parts in Indigenous ontologies and epistemologies. In this dissertation, I first synthesise the literature on actor-network theory (ANT), and analyse how this approach to understanding human/nonhuman networks could also inform understandings of knowledge weaving and pluralistic natural resource governance. To demonstrate empirically how knowledge weaving can challenge network governance approaches, I conduct a case study of moose and forestry governance in Eeyou Istchee, the James Bay Cree Territory of northern Quebec, Canada. Cree livelihoods are closely linked to wild food species like moose. However, these species are being heavily impacted by forestry and other resource development. Fuzzy cognitive mapping was conducted with Cree land-users to explore the different social-ecological impacts to moose habitat. The case study shows that, while some differing Cree and scientific understandings of boundary spanning factors are relatively easy to reconcile, some factors, especially those related to specific local culture and belief, are not. A second case study of lake sturgeon governance in the Cree community of Nemaska demonstrates how an ANT-inspired approach to network governance could help span boundaries between pluralistic governance actors. Like moose, lake sturgeon is an important wild food species being impacted by resource development. Using interviews and participant observation, I describe lake sturgeon actor-

networks in Nemaska, identifying the relational networks of humans and nonhumans that influence governance. Through the tracing of these networks, boundary-spanning roles that may be hidden from other approaches are highlighted. Natural resource governance regularly depends on complex relationships and consensus between local land-users, scientists, and policy makers. In such pluralistic settings, shared understandings can be challenging to develop, and I conclude that ANT and a wider turn towards posthumanism would help decentralise the human in network governance methods, thereby creating novel insights for overcoming conflicts and improving collective action.

RÉSUMÉ

La gouvernance des ressources naturelles est souvent caractérisée par une complexité écologique, sociale et juridictionnelle. L'une des dimensions de cette complexité est le pluralisme épistémologique et ontologique, dans lequel les structures et les processus de gouvernance doivent faire face à de multiples systèmes de connaissances et de visions du monde. Au Canada, par exemple, la gouvernance pluraliste des ressources naturelles inclut souvent les Peuples Autochtones, en plus des acteurs gouvernementaux, non gouvernementaux et industriels. Même lorsque ces divers acteurs de la gouvernance partagent des objectifs de conservation et de développement durable largement acceptés, le pluralisme peut avoir des implications significatives sur leur prise de décision, ainsi que sur la justice épistémique et la réconciliation. Des systèmes de connaissances et de visions du monde différents peuvent créer des frictions et des controverses. Les systèmes de connaissances autochtones sont souvent incommensurables avec les systèmes de connaissances scientifiques et bureaucratiques dominants de la gouvernance des ressources naturelles. Cela est particulièrement évident dans les cas impliquant les rôles sociaux des acteurs non humains, qui jouent une fonction active dans les ontologies et épistémologies autochtones. Dans cette thèse, je synthétise d'abord la littérature sur la théorie du réseau-acteur (TRA), et j'analyse comment la compréhension des réseaux humains/non humains pourrait éclairer le tissage de connaissances et la gouvernance pluraliste des ressources naturelles. Pour démontrer empiriquement comment le tissage de connaissances peut remettre en cause les approches de gouvernance en réseau, je mène une étude de cas sur la gouvernance de l'orignal et de la foresterie dans l'Eeyou Istchee, le territoire des Cris de la Baie James, dans le nord du Québec, au Canada. Modes de vie des Cris sont étroitement liés à des espèces sauvages comme l'orignal. Cependant, ces espèces sont fortement touchées par l'exploitation forestière et d'autres ressources. La cartographie cognitive floue a été réalisée avec des utilisateurs cris du territoire afin d'explorer les différents impacts socio-écologiques sur l'habitat de l'orignal. L'étude de cas montre que, si certaines interprétations scientifiques et cries des facteurs de délimitation sont relativement faciles à concilier, il n'en va pas de même pour d'autres facteurs, en particulier ceux liés à la culture et aux croyances locales. Une deuxième étude de cas de la

gouvernance de l'esturgeon jaune dans la communauté crie de Nemaska, démontre comment une approche de la gouvernance en réseau inspirée de la TRA pourrait aider à frontières entre les acteurs de la gouvernance pluraliste. Comme l'orignal, l'esturgeon jaune est une espèce importante du système alimentaire cri qui subit l'impact du développement des ressources. À l'aide d'entrevues et d'observations participatives, je décris les réseaux d'acteurs de l'esturgeon jaune à Nemaska, en identifiant les réseaux relationnels d'humains et de non humains qui influencent la gouvernance. Le traçage de ces réseaux permet de mettre en évidence des rôles qui s'étendent au-delà des frontières et qui ne sont pas nécessairement pris en compte par d'autres approches. La gouvernance des ressources naturelles dépend régulièrement de relations complexes et d'un consensus entre les utilisateurs locaux du territoire, les scientifiques et les décideurs politiques. Dans de tels contextes pluralistes, il peut être difficile de parvenir à une compréhension commune, et j'en conclus que TRA et un tournant plus large vers le posthumanisme contribueraient à décentraliser l’humain dans les méthodes de gouvernance des réseaux, créant ainsi de nouvelles perspectives pour surmonter les conflits et améliorer l’action collective.

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In the spirit of actor-network theory, thank you to all the non-human actors who played instrumental and agential roles in this process, but particularly my laptop (now on its last legs), Zotero, and my moka pot.

McGill is situated on unceded Indigenous lands historically known as a gathering place for many First Nations, and today recognized as traditional territory of the Kanien’kehà:ka. Much of my thesis research took place in the Cree or Eeyou territory of Eeyou Istchee. As a

visitor to these lands, I recognise that acknowledgment without meaningful action is only a gesture, and my ongoing responsibility to work actively against colonialism and towards reconciliation.

Finally, thank you to my family, and especially Tian, who started out as my lab-mate, and then became so much more. Your support made this possible.

CONTRIBUTIONS TO KNOWLEDGE

This dissertation makes empirical and theoretical contributions to several overlapping fields of research and practice. It identifies gaps and opportunities for weaving together diverse knowledges in natural resource governance, particularly with Indigenous knowledges. It advances scholarship on one such opportunity, actor-network theory, by applying it in case studies of natural resource governance, where it is underrepresented. Individual case studies also advance knowledge of their subjects, which is the governance of wild foods in the Cree territory of Eeyou Istchee, northern Quebec. Chapters 4 and 5 contribute to Cree communities' knowledge of the diverse actors, structures, and processes that intersect to shape wildlife governance. Through these cases, we demonstrate empirically that some network governance methods struggle to address knowledge pluralism and weaving, and that actor-network theory can help span those boundaries between knowledge systems, namely Indigenous, scientific, and bureaucratic. Finally, this dissertation serves as a jumping-off point for practitioners working in pluralistic natural resource contexts, who are looking for inspiration for tools to enhance collective action among diverse actors.

Chapter 3: Enhancing collaboration across the knowledge system boundaries of ecosystem governance

- This chapter synthesizes current knowledge on actor-network theory and knowledge weaving in natural resource systems and highlights their shared relevance to governance.
- It identifies that, in pluralistic governance contexts, ontological boundaries can create significant obstacles to knowledge weaving, and that these boundaries are largely unaddressed by standard methods and approaches.
- It proposes actor-network theory may be able to address some of these ontological boundaries and improve collective action.

Chapter 4: Boundary-spanning methodological approaches for collaborative moose governance in Eeyou Istchee

- This chapter analyses empirically an instance of knowledge weaving between Cree knowledge of moose habitat and moose GPS collar data.
- It explores the opportunities and challenges for knowledge weaving offered by fuzzy cognitive mapping, a network method increasingly popular in natural resource governance research.
- It contributes to the literature on resource management in Indigenous co-management settings by concretely identifying challenges posed by ontological boundaries.
- It offers insights for local governance actors into specific knowledge weaving challenges facing moose and forestry governance in Eeyou Istchee.

Chapter 5: Using actor-network theory to untangle complexity in the analysis of pluralistic social-ecological systems: The case of transboundary lake sturgeon governance in Nemaska, Eeyou Istchee, Canada

- This chapter explores the possible applications of actor-network theory in network governance research for enhancing understandings of complexity and pluralism in natural resource systems.
- It expands on concepts of network governance to include nonhumans as social actors, opening new directions for academic research on natural resource governance.
- It contributes a new case study and lessons learned to the transdisciplinary actor-network theory literature.
- It documents contemporary and traditional practices related to lake sturgeon in Nemaska, with implications for ongoing management by diverse governance actors.

CONTRIBUTIONS OF AUTHORS

This thesis follows a manuscript-based format containing three manuscripts, all of which Nathan A. Badry is the primary author of and wrote the original drafts for. Academic supervision was provided by Profs. Gordon M. Hickey (McGill University) and Murray M. Humphries (McGill University) for these manuscripts and throughout the PhD process.

For Chapter 3:

Nathan A. Badry: Conceptualisation, document review, review and editing

Gordon M. Hickey: Conceptualisation, review and editing

For Chapter 4:

Nathan A. Badry: Conceptualisation, data collection and analysis, review and editing

Gwyneth A. MacMillan: Conceptualisation, data collection and analysis, review and editing

Eleanor R. Stern: Data collection and analysis, review and editing

Manuelle Landry-Cuerrier: Visualisation

Gordon M. Hickey: Conceptualisation, review and editing

Murray M. Humphries: Conceptualisation, review and editing

For Chapter 5:

Nathan A. Badry: Conceptualisation, data collection and analysis, review and editing

Murray M. Humphries: Conceptualisation, fieldwork support, review and editing

Gordon M. Hickey: Conceptualisation, review and editing

CHAPTER 1. GENERAL INTRODUCTION

1.1 Background

Different social groups understand the world in different ways. These different understandings can be a function of many factors: social group membership, relationships, culture, history, geography, and more. In natural resource management discourse, perhaps one of the most prominent of these differences in understanding is the difference between knowledge systems. Different knowledges can significantly impact the actions of practitioners and researchers in pluralistic spaces, and subsequently, governance outcomes. Knowledge systems help dictate what questions can be asked, what approaches can be taken, and what counts as data or not.

These differences often arise in natural resource management contexts in which Indigenous Peoples play a role in governance structures and processes. Questions of how to address these differences are becoming both more common and pressing, as Indigenous Peoples around the world continue to assert their rights to the management of their territories through new treaties, agreements, and governance arrangements. Determining how Indigenous knowledge systems work with different scientific and bureaucratic knowledge systems is increasingly relevant.

In natural resource management, scientific knowledge is frequently defined in relation to other knowledges, particularly to Indigenous knowledges. Western scientific knowledge is typically considered to be more quantitative, reductionist, positivist, and materialist (Mazzocchi, 2006). In recent years, a growing emphasis has also been placed on creating science that is responsive to the needs of bureaucratic decision-makers. Felten and von Oertzen view bureaucracies as constantly evolving socio-material structures, made up of states, companies, capitalism, colonialism and more (2020). Bureaucratic knowledge is the knowledge of governance; the knowledge of policies, norms, relationships, and administration, embedded within these same socio-material structures. However, bringing together all these knowledges can introduce complexities and difficulties for collective action. Despite there having been research interest in the weaving of scientific, bureaucratic, and Indigenous knowledge systems for several decades (Agrawal, 1995), many challenges still remain.

For example, ecologist Fikret Berkes, in their work with the Indigenous Cree Peoples of Eeyou Istchee, northern Quebec, describes a story about caribou and hunting (Berkes, 2018). Caribou are an important wild food species for the Crees, and the Crees and caribou share significant relational ties. Caribou are not just a source of nutrients, but have far-reaching roles in the Cree world, intersecting with Cree cultures and economies. But in the early 1900s, caribou began to decline, raising concerns about their long-term persistence. Nonetheless, in one area of Eeyou Istchee, the Caniapiscau river, caribou were still abundant, and people traveled from all over the surrounding region to hunt them. The result was overhunting and waste, as caribou were slaughtered, and their carcasses left behind to rot. This broke the relationships of respect and reciprocity between hunter and hunted, and the caribou subsequently left the land, and disappeared. The story went that, despite the disappearance of the caribou, they would one day return, as all change is cyclical.

This belief, that human and nonhuman share a mutual responsibility towards each other, and that the nonhuman can possess just as much agency within that relationship as the human, is shared among many Indigenous Peoples (Reo, 2019). However, this belief is also contrary to most modern scientific and bureaucratic understandings of the relationships between human and nonhumans, and perhaps more relevantly, contrary to understandings of how those relationships should be managed.

One scientific framework for thinking about human and nonhuman relationships is the social-ecological system (SES). SES frameworks are models of complex systems that include both social and ecological elements and dynamics. A number of different examples can be found in the scientific literature (Schoon & van der Leeuw, 2015). One of the best known is Elinor Ostrom's (2009), which builds on earlier work on institutional analysis, and has predefined and interrelated spheres for resource units, resource systems, users, and governance systems, all of which are linked together. SES theory has arguably gained popularity largely because of its recognition as a boundary-spanning framework. By bringing together social and ecological perspectives, it can help the analyst include some of the complex relationships discussed above.

However, there are still boundaries that SESs do not address. Boundaries between knowledge systems, yes, but also boundaries between social groups, ontologies, as well as humans and nonhumans. Boundaries of these kinds are often present in complex natural resource systems. However, few of the commonly applied theoretical and methodological approaches, like SESs, are designed to address them.

The story of the caribou was one that was told during the 1980s by the elders of Chisasibi, a Cree community within Eeyou Istchee. The story was being told because the caribou had indeed returned, and they had now become abundant enough to be hunted once again, two generations after their disappearance. But the same concerns were being raised. Overeager hunters were treating the caribou with disrespect, and the caribou could leave just as quickly as they had reappeared. The story was meant to be a lesson for younger hunters that would reinforce the proper way in which to interact with the caribou and prevent another population collapse. Subsequent hunting was carried out in a responsible manner according to the Cree hunting ethic. there was no waste, and the Cree exercised their right to govern the hunting of caribou in their traditional territory.

How would such belief and practice affect pluralistic wildlife governance today? While both the Cree, as well government biologists and managers trained in Western science, have observed and subscribe to the same concept of population cycles, they do so according to different logics and understandings. Cree and scientific knowledge converge on many ideas and observations, but how would biologists make use of Cree knowledge that contradicted scientific data? How could they justify that to managers and policy makers? There are effectively multiple languages being spoken, one of Indigenous ways of knowing, one of science, one of policy. A bridge is needed in order to begin relating ontologically conflicting ideas and taking productive steps forward.

1.2 Opportunity

There is a need for further empirical exploration of transboundary obstacles to collective action, and the possible methodological approaches for addressing them (Norman, 2015). Many of todays natural resource and environmental governance problems, from climate

change to species conservation, have complex drivers and involve numerous governance actors. To address this complexity, creative new methodological approaches that do not replicate injustices, and can tell new stories about our human and nonhuman relationships (Foster, 2023), must be developed. These transboundary methods would need to operate in pluralistic contexts, and span boundaries that go beyond social and ecological, as well as fit within Indigenous models of collaboration like Two-Eyed Seeing (Popp et al., 2020). There are bodies of scholarship like posthumanism and actor-network theory (ANT), which could potentially fill some of these gaps. However, the uptake of these concepts and approaches in SES scholarship has been slow. New transdisciplinary methods could potentially help researchers and practitioners better analyse the complex relationships within SESs, and enhance collective action by, for example, helping actors work more effectively across different knowledge systems.

1.3 Research objectives and questions

The overall research objective for this work is to answer the question: What are the gaps and opportunities in transboundary methods for pluralistic natural resource governance in Eeyou Istchee? To more fully develop an understanding of the relationship between transboundary methods, governance, and pluralism in Eeyou Istchee, each of the research chapters were guided by more specific research questions.

My sub-questions are:

1. Can natural resource governance methods be improved to help address knowledge weaving obstacles in collaborative natural resource governance spaces?
2. To what extent can the participatory mapping method, fuzzy cognitive mapping, help bridge ontological gaps inherent to knowledge weaving processes in moose and forestry governance in Eeyou Istchee, and better support diverse governance actors working together towards shared goals?
3. Can an ANT-inspired approach to analyzing natural resource governance networks help improve understandings of a complex, transboundary lake sturgeon SES in Eeyou Istchee?

1.4 Methodological approach

Chapter 3 synthesises research on ANT and traditional ecological knowledge to propose a new method for pluralistic natural resource governance, filling a key gap in the academic literature. This dissertation employs an instrumental case study approach (Yin, 2018) in Chapters 4 and 5. Instrumental case studies provide insights into specific issues or phenomena (Denzin & Lincoln, 2005). In this dissertation, that insight is whether new methods are needed to address complexity and pluralism in natural resource governance, and whether actor-network theory could be one of those methods. The subject of the following case studies is Cree wild food governance.

A number of bodies of academic theory were drawn on to inform our approach, including network governance, analytical network methods, posthumanism and actor-network theory, and knowledge weaving. Field research for Chapters 4 and 5 of this dissertation was conducted in Eeyou Istchee, as described in Sections 4.4 and 5.3.

1.4.1 Data collection

Research activities included both Cree and non-Cree participants, and involved those who were directly related to wild foods, as well as those who were more generally involved in wildlife management, conservation, or natural resource development in the territory. Efforts were made to include participants of different genders, age groups, and occupations. A large number of different governance organisations are also represented, including band councils, the Cree Nation Government, the Cree Trappers' Association, the Ministère des Forêts, de la Faune et des Parcs, the Cree-Québec Forestry Board, Niskamoon, and Hydro-Québec. Many of the participants were identified through snowball sampling, as well as with the help of local research assistants, who were hired to help enroll participants and translate between Cree and English.

Data were collected using a variety of methods, and often in multiple methods approaches. Specific methods included semi-structured (Özesmi & Özesmi, 2004) and unstructured interviews (Corbin & Morse, 2003), participatory mapping (Andersson & Silver, 2019), workshops (Caretta & Vacchelli, 2015), participant observation (Jorgensen, 2015), and document analysis (Bowen, 2009). Many of the methods, such as unstructured interviewing,

were chosen because of their synergies with Indigenous understandings of the importance of storytelling and the orality of knowledge transfer (Bessarab & Ng'andu, 2010; Kovach, 2010).

1.4.2 Data analysis and representation

A number of analytical techniques were applied in this dissertation. Data analysis was typically done as part of an iterative research process, beginning as data was still being collected, to help inform additional avenues of inquiry and other research activities.

Coding was used to help analyse some of the data from interviews, workshops, document analysis, and participant observation. A combination of open and constant comparison coding was used (Saldana, 2016). Fuzzy cognitive mapping techniques were used to analyse the data from participatory mapping exercises. This involved synchronising and categorising network node variables across research teams, accounting for indirect relationships between nodes by calculating fuzzy transitive closure values (Sarmiento et al., 2020, 2022), and developing adjacency matrices of the data. ANT techniques were used throughout the dissertation to inform analyses. There is no single way to "do" ANT, but I followed the recommendations of scholars like Latour (2005) and Law (1992) for tracing the relationships between networked actors, and applied key ANT concepts like translation (Callon, 1984) and agency (Sayes, 2014).

Some of the complementary data collection and analysis which informed the results of the dissertation was conducted primarily by other researchers. This includes the collection and analysis of moose GPS collar data in Chapter 3. This is clearly noted where applicable.

The results of this research have been represented primarily in thick qualitative description and network diagrams. Results have been communicated through scientific articles, plain language summaries, and presentations to both academic and Cree audiences.

1.4.3 Limitations and assumptions

The reliability of dissertation results was maintained and evaluated using a framework of trustworthiness, inspired by criteria and strategies from Lincoln & Guba (1985) and Baxter & Eyles (1997). Throughout the course of this dissertation, various measures were used to

maintain the trustworthiness of the research. These included: purposive sampling, prolonged engagement, persistent observation, triangulation between methods, co-researcher debriefing, low inference descriptors of data, thick qualitative description, and member checking workshops with participants.

Throughout this research, assumptions were made that ANT was an appropriate choice of method, as opposed to other overlapping approaches like multi-species ethnography (Kirksey & Helmreich, 2010), material semiotics (Law, 2009), or other various approaches under the umbrella of Posthumanism and New Materialisms (Alaimo, 2012). ANT was selected due to its history of transdisciplinary use across a wide number of fields (Donaldson et al., 2002; N. Watts & Scales, 2015), and because of its synergies with network methods and concepts already common to studies of natural resource management and governance (Dwiartama & Rosin, 2014; Nabavi & Daniell, 2017; Steins, 2001). However, the use of ANT is not without criticism, especially for research in Indigenous spaces, where it is argued that the application of a non-Indigenous method to Indigenous worlds can perpetuate hierarchies (This is discussed in further detail in Section 3.4; Todd, 2016; V. Watts, 2013). Thus, I sought to apply an ANT that has been deemed "ANT-adjacent" (Williams, 2020), and that draws on a wide body of these overlapping approaches, including the work of Indigenous scholars.

This research also assumes that the chosen case study subjects are representative of pluralistic natural resource governance, and that applications of ANT to these contexts can provide evidence of transboundary knowledge weaving.

1.4.4 Positionality statement

My positionality as a researcher and individual has highly affected this research. No research is value free, and all research is situated. Berger (2015) describes a researcher's positionality as consisting of three things: their social positions, their personal experiences, and their ideologies. This has impacted my access to the field, relationships with participants, and the worldview the data has been interpreted through. The question of who is conducting research and why is ever-present in Indigenous research contexts. My positionality as a white, settler, cisgender man, heterosexual, and formally educated graduate student has undoubtedly

influenced this work. During this research, I referred to what Cloke et al. (2000) suggest are five key ethical concerns in research—informed consent, privacy, harm, exploitation, and sensitivity to cultural differences and gender—to frame my ethical reflections.

However, the concept of reflexivity, while commonly applied in qualitative research, has faced some criticism from posthumanist scholars (Jenkins et al., 2021). For Karen Barad (2007), reflexivity implies a separation, an examination from outside. This would contrast with a posthuman understanding of the researcher as being deeply embedded in their research context. Donna Haraway (1997) has proposed instead the metaphor of diffraction, which has also helped to inform my positionality. Accordingly, the researcher disrupts and has a measurable impact on the world around them, and this recognition allows for new insights.

Throughout the development of this dissertation, I have worked with the Cree Nation Government as a contractor on additional projects related to wildlife management. I have been brought into contact with various people and organisations, developing working relationships outside of research, and this will have also had an impact on the outcome of my dissertation, shaping relationships in the field and new research directions.

1.5 COVID-19 Pandemic

The COVID-19 pandemic had a major impact on the development of this dissertation. Initial fieldwork began in 2019 but was postponed in 2020 when some university activities were suspended due to the pandemic, including in-person fieldwork. The start-up of fieldwork was further delayed due to concerns for the health and well-being of researchers, participants, and host communities. Overcrowding, a relative lack of public health resources, and other structural inequalities often meant that Indigenous communities in Canada faced greater risks during the COVID-19 pandemic. Indeed, in 2020 and 2021, COVID-19 mortality was higher among Indigenous Peoples in Canada than non-Indigenous people (Statistics Canada, 2024). Fieldwork for this dissertation would begin again in Fall 2021, but involved collaboration with local health and safety officers and a quarantine period before entering the region, among other more standard health and safety measures. Apart from the added delays, fieldwork challenges, and increased risks to participants, the pandemic also introduced difficulties in communicating

results back to communities and to academic audiences. Some planned activities were done remotely, while others needed to be cancelled altogether. Overall, the pandemic had a profound impact on the timelines and scope of this dissertation, and influenced the research questions, data collection, and results sharing.

1.6 Organisation of the dissertation

This is a manuscript-based thesis and therefore a certain level of repetition is unavoidable. Most of the chapters are at various stages of submission and publication in international peer-reviewed journals.

Chapter 2 is a literature review which expands on the knowledge gaps and opportunities outline above, and also includes key references and descriptions for the dissertation's synthesis and case study research contexts.

Chapter 3 presents a synthesis of scholarship on collaborative natural resource governance, knowledge weaving, and ANT. It explores the challenges that knowledge pluralism has posed for collective action and decision-making in governance, and helps identify the research questions that shape the rest of this dissertation. Chapter 3 was published in *Advances in Ecological Research* (2022).

Chapters 4 and 5 are empirical case studies of wild food governance in Eeyou Istchee, building on the general synthesis presented in Chapter 3. Chapter 4 explores some of the challenges that face pluralistic governance networks. Knowledge weaving obstacles are identified in a participatory network analysis of moose and forestry governance in Eeyou Istchee, northern Quebec. The results support the Chapter 3 findings that social-ecological network methods can lack the flexibility to address ontological pluralism, and that posthumanist network methods like ANT could offer solutions. Chapter 4 was published in *Environmental Management* (2024).

Chapter 5 describes a second case study, in which ANT is used to analyse lake sturgeon governance in the community of Nemaska, Eeyou Istchee. The potential of posthuman methods like ANT to span ontological boundaries in pluralistic governance networks is explored through

the tracing of complex sturgeon governance relationships between humans and nonhumans. Chapter 5 will be submitted to the journal *Environment and Planning E: Nature and Space*.

The final chapters of the dissertation include the general discussion, which summarises the major cross-cutting findings, contributions to theory and practice, future research directions, and the conclusion.

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PREFACE TO CHAPTER 2

Chapter 1 introduces the knowledge gaps and opportunities in natural resource governance and social-ecological systems scholarship related to pluralism and collective action. Chapter 2 builds on this by reviewing the relevant academic literatures related to these knowledge gaps and opportunities, as well as literature related to our case study research context. The chapter in particular focusses on different natural resource governance theories and methods, as well as the social, political, economic, and environmental background of Eeyou Istchee and Cree wild food systems.

CHAPTER 2. LITERATURE REVIEW

2.1 Natural resource governance

Natural resource governance has been described by Graham et al. (2003, p. ii) as: "the interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens or other stakeholders have their say." This definition reflects a shift in perspective on natural resource governance from state-centric government approaches, to new governance approaches (Lockwood et al., 2010; Turnhout et al., 2014), which recognise the governance of natural resources as being "characterized by complexity and contestation originating from multiple problem causes, divergent problem perspectives and solution strategies, and fragmented institutional settings" (Lockwood et al., 2010, p. 986), as well as numerous social and ecological interdependencies (Bodin et al., 2005; Steins, 2001).

New governance is distinct from what came before in that it conceptualises governance as a collaboration between a wide variety of actors, both public and private. These collaborative governance arrangements allow for diverse actors to collectively address complex issues which they could not address in isolation (Bodin & Crona, 2009; Emerson et al., 2012). Governance benefits from actors agreeing on rules and practices, coordinating resource use, building common knowledge, and other forms of cooperation (Bodin & Crona, 2009). Top-down, centralised control does not do this well (Carlsson & Sandström, 2008). Similar governance ideas are discussed across a wide body of academic literatures and with a variety of terms, including works on environmental governance (Armitage et al., 2012; Plummer et al., 2013), landscape governance (Ros-Tonen et al., 2014), earth system governance (Biermann et al., 2009), and natural resource management (Bodin et al., 2005; Lockwood et al., 2010; Steins, 2001).

The shift to new governance and related theoretical developments have been linked by some academics to a broader movement towards the neo-liberalising of governance institutions (Turnhout et al., 2014). New public management is one prominent example. Gaining popularity during the 1980s, New Public Management reflects a trend towards

decentralised administration and governance, private sector actors, internation actors, and a reduced role for state actors. Much of recent scholarship on governance has continued this, focussing on decentralised governance structures and processes.

In natural resource governance spaces, the rise of collaborative governance theory is particularly indicative of this trend. Collaborative governance is the "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" (Emerson et al., 2012, p. 2). Actors spanning different social groups, as well as other boundaries like those between scales or knowledge systems, may have shared goals, but they do not always agree on how to meet those goals. In this context, boundary-spanning actors that can act effectively as intermediaries are highly valuable (Cash et al., 2006).

These concepts are similarly reflected in specific approaches taken by governance practitioners, like co-management. In Canada, co-management arrangements are becoming increasingly common when diverse groups of governance actors are involved in the management of a resource like wildlife, particularly when this involves Indigenous rights and interests (Popp et al., 2019). Co-management can be described as a form of adaptive, collaborative governance, "characterized by collaboration, negotiation, joint learning, and problem solving" (Hessami et al., 2021, p. 1295). This involves sharing power among different actors, cooperative decision-making, and agreeing on shared goals (Berkes, 2009). Co-management was originally conceptualized as occurring mainly between two groups: government and local actors. Co-management has since evolved towards an understanding that co-management can, and typically does, involve a wide variety of actors across sectors and scales (Marín & Berkes, 2010). This expanded roster of actors can also help address some of the natural complexity of resource systems (Carlsson & Sandström, 2008).

2.2 Network governance

With the evolution in co-management and other collaborative governance arrangements has come a recognition that these approaches synergise quite well with network methods (Carlsson

& Berkes, 2005). A network can be described simply as a "structure of relationships linking social actors" (Marsden, 2000, p. 2727). Network approaches famously have their start in the social sciences in 1932, where they were first applied to runaways from a girls' school in New York (Borgatti et al., 2009). Psychologist Jacob Moreno and colleagues found that the best explanation for why an individual child ran away was not offered by any one particular established theory, but rather the child's relationships with other children, or in other words, their place within a network (Moreno, 1934). Today, there are many different understandings of networks in the social sciences (Pescosolido, 2007), and questions remain unresolved. Do networks underly social structures, or social structures govern networks? Do networks primarily form the linkages between the scales of social life? However, regardless of which understanding of networks one subscribes to, networks offer a fundamental shift in focus in the social sciences, from social categories like race and gender, to relationships (Pescosolido, 2007).

Like collaborative governance, network governance recognises that "responsibility for policy making and delivery is shared across organisation boundaries", distinguishes them from other models of governance, like hierarchal control of the state or competitive market regulation (Newman, 2004, p. 17). The effectiveness of a governance network is measured according to its ability to achieve positive outcomes that would be unachievable by individual governance actors (Provan & Kenis, 2008). Because networked actors depend on each other to realise outcomes, actors are somewhat mutually dependent, and this can lead to increased network longevity, as well as evolving values, norms, and rules (de Bruijn & ten Heuvelhof, 1995).

There are many different approaches to the study of governance networks, like policy networks. These are network approaches within policy analysis, focussing on problem-solving networks (Carlsson & Sandström, 2008). Policy networks are another form of distributed, collective action, targeting specific problems and policy areas. However, it is important to acknowledge that there is no universal theory of networks (Pescosolido, 2007). Network approaches are best considered a group of related frameworks for analysing data and developing social theory.

2.3 Social network analysis and other empirical network methods

One common analytical method in the study of collaborative natural resource governance is social network analysis (SNA). This approach builds on the rich history of network approaches in the field of sociology (Borgatti et al., 2009), and allow researchers to describe collaborative governance as a structure of nodes (actors) and links (relationships and interactions among actors; Rathwell & Peterson, 2012). SNA has contributed to the empirical understanding of natural resource governance in a number of ways: by demonstrating that there are interdependencies between actors, network structures, and network function; that different network connections and patterns affect governance differently; that different network structure characteristics are predictive of certain governance outcomes; and that governance operates across scales (Salpeteur et al., 2017). SNA has also been used to assess obstacles and opportunities to collective action by collaborative actors through measures like social capital (Barnes-Mauthe et al., 2015). Social capital is the "the norms and networks facilitating collective action for mutual benefit" (Woolcock, 1998, p. 155), and incorporates social phenomena like trust and reciprocity (Mirzaei et al., 2020). SNA has demonstrated that social capital within networks is a determining factor in the outcomes of collective action (Rico García-Amado et al., 2012).

SNA is a powerful tool for governance researchers. It allows researchers to describe governance networks qualitatively or quantitively, and to prescribe solutions for improving social linkages between actors. This can improve collective action outcomes by facilitating knowledge creation and transfer; resource mobilization and acquisition; commitment to shared rules; and conflict resolution (Bodin & Crona, 2009).

SNA is only one example of an analytical network method. There are numerous other examples from across a wide variety of fields and disciplines, including social ones like SNA, as well as ecological ones (Hobbs et al., 2002; Keyes et al., 2021; Özesmi & Özesmi, 2004). Others, like Fuzzy Cognitive Mapping (FCM), include both social and ecological dimensions. FCM is a semi-quantitative method of mental modelling, often applied in multi-stakeholder and rightsholder governance contexts. Data for FCM is collected in a variety of ways, including

surveys, interviews, and document analysis (Özesmi and Özesmi, 2004). Nodes and relationships are established qualitatively, creating a simplified model of causal relationships (Kosko, 1986). The 'fuzziness' in FCM describes the combination of subjective, qualitative knowledge with approximate quantitative values (Alizadeh & Jetter, 2017), leading to a fuzzy model. The fuzzy logic of this sort of model potentially makes it more useful for decision-making in systems characterised by complexity and uncertainty (Kok, 2009), including many natural resource systems. Fuzzy logic models allow for more flexible and holistic analyses of the world (Peloquin & Berkes, 2009).

2.4 Knowledge networks, pluralism, and Indigenous methodologies

A key element of the network governance of natural resources is knowledge co-development, sharing, and application. A growing body of empirical research explores how these processes are underpinned by social relationships, termed knowledge networks (Phelps et al., 2012). Knowledge networks, like wider governance networks in natural resource governance contexts, are often highly diverse. In International Relations scholarship, these networks are sometimes known as epistemic communities (Cross, 2013). Epistemic communities are defined by epistemic pluralism, comprising knowledgeable actors from across sectors, including those governmental and non-governmental, scientific and non-scientific. The success of epistemic communities relies on maintaining cohesiveness and working towards shared goals.

Thus, boundaries between actors can become obstacles to collective action in collaborative networks like knowledge networks (Norman, 2015). Indigenous and local knowledge (ILK), for example, has represented a significant challenge to traditional models and frameworks of environmental governance for decades, and continues to do so (Berkes, 2018). Since the 1980s, there has been a gradual shift within Western science and academia towards recognising ILK as a knowledge system with validity and applications for decision-making. Prior to this, Indigenous knowledge was typically marginalised in both governance structures and processes. Today, recognition of Indigenous knowledge systems is enshrined in land claims, treaties, and international agreements (Saku et al., 1998), and its inclusion is considered best practice for good governance. It is now well established that an approach inclusive of both ILK

and Western science can help achieve management and sustainability goals (Bohensky & Maru, 2011; Davis, 2006; Folke, 2004), as well as inform research in the conservation and ecological sciences (Berkes, 2004; Molnár & Babai, 2021). The inclusion of ILK in governance is also an important step in advancing epistemic justice and participatory processes (Castleden et al., 2012; Toncheva & Fletcher, 2021). Despite this, the bringing together of ILK and Western science in pluralistic spaces is highly contested.

An important dimension in this collaborative space is Indigenous methodologies. Informed by foundational works by Indigenous scholars like Decolonizing Methodologies (Smith, 1999), as well as more recent developments like Indigenous Metissage (Donald, 2012), the Herringbone Stitch Model (Andrews, 2021), Ethical Spaces (Greenwood et al., 2017), and Two-eyed Seeing (Popp et al., 2020). These aim to improve the equitability of work at the interface of Indigenous and non-Indigenous Peoples (Hessami et al., 2021), while also improving collaboration between Indigenous and non-Indigenous knowledge holders.

2.5 Posthumanism and actor-network theory

In this collaborative and often contested space, new theories and approaches are now being considered. Posthumanism refers to a strain of theoretical and philosophical thought which seeks to decenter the human. Unlike the similarly styled postmodernism, which positions itself in opposition to modernism, posthumanism does not seek to reject humanism, but to build on it. As a field, posthumanism interrogates the boundaries between human and nonhuman, and highlights the contributions of more-than-human relationships to the social world (Kaarlenkaski & Steel, 2020).

ANT is a body of approaches for understanding and analysing the world as relational webs of human and nonhuman actors. ANT could be considered akin to material semiotics or an empirical poststructuralism (Law, 2009), or, more relevantly, an analytically focussed domain of posthumanism (Coffey, 2021). Nonetheless, there is no singular ANT. As ANT has become more transdisciplinary, it has increasingly become multiple, and unique to the individual researchers who apply it (Kanger, 2017; Law, 2009). However, the concept of symmetry, or a flat ontology (Höppner, 2021), is often central to these different applications. A flat ontology

means that all elements of a network have the potential to be agential actors. No *a priori* judgements are made of actors by the researcher, prior to analysis. A flat ontology provides ANT with the potential use of investigating gaps and contestations between knowledge systems, as well as ways to communicate across them.

2.6 Social-ecological systems

SESs are a broader framework from within which we can begin considering these different ideas on governance, networks, and pluralism. SESs are complex adaptive systems made up of interwoven social and natural elements and processes (Biggs et al., 2021). They typically include diverse social groups, cultures, ecosystems, knowledge systems, and more. SES scholars make sense of these different SES dimensions by drawing on a variety of diverse interdisciplinary perspectives and approaches, such as institutional analysis (McGinnis, 2011), ecology (Berkes et al., 1998), ecosystem services (Ban et al., 2015), and sustainability (Partelow & Winkler, 2016), recognising that traditional, siloed disciplinary approaches have struggled to fully address SES complexity (Schoon & van der Leeuw, 2015). In many SES frameworks, governance and governance networks play important roles (Ostrom, 2009).

However, like other academic approaches and theories discussed above, SES frameworks can be universalising and exclude local perspectives and other ways of knowing (Bohensky & Maru, 2011; Martinez et al., 2023). In the pluralistic governance contexts characteristic of natural resource systems, applying SES frameworks can be problematic, as some governance actors may not subscribe to the same worldview or agree with the same course of action (Holzer et al., 2022). Diverse peoples holding diverse knowledges within these systems have equally diverse understandings of natural and social worlds. In Indigenous contexts, for example, some ontological assumptions about the relationships between humans and the natural world fit poorly in SES frameworks (Watts, 2013).

2.7 Eeyou Istchee and the James Bay Cree

Eeyou Istchee (ᐄᔨᔫ ᐊᔅᒌ), the James Bay Cree Territory of northern Quebec, Canada (Figure 2-1), encompasses a large portion of northern Quebec, and is characterised by several

ecologically and culturally important rivers that flow from east to west, draining into James Bay. The landscape is relatively flat, dotted by wetlands and lakes. Most of Eeyou Istchee is covered by boreal forest, dominated by black spruce.

Figure 2-1. A map of Cree and Inuit communities in northern Quebec.

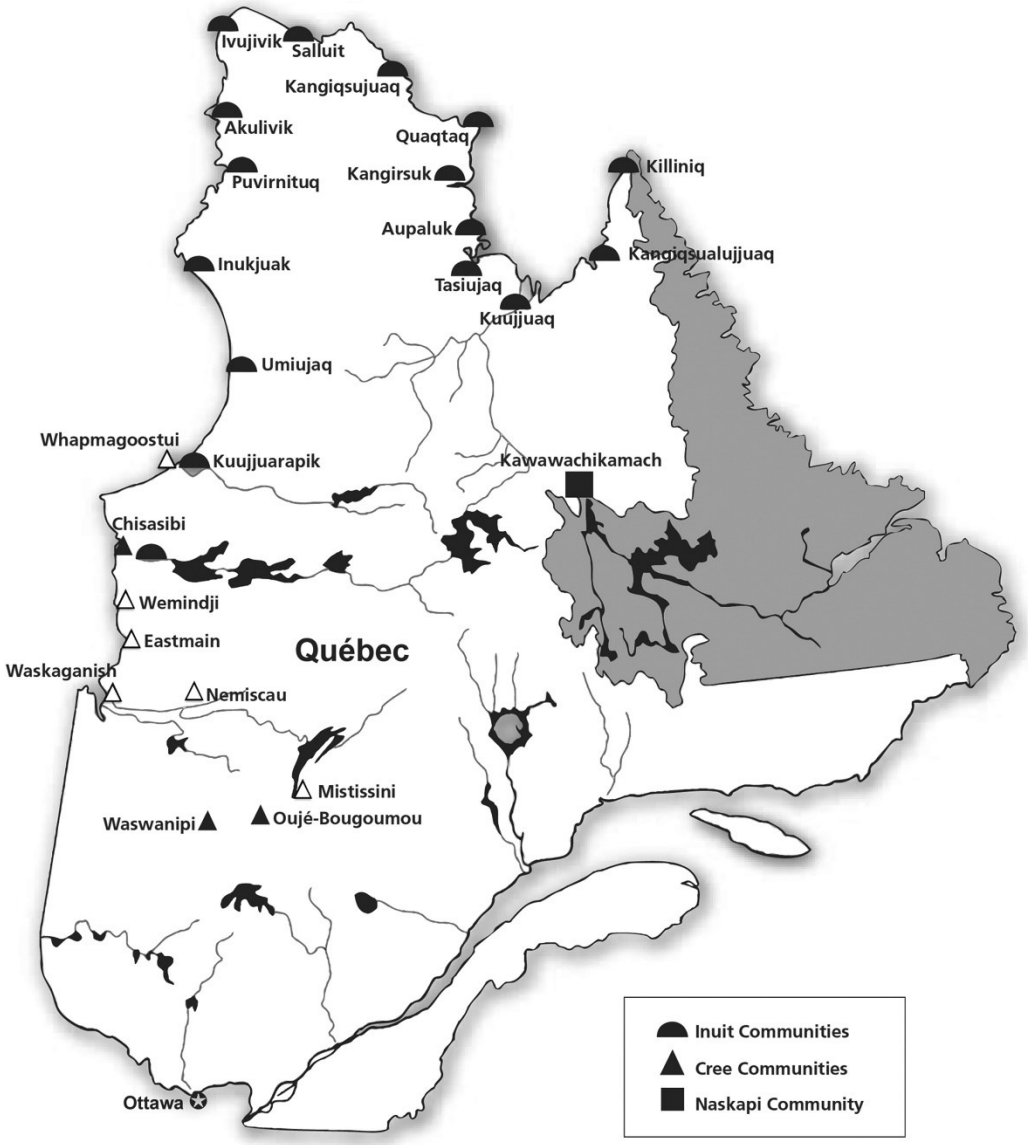

Figure 2-1 shows the locations of Cree and Inuit communities, the Naskapi community of Kawawachikamach, and Ottawa, in relation to Quebec. The Cree and Inuit communities are part of the territory established within the James Bay and Northern Quebec Agreement. The Cree community of Washaw Sibi is not shown. Retrieved from Rapinski et al (2014).

The Crees have occupied this territory since time immemorial. Historically, they would move around the landscape seasonally, spending warmer months at communal sites, and colder months out on the land, using the snow cover to travel across otherwise difficult terrain (Bearskin and Berkes, 1984). Cree land-use was organised according to traplines (Indoh-hoh Istchee), family hunting territories, as it still is today. The traplines are stewarded by tallymen (Kaanoowapmaakinch), who, among other things, manage the numbers of people accessing the land, at what times of year, and for what purpose.

Eeyou Istchee's recent history has been hugely influenced by natural resource development (Rodon, 2014). This began with the fur trade in the 1600s, and later would expand to include small scale mining and forestry operations in the more southern, accessible portions of the territory. However, the James Bay Hydroelectric Project would represent an enormous change in the magnitude and scale of development. Construction of this project began in 1975, but surveys were initiated as early as 1950. The James Bay project created a series of reservoirs and impassible obstacles along the Le Grande and other adjacent rivers. This hydroelectric complex would later be expanded, when in 2005, a dam, powerhouse, and reservoir were built on the Eastmain River, with flows being directed into the La Grande complex. In 2009, the Rupert River was also partially diverted into the complex.

This project was highly controversial. It dammed several of the largest rivers in the territory, affecting lands and waters used by the Crees for numerous purposes, including habitation, travelling, and harvesting. Famously, the Crees found out about the project, not from consultation with the project proponent or federal or provincial government, but from Cree students attending university in urban centers, who read about the project in the news (MacGregor, 1998). This would lead to a series of court cases, and eventually, the signing of the James Bay and Northern Quebec Agreement (JBNQA), discussed further in Section 2.11. The project would have wide ranging social, economic, and ecological impacts on Eeyou Istchee, while also opened up the territory to new development. Many of these changes impacted local food systems, either directly or indirectly

2.8 Local wild food systems of Eeyou Istchee

Crees of Eeyou Istchee have always had relationships of respect and reciprocity with wild food species. Cree land-users, or Indoh-hoh Eeyou, harvest a number of different wild foods throughout the year, including both plants and animals. Some of the most important are species like geese, caribou, beaver, and bear (James Bay and Northern Quebec Native Harvesting Research Committee, 1982). These wild foods are plant or animal species obtained from the land through subsistence activities and consumed locally (Kuhnlein & Receveur, 1996).

Wild foods are a fundamental contributor to the health and well-being of Indigenous Peoples and communities (Council of Canadian Academies, 2014). For the Crees, they have important nutritional, social, cultural, economic, spiritual, and medicinal roles. Wild foods in northern communities are often more nutritionally dense, healthy, and affordable than the store-bought foods available (Warltier et al., 2021). Wild foods are also linked to traditional practices, which contribute to the development and maintenance of social relationships and culture (Feit, 1991; Sayles & Mulrennan, 2010). Wild foods embody the more-than-human relationships and reciprocities central to Indigenous worldviews (Berkes, 2004; Scott, 2006).

Cree relationships with animals are governed by respect. Hunted animals are only caught when the animals offer themselves to the hunter (Feit, 1973). When relationships between hunter and hunted are in balance, both will persist and thrive. Hunters may be capable of killing more animals than they are given, but it is the hunters' responsibility to not kill too many, and to not kill for sport or self-aggrandizement (Feit, 1973). Naacatawaayatacano, which translates roughly to conservation in Cree, captures the idea that the land and its occupants are of great value to the Cree, and that by maintaining these relationships in balance, the well-being of the land will be maintained for the future (*Eeyou Indoh-Hoh Weeshou-Wehwun (Traditional Eeyou Hunting Law)*, 2009).

Wild food systems are social-ecological systems, with deeply intertwined social, cultural, economic, and ecological elements and processes. Likewise, impacts on wild food systems are multidimensional. In Eeyou Istchee, many of these impacts are related to anthropogenic pressures like natural resource development and climate change. Climate change is a concern for wild food systems worldwide (Powell et al., 2023), and Crees are already observing effects in

Eeyou Istchee, including changes to freeze-up and spring melt timings, unpredictable ice conditions, melting permafrost, and an increase in the frequency and magnitude of forest fires (Hennigs and Bleau, 2017). Predictions for the next century include both large increases in air temperature and precipitation (Bush and Leman, 2019). Community concerns about the ongoing impacts of climate change typically focus on declining wildlife populations, changes to animal health or behaviour, and challenges associated with travelling over land, water, and ice (McDonald et al., 1997).

Wild food systems are therefore an important research priority for both Crees and non-Crees. For example, in Eeyou Istchee, a focus on climate change and wild food systems is shared by the Governments of Canada and Quebec, Cree communities, the Cree Nation Government and other regional Cree organisations, universities, industry actors, and NGOs. Research on food security in the face of environmental and social change targets impacts to wild food systems, mitigation measures, and adaption strategies (Council of Canadian Academies, 2014). This research will allow actors to codevelop futures where wild foods and wild food use persist and become more resilient to ongoing and future impacts. Research on wild food systems must also be multidisciplinary, as the systems themselves include natural, health, and social dimensions.

In this dissertation, I focus primarily on two wild food species in Eeyou Istchee: moose and lake sturgeon.

2.9 Moose

Moose (Cree: ᒧᐢ, muus; scientific: *Alces alces)* are one of the important "big game" species for many Crees, particularly in the southern portions of Eeyou Istchee. Moose are hunted both for their meat, and for body parts like moose hides, which are used for a range of cultural products and practices. The importance of moose has been demonstrated both in harvest surveys and testimonials by the Cree (Feit, 1973; James Bay and Northern Quebec Native Harvesting Research Committee, 1982).

Moose are ungulates and the physically largest member of the Cervidae (or deer) family. Moose are distributed widely across North America and can be found in many different habitats depending on the season. Moose seasonal habitat selection is based on requirements for food, water, and social relationships, as well as shelter from predation and the environment (Jacqmain et al., 2008). Moose are herbivores, and commonly feed on young tree species, including willow, balsam fir, maple, birch and trembling aspen.

Moose within Canada are not listed as threatened or endangered, however, there are widespread concerns over declining populations (Kuzyk et al., 2019; Patterson et al., 2013). Typical threats to moose throughout Canada can include habitat encroachment, forest fires, pollution, harvesting pressure, predation, road collisions, parasites and diseases, and climate change. In Eeyou Istchee specifically, land-users have often raised concerns over the impact of forestry and other natural resource development on moose. Scientific research would suggest that carefully managed forestry can enhance moose habitat, but for many Crees, the relationship between productive moose habitat and forestry is much less clear (Jacqmain et al., 2012).

Moose and other big game in the territory are managed according to the traplines, which are each the responsibility of individual tallymen (Kaanoowapmaakin). Tallymen monitor, supervise, and provide guidance for hunting on their traplines, as well as monitor the land and share teachings (*Eeyou Indoh-Hoh Weeshou-Wehwun (Traditional Eeyou Hunting Law)*, 2009). They are generally responsible for managing traplines and wildlife for future generations, and land-users are expected to obtain permission from tallymen before hunting on their trapline. When it comes to moose, tallyman will monitor their numbers on their territory, and if necessary, can restrict hunting activities to protect them (*Eeyou Indoh-Hoh Weeshou-Wehwun (Traditional Eeyou Hunting Law)*, 2009). Rotational hunting, in which tallymen may restrict hunting in portions of their traplines to allow habitats and animals to recover, is one common practice, and has been shown to improve conditions for wildlife even after a single year of rest (Feit, 1973). Tallymen also reinforce norms around the sharing of the moose harvest with tallymen, elders, and others who may be unable to hunt themselves. The role of tallyman is typically passed down through family (Bearskin & Berkes, 1984). New tallymen are not “given”

the land, but becomes responsible for the distribution of resources. It is not ownership in the sense of private property, but more akin to stewardship or custodianship.

Moose harvests were historically higher in the southern portion of the territory and lower in the north (James Bay and Northern Quebec Native Harvesting Research Committee, 1982). In a survey conducted prior to the completion of the James Bay Hydroelectric Project, the southern, inland communities of Mistissini and Waswanipi made up 78% of the mean annual moose harvest, and 90% of the reported harvest was within hunters' own family traplines. A separate research project found that moose, along with beaver, were considered the most important animal resources in Waswanipi (Feit, 1973). 30% of all winter calories were found to come from moose, and it was the most calorie efficient hunting activity. However, despite regional differences, moose was highly valued throughout the territory. Another survey during this time found that moose comprised 19.1% of the food weight harvested across Eeyou Istchee (Berkes & Farkas, 1978), the largest of any one wild food species.

2.10 Lake sturgeon

Lake sturgeon (Cree: nameu (ᓇᒣᐤ)/nimaau (ᓂᒪᐤ); scientific: *Acipenser fulvescens*), as an aquatic species, has a different relationship to the Crees than many terrestrial species like moose. While species like moose are the responsibility of tallymen, fish species like lake sturgeon have often been treated more as common pool resources, with fewer institutions regulating their harvest (*Eeyou Indoh-Hoh Weeshou-Wehwun (Traditional Eeyou Hunting Law)*, 2009). Nonetheless, lake sturgeon are a particularly vulnerable fish, maturing and reproducing late, and being sensitive to the impacts of resource developments like the hydroelectric structures found across the territory (COSEWIC, 2017). Sturgeon are also somewhat charismatic compared to other fish in the territory, being uniquely large and long-lived, and a “living fossil”, with some morphological characteristics having changed little for millions of years.

Lake sturgeon is one of five sturgeon species found in Canada and 26 species worldwide. Nearly two-thirds of these 26 are now endangered, largely due to relatively recent anthropogenic impacts (Haxton and Bruch, 2022). Like most sturgeon species, lake sturgeon are large-bodied, with lengths that can exceed two meters, and a partly cartilaginous skeleton

(COSEWIC, 2017). As adults, lake Sturgeon diets are quite varied, but typically consist mainly of small invertebrate species, particularly insect larvae and mollusks (Barth et al., 2018). There is also evidence that lake sturgeon feed on benthic organisms and organisms drifting in the water column (COSEWIC, 2006).

Sturgeon in Eeyou Istchee are generally considered to be present as far north as the La Grande River and as far east as Mistassini Lake (Harkness & Diamond, 1961). It is believed sturgeon in Eeyou Istchee, like other freshwater fish in the region, colonized northern Quebec from more southerly refugia during the post-glacial period (Legendre & Legendre, 1984; Morin & Dodson, 1986). In Eeyou Istchee, generally low temperatures, short summers, and scarce food resources slow the growth of lake sturgeon compared to those in southern Canada (Fortin et al., 1992). Lake sturgeon abundance is also generally lower in Eeyou Istchee than in rivers further south.

Lake sturgeon require a wide variety of habitats to complete their lifecycle. Spawning usually occurs near the upper reaches of a watershed, in areas with course, gravel substrate and moderate water velocity, often found near waterfalls or rapids. Lake sturgeon begin moving towards these spawning grounds in spring, with spawning usually occurring between late-May and mid-June in waters between 10 and 16°C (Environnement Illimité, 2012). Lake sturgeon do not spawn every year, with males usually spawning every two years, and females every four to six. After hatching, young lake sturgeon drift in the current and colonize downstream habitats. Outside of the spawning season, lake sturgeon mainly stay in deeper and colder parts of lakes. This type of habitat is essential in the hot summer months as well as in the winter. Lake sturgeon have also been observed moving between shallower and deeper waters based on temperature changes throughout the day.

Even more so than moose, lake sturgeon are highly impacted by natural resource development. Lake sturgeon in Eeyou Istchee are experiencing a decrease in habitat availability and mobility due to watershed modification from hydroelectric development, clogging of spawning habitat from increased sedimentation due to forestry activities and forest fires, and a decline in water quality due to pollution from mining activities (Badry & Dunn, 2022).

Lake sturgeon are mainly harvested by Crees in spring and summer, which according to a survey conducted prior to the completion of the James Bay Hydroelectric Project, accounted for 87% of the annual harvest (James Bay and Northern Quebec Native Harvesting Research Committee, 1982). The same survey found that lake sturgeon was harvested by members of all Cree communities apart from Whapmagoostui, which is above the northern limit of the lake sturgeon's range.

2.11 James Bay and Northern Quebec Agreement (JBNQA)

The political and economic circumstances in which these wild food species are governed have changed rapidly over the past several decades. These changes have been largely dictated, directly or indirectly, by the JBNQA. The JBNQA was signed in 1975, following the proposal for the James Bay Hydroelectric Project in Eeyou Istchee, and subsequent opposition from the Crees. The JBNQA represents one of the first "modern" land claims agreements with Indigenous Peoples in Canada (Saku et al., 1998). While much of the initially proposed hydroelectric development would ultimately proceed, the JBNQA was meant to enshrine Cree rights and provide the Crees with a voice in the ongoing development of the territory (Cyr et al., 2022). It would also establish a wildlife co-management regime.

During JBNQA negotiations, discussions were held on establishing guaranteed protections to the Cree harvests of wild food species, to ensure that harvesting rights would be maintained. However, establishing this guarantee required knowledge of the current levels of harvest. Surveys were conducted between 1972–1973 and 1978–1979 to establish these levels. Results of these survey data—collected using interviews, questionnaires, diaries, and calendars—were compiled in the Wealth of the Land Report (James Bay and Northern Quebec Native Harvesting Research Committee, 1982). Several important or vulnerable wild food species, including lake sturgeon, would become reserved exclusively for Cree use, meaning they could no longer be fished by non-Crees throughout the majority of Eeyou Istchee .

The signing of the JBNQA, and the following hydroelectric and other natural resource development projects, marked huge changes for the Crees and Eeyou Istchee. Communities which had previously only been accessible by air and river, became connected to southern

Quebec by road. There was a large influx of non-Crees to the territory, particularly construction workers. Significant forestry operations would begin in the southern parts of the territory, and mining exploration and exploitation accelerated. What had been a largely traditional subsistence economy shifted to a mixed economy as more goods and wage labor opportunities became available. This shift, along with concurrent impacts like residential schools, led to fewer Crees practicing land-based activities, and fewer Crees passing skills and traditions to subsequent generations. Working relationships between diverse actors would become crucial in this new governance context, including between JBNQA signatories like the Government of Quebec, the James Bay Energy Corporation, the James Bay Development Corporation, Hydro-Québec, the Grand Council of the Crees (of Quebec), the Northern Quebec Inuit Association, and the Government of Canada, as well as organisations like the Cree Trappers' Association and the Cree-Quebec Forestry Board (established through the later "Paix des Braves Agreement").

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PREFACE TO CHAPTER 3

Chapters 1 and 2 describe knowledge gaps and opportunities for new research, as well as review relevant literature on natural resource governance theory. Chapter 3 builds on this work by synthesising recent key ideas from actor-network theory and posthuman scholarship, and uses these to explain obstacles to knowledge weaving in collaborative governance contexts. It identifies ontological pluralism as a primary challenge to collective action in pluralistic natural resource systems. Chapter 3 then explores how methods like actor-network theory could contribute to new transdisciplinary methodological approaches that span knowledge system boundaries and address these obstacles. The chapter concludes with research needs that inform the subsequent chapters of this dissertation.

CHAPTER 3. ENHANCING COLLABORATION ACROSS THE KNOWLEDGE SYSTEM BOUNDARIES OF ECOSYSTEM GOVERNANCE

Nathan A. Badry[1] & Gordon M. Hickey[1]

[1]*Department of Natural Resource Sciences, McGill University, Canada*

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Abstract

In ecosystem governance, due to the ecological, social, and jurisdictional complexity of these systems, pluralities of knowledge are increasingly necessary for informed decision-making. However, there are frictions between different kinds of knowledges, whether scientific, bureaucratic, or local. The bringing together of Indigenous and Western knowledge systems is an especially intractable challenge. Indigenous knowledge is frequently incommensurable with dominant scientific frameworks, particularly in how many Indigenous Peoples conceptualize the social roles of nonhumans. Nonetheless, Indigenous and scientific knowledges are regularly brought together in contexts ranging from wildlife co-management to global environmental assessments, and this can involve Indigenous knowledge being selectively adopted, integrated, translated, or just ignored to fit within those frameworks. In this literature review we suggest that actor-network theory—a way of accounting for the webs of relations constituting and generating social and natural worlds—has the potential to help researchers and practitioners challenge the ontological boundaries that make this work difficult. ANT, as well as other approaches under the wider umbrella of posthumanism, could fit within existing pluralist frameworks like Two-Eyed Seeing which strive to address entrenched power dynamics in work involving Indigenous and non-Indigenous Peoples, and help inspire new participatory methods for understanding and enhancing knowledge pluralism in governance.

3.1 Introduction

> "Animals, it would seem, can serve as food or as food for thought, but they can never interact with humans as intelligent actors in their own right" (Nadasdy, 2007, p. 30).

At the ecosystem level, the governance of natural resources is typically conceived of in social terms. It is determined by social structures and processes, people, and organizations. But natural resource governance is about more than just the social. Microbes, animals, plants, laws, policy documents, new technologies, rivers, and weather (among many other things) can affect governance processes in their own ways. However, these nonhuman things, and the roles they play, are often obscured or left out of governance accounts. In the epigraph above, Paul Nadasdy, drawing on their research on Dall sheep co-management in northern Canada with the Kluane First Nation, observes that animals are always viewed in one of two ways: as natural resources ("food") by biologists and ecologists, or symbols ("food for thought") by anthropologists. Nadasdy contrasts these conceptions of animals, as resources or symbols, with how the Kluane conceptualize animals, as social actors with agency. This understanding of sheep as agential actors is prevented from influencing co-management decisions, limiting Kluane participation in governance processes, and leading to poor decision-making based on insufficient knowledge of the system. If this obstacle to collaboration was overcome, what would that kind of governance look like, and what could it achieve?

Indigenous knowledges often have separate ontological assumptions than the scientific, bureaucratic, and local knowledges of other governance actors, and this can challenge communication and collaboration (Diver, 2017; Verran, 2002; Walsh et al., 2013; Watts, 2013). Is a river, like the Whanganui, famously granted legal personhood by the New Zealand Parliament, a body of flowing water, or an honoured ancestor of the Māori (Salmond, 2018)? Among some Northern Peoples of North America, nonhumans have relationships with humans defined by respect, reciprocity, and agency (Miller and Davidson-Hunt, 2013). Are nonhumans like wildlife, for example, resources waiting to be harvested by humans, or do they actively offer themselves to the hunter (Watson and Huntington, 2008)? Boundaries—between human and nonhuman, social and natural, subject and object, and scientific and Indigenous—all contribute to challenging collaborative governance (Norman, 2015). Nevertheless, Indigenous knowledge and Western science are still commonly brought together in governance structures

and processes, from wildlife co-management boards (Nadasdy, 1999), to environmental impact assessments (Huntington, 2000), to bodies of global environmental governance like the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES; Diaz et al., 2019).

A key objective behind this knowledge synthesis is pluralism in governance, and in particular, epistemic pluralism. Pluralism has long been a topic of study in environmental governance, particularly in how it influences the processes and outcomes of decision-making (Davidson and Frickel, 2004). Pluralism in environmental governance generally describes a diversity of approaches and perspectives that can be applied in problem-solving. In the case of epistemic pluralism, it describes a diversity in theories of knowledge and ways of knowing. Different knowledge systems, like Indigenous and Western scientific ones, are often brought together in natural resource governance to advance this epistemic pluralism, improving understandings of complex governance systems (Apetrei et al., 2021), and hopefully leading to more informed and responsive action (Bennett and Satterfield, 2018). However, compared to epistemic pluralism, ontological pluralism within natural resource governance is not as well understood. Ontological pluralism refers to a diversity of deeply held understandings of what exists in the world and how those things interact (Theriault, 2017). There are few tools to help governance scholars and practitioners navigate different ontological commitments, like those regarding the social roles of Dall sheep or rivers. These diverse understandings are intertwined with other forms of pluralism like epistemic pluralism, and hamper efforts to improve collaboration in pluralistic governance contexts (Brennan, 2022).

For more pluralistic natural resource governance structures and processes to be advanced, new approaches for addressing ontological pluralism may be needed. In this literature review, we explore this need, as well as the potential for new methods to address it. We specifically consider what actor-network theory (ANT)—an analytical and empirically driven strand of posthuman thought—can offer a new methodological approach for collaborative spaces (Callon, 1984; Latour, 2005; Law and Joks, 2019). ANT has a long history of transdisciplinary applications (Donaldson et al., 2002; Watts and Scales, 2015), and synergies with network methods already well established in the field of natural resource policy and

governance (Bodin and Crona, 2009). We review the literatures on governance in social-ecological systems (SESs), traditional ecological knowledge (TEK), and ANT, with the aim of identifying opportunities for supporting collaborative work across knowledge system boundaries.

3.2 Governing transboundary social-ecological systems

SES theory has been called a new ontological approach to doing science; an approach that integrates the ecological and social, embraces transdisciplinary approaches, and refutes equilibrium-based understandings of systems (Schoon and van der Leeuw, 2015). SESs are a type of complex adaptive system made up of interdependent social and ecological components (Biggs et al., 2021). The interactions of these components lead to emergent, system-wide patterns, which in turn influence these components and their interactions. In SESs, the problems that arise are complex (Brehony et al., 2020; Scarlett and McKinney, 2016), spanning political, ecological, social, biophysical, and cultural boundaries; and require the collective action of diverse actors to address them (Cash et al., 2006; Plummer et al., 2013). Because natural resources are often entangled within complex social and ecological relationships, when it comes to these problems, it can be productive to consider natural resources as embedded within SESs (Abrams et al., 2021; Hotte et al., 2019; Kobluk et al., 2021; Miller et al., 2020).

Natural resource governance[1] scholarship has increasingly adopted systems-thinking perspectives to better account for the complex social-ecological processes driving management problems (Ban et al., 2013). This has resulted in a shift from state-centric government approaches, to new governance approaches (DePuy et al., 2021; Turnhout et al., 2014) that recognise the governance of natural resources as being "characterized by complexity and contestation originating from multiple problem causes, divergent problem perspectives and solution strategies, and fragmented institutional settings" (Lockwood et al., 2010, p. 986), as well as numerous social and ecological interdependencies (Bodin et al., 2005; Steins, 2001).

[1] Natural resource governance can be defined as: "the interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens or other stakeholders have their say" (Graham et al., 2003, p. ii).

Faced with complexity, the need for collaborative governance has become clear; defined here as the "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" (Emerson et al., 2012, p. 2). In particular, collaborative forms of networked governance can allow for diverse actors to collectively address complex issues which they may struggle to address in isolation (Bodin and Crona, 2009; Emerson et al., 2012; Malekpour et al., 2021), and which may require agreement on rules and practices, coordination of resource use, the building of common knowledge, or other forms of cooperation (Bodin and Crona, 2009). In natural resource systems, collaborative strategies like co-management help varied governance actors—holding scientific, bureaucratic, and local knowledges—to work across boundaries through "knowledge co-production, mediation, translation, and negotiation" (Cash et al., 2006, p. 1), and "to foster synergies across different knowledge systems to enrich understanding of, and solutions for, environmental challenges" (Pyke et al., 2021, p. 27). For collaborative governance strategies, knowledge co-production and sharing is a key determinant of successful outcomes.

However, bringing together diverse actors and knowledges creates significant challenges for transboundary governance networks in SESs (Folke, 2004; Zetina-Rejón et al., 2020). Different actors understand systems in different ways and have different priorities. Theories, frameworks, models, and methods of collaborative governance promote particular ontological perspectives of how SESs work (DePuy et al., 2021). For example, Ostrom's frequently cited framework (Ostrom, 2009) divides all SESs into subsystems of resource units, resource systems, users, and governance systems, all situated within a wider social, political, and ecological setting. What a resource is, and the ways in which it can interact with other variables to result in outcomes, is prescribed. The conceptual framework adopted by IPBES, used to explain linkages between human and natural worlds, includes Indigenous-inspired concepts like Mother Earth derived from Bolivia's Mother Earth Law, but fits these within broader categories and relationships determined by the ontological underpinnings of ecology and ecosystem services (Díaz et al., 2015). While valuable, these governance and management perspectives do not

always resonate with, and can even be exclusive of, the diverse actors and knowledge systems within SESs (Howitt and Suchet-Pearson, 2006). In particular, differences in values, priorities, knowledge systems, and worldviews, particularly between Indigenous and non-Indigenous actors, create barriers to communication and collaboration on transboundary issues, limiting the potential for collective action (Adade Williams et al., 2020).

3.3 Traditional ecological knowledge and natural resource governance

TEK has been described in SES literatures as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, 2018, p. 8). Alternatively, TEK has been described as "the culturally and spiritually based way in which indigenous peoples relate to their ecosystems" (LaDuke, 1994, p. 127). The term TEK has been widely criticized from a variety of angles (see Berkes, 2018, pp. 8–10 for a brief overview), among them that speaking in terms of TEK and Western science leads to dichotomous thinking, which lacks nuance and the diverse perspectives to be found under these umbrella terms (Henriksen et al., 2021). Combining all the knowledges and relationships within TEK into a single category is as much an oversimplification as distilling all of science into a single category (Agrawal, 1995). TEK is unique to people and place, and can often be characterized more by difference than similarity. Further, making a clear distinction between TEK and Western science is not always useful, as one influences the other whenever they come into contact (Law and Joks, 2019). However, TEK is above all an academic construct, and the use of these terms is often necessary in more general discussions of the role of Indigenous knowledge in governance. We refer to TEK in this paper, while acknowledging that some of the above complexity will invariably be lost, despite our intentions to do justice to the nuance and diversity of perspectives. And while we focus on TEK, we also draw on concepts like Indigenous and local knowledge (ILK; Rarai et al., 2022) and local ecological knowledge (LEK; Shaffer et al., 2022) when their use overlaps with TEK.

The term TEK was first used by anthropologists in the field of ethnoecology during the 1980s (Berkes, 2018), but concepts like Indigenous knowledge and traditional knowledge have

been in use in the development literature since the 1950s, and were used similarly (Agrawal, 1995). Until relatively recently, the prevailing academic attitude was that this knowledge was unscientific, imprecise, and too embedded within social and cultural practice to be of substantial management use (Berkes, 2018). This attitude changed as recognition grew among a wide variety of scholars and practitioners that TEK held relevance to the achievement of management and sustainability goals (Armitage et al., 2011). The potential for TEK to aid in these goals, as a complement to Western science, is now well established (Berkes, 2004; Bohensky and Maru, 2011; Davis, 2006; Folke, 2004), particularly in natural resource management and climate change adaptation contexts (Rarai et al., 2022). The possible applications of TEK in conservation science and restoration ecology have also been noted, especially for advancing understandings of biodiversity and traditional management practices (Molnár and Babai, 2021; Pyke et al., 2021). More specific ecological applications have included scientific research into multi-species management, resource rotation, succession management, landscape patchiness management, and responses to ecological pulses and surprises (Berkes, 2004). Beyond the value TEK could bring as a complement to Western science, it is further thought that the inclusion of TEK will empower Indigenous Peoples and communities (Agrawal, 1995; Bohensky and Maru, 2011; Nadasdy, 1999, 2005), and could even promote Reconciliation and epistemic justice through the advancement of full and equal participatory processes (Castleden et al., 2017; Toncheva and Fletcher, 2021).

In light of these advancements, questions regarding the relationship between Western science and TEK have been raised by both Indigenous (Reo, 2019) and non-Indigenous scholars (Agrawal, 1995; A. Miller and Davidson-Hunt, 2013; Verran, 2002). In academic discourses, the combining of TEK and Western science approaches has gone by many names, from the much criticized “integration” to the more recently popular “bridging” (Bohensky and Maru, 2011). And while progress has been made, and terms and approaches have evolved, problems remain. Many studies have recognized that true integration of knowledge systems is difficult (Ban et al., 2018; Scott, 1996; Watts, 2013), or even impossible (Watts, 2013). Complementary strengths and weaknesses of TEK and Western science are usually presented in a simplified manner, often in the form of a table or Venn diagram (Albuquerque et al., 2021), which can lead to integration

being treated like a box-ticking exercise (Bohensky and Maru, 2011) and risks tokenizing TEK in governance processes (Huntington, 2000). Combined with the historically rooted and uneven power dynamics often present in these systems, working across knowledges can be fraught with challenge and risk.

Berkes (2018) described TEK as a nested knowledge-practice-belief complex, comprising knowledge of plants and animals, management systems, social institutions, and a worldview. However, when TEK is integrated with Western science, it is often only in the form of specialised knowledge of plant and animal species, or climate change, or the medicinal qualities of plants, while everything else is excluded (Shaffer et al., 2022). Similarly, Nadasdy (1999) has described how TEK is distilled and compartmentalised when it is made to fit within scientific paradigms in order to be incorporated into management and policy. As Berkes puts it: "it is clear that the positivist–reductionist paradigm holds little promise as a framework for understanding Indigenous knowledge or for integrating Western science and other kinds of knowledge" (Berkes, 2018, p. 287). Indigenous scholars like Vanessa Watts (2013) have argued that Western science is based on a fundamentally different ontological-epistemological frame than place-based Indigenous cosmologies. For Indigenous peoples, "TEK is not just knowledge about the relationships with the environment, but it is the relationship itself; it is the way that one relates" (Ramos, 2022, p. 2). Integrating TEK into governance processes—for example, distilling rights and customs into Valued Components for Environmental Impact Assessment—can advance sovereignty and pluralism (Butler et al., 2021), but is still antithetical to many Indigenous cultures, and represents only incremental progress.

One aspect of TEK that is often excluded from formal natural resource governance processes is relationships between humans and nonhumans. For many Indigenous Peoples, wildlife and rivers have a much more active role in social relations than the passive role typically conceptualised in the mainstream natural and social sciences (Chaplier and Scott, 2018; Watts, 2013). This understanding of nonhuman social roles falls well outside of the Cartesian duality between social and natural that dominates Western science–based approaches to natural resource governance. Nadasdy (2007) describes how the relationships between the hunter and hunted are defined by reciprocity for many Indigenous Peoples, and

that this ontological commitment is antithetical to many approaches in natural resource sciences. Other contestations over the relational roles of nonhumans—like supernatural beings among the Palawan in the Philippines (Theriault, 2017), or the Orca Tsu-xiit among the Mowachaht/Muchalaht in Canada (Norman, 2015)—are common, and this poses significant challenges for collaborative, transboundary natural resource management. As Shaffer et al. describe in their work with spider monkeys in Guyana:

> "it is much easier for scientists to integrate scientific and Indigenous knowledge on spider monkey ecology when they both agree that a spider monkey is an animal and not a person. However, finding commensurability (the extent to which these knowledges overlap and can be integrated) becomes more difficult if one ontological system identifies both humans and monkeys as persons" (Shaffer et al., 2022, p. 4).

This kind of ontological friction makes efforts at knowledge integration very difficult. Indigenous knowledge of species and ecosystems cannot be understood if divorced from its relational and place-based context, let alone Indigenous knowledge of management systems, social institutions, or worldviews (Molnár and Babai, 2021). With increasing attention being given to Indigenous sovereignty and epistemic justice in Canada (Castleden et al., 2017), and internationally (Harcourt, 2021; Rarai et al., 2022; Sundberg, 2014; Verran, 2002), Indigenous knowledges and ways of knowing, and how these can help achieve broadly shared goals of sustainability and conservation are increasingly part of the discourse. Models of governance in Indigenous contexts often acknowledge the importance of reconciling different worldviews to successful management, but rarely provide tools for addressing conflicts between different worldviews (Maxwell et al., 2020). Indigenous frameworks and approaches such as Two-eyed Seeing (Popp et al., 2020), Indigenous Metissage (Donald, 2012), and the Herringbone Stitch Model (Andrews, 2021) are increasingly being developed and applied to make work at the interface of Indigenous and non-Indigenous Peoples more equitable (Hessami et al., 2021). However, there are limited tools available within these frameworks to support researchers and practitioners to, for example, reconcile knowledge system contestations like the roles nonhuman actors play in SESs to inform collaborative governance.

This paper arose from observations by the authors of TEK's role in transboundary natural resource governance, and the gaps between aspirations and practice identified by both Indigenous and non-Indigenous peoples. In what follows, we aim to prompt a discussion that moves beyond the integration of TEK and towards practical steps to achieving more collaborative, boundary-spanning natural resource governance, and suggest ANT as one possible way forward. Within this pluralistic space, the question of who can speak and write on matters of Indigenous knowledges and integration is increasingly, and rightly, being raised. This is particularly true in academia, in which Indigenous voices have historically been marginalised. As scholars of white, settler descent, our goal is not to explain Indigenous worldviews through Western posthumanist frameworks, but rather to explore how ANT-inspired methods might help Indigenous and non-Indigenous researchers and practitioners challenge the ontological boundaries that make transboundary collaboration difficult, thereby supporting the implementation of pluralist knowledge frameworks (Hessami et al., 2021).

3.4 Actor-network theory and other ways of accounting for complexity and nonhuman agency

ANT emerged from the field of science and technology studies during the late 20th century, largely through the works of Bruno Latour, Michel Callon, and John Law. ANT is a family of tools, sensibilities, and analytical methods used to account for the webs of relations which constitute the social (Law, 2009). In the context of ANT, 'social' includes heterogenous, interwoven human and more-than-human actors (or actants in ANT parlance; Latour, 2005). These actors, whether human or not, all have the potential for demonstrating agency, which, rather than conscious thought and intentionality, can be understood simply as the ability of actors to affect change on other associated actors (Toncheva and Fletcher, 2021). In this way ANT differentiates itself from mainstream sociological perspectives, seeing many more human and more-than-human actors as possessing this ability (mediators) than not (intermediaries). Classic examples include the structural characteristics of Portuguese caracks enabling the control of colonial empires (Law, 1984), and French scallop larvae refusing to behave as their biologists expect and dooming fledgling aquaculture management plans (Callon, 1984).

ANT allows for the tracing of associations among heterogenous human and nonhuman actors whose actions were driven by multiple entangled agencies (Law, 1992). ANT was described by Latour not as a "sociology of the social", but a "sociology of associations", an explicit recognition of the wide and diverse array of things that come together to do 'social' work (2005). While ANT has 'theory' in its name, it is better thought of as a way of doing things, or a methodological approach. The role of the ANT analyst is to make no a priori assumptions about the actors in an actor-network. Whether an actor is human or not, no differences are assumed until they are observed by the analyst. According to ANT, collective action is complex; it cannot be fully understood without considering everything that makes that action possible; Networks are more than the sum of their (human) parts. ANT can be considered an analytically focussed part of a wider 'posthuman' movement in academic discourse that seeks to decentre the human subject (Coffey, 2021). The legal field has seen several prominent examples of this movement, including the previously mentioned Whanganui River, granted legal personhood in New Zealand. Posthuman ideas have also been taken up by and overlap with a variety of other academic fields, including in geography (Watson and Huntington, 2008), political ecology (Gesing, 2021), critical posthumanism (Braidotti, 2016), new materialisms (Alaimo, 2012), queer and feminist theory (Hayward, 2010), and multispecies ethnography (Kirksey and Helmreich, 2010).

Some recent examples of posthuman scholarship include the work of Eduardo Kohn, who used more-than-human ethnography and semiotics to move anthropology beyond the human to include human-nonhuman interaction, with dogs in the Amazon (Kohn, 2007), and later with forests (Kohn, 2013). The role of oysters in coastal infrastructure in New York, and how that role requires not only work by humans but also the oysters themselves, has been studied through the lens of biopolitics (Wakefield, 2020). Oysters have also been studied for their role in the gentrification of coastal communities in the UK through the lens of posthumanism and ANT (Brooks and Hubbard, 2021). Paul Robbins, in Lawn People (2007), drew and built upon apolitical ecology to examine lawns as environmental actors, with agential relations towards everything from humans to earthworms. While Theriault (2017), grounding their work in ontological multiplicity, showed how social relationships between supernatural

beings and Indigenous Peoples relates to and contests environmental governance in the Philippines. Cambodian irrigation infrastructure has been studied through a science and technology studies perspective (Venot and Jensen, 2021), which described how different related practices and enactments result in a socionatural mosaic landscape of human and more-than-human. And Gesing (2021) applied a more-than-human approach to political ecology to explain how coastal restoration in New Zealand could be made more sustainable by acknowledging the entanglements of plants, animals, humans, artefacts, and abiotic elements that do restoration work.

Much of the work has also focussed on human-animal interactions. In a recent study, Ampumuza and Driessen (2021) applied tools from ANT and more-than-human geography to help understand how the agency of gorillas in Uganda shaped conservation and tourism development. Li and von Essen (2020) adopted a new materialist perspective in their work to explore interactions between macaques and the farmers whose crops they damage in China, and how these interactions were mediated by other nonhumans: crops, topography, and management tools. Human-shark encounters in Australia were contextualised by analysing how agency is distributed among ocean-users and sharks and their relations with the ocean (Gibbs, 2021). Bear (2021) employed more-than-human-geography to show how UK insect farmers' care for their charges was shaped by the insects themselves. And Toncheva and Fletcher (2021) used a case study of human-bear relationships in the mountains of Bulgaria to add to discussions of how nonhumans fit within conservation and policy-making.

Outside of academia, the rise of posthuman ideas and concepts can also be observed in popular discourses. At the 2020 Sundance Film Festival, there were multiple works that grappled with environmental concerns and which were experienced from the perspective of the more-than-human (Mendez, 2020). One example, Natalie Cabrera's virtual reality film Hypha (Cabrera, 2020), imagined the viewer as a fungal spore, which over the course of the film grows into a hyphae, forms relationships with other fungi and plants, and eventually realizes its great potential for bioremediation and healing (Harms et al., 2011). This trend comes at a time of worsening environmental and sustainability challenges, during which academia and society

at large is struggling to come to terms with how to understand the relationships and divisions among humans and nonhumans.

Crucially however, this widespread shift towards the posthuman overlaps with, and draws from, the lived experience of many Indigenous Peoples, and the great number of Indigenous scholars within and without academia who work on ideas of ontology and more-than-human agency (Hunt, 2014; Reo, 2019; Todd, 2016; Watts, 2013). Some have gone as far as to say that "Indigeneity can be positioned as ontologically prior to posthumanism" (Henriksen et al., 2021, p. 1). We take seriously Todd's claim that: "when we cite European thinkers who discuss the 'more-than-human' but do not discuss their Indigenous contemporaries who are writing on the exact same topics, we perpetuate the white supremacy of the academy" (Todd, 2016, p. 18). Posthumanism (Sundberg, 2014; Watts, 2013) and Latour's ANT more specifically (Todd, 2016), has been criticized for privileging Euro-Western thought, and not doing enough to work against the colonial systems they are embedded in. However, there is considerable overlap between these bodies of work. Collaborative projects incorporating elements of posthuman and Indigenous perspectives are beginning to emerge (Engman and Hermes, 2021), and posthumanist philosophies, and their more-than-human assemblages, which could include everything from spiritual stories, to animals, to tools, to landscapes, have been recognised for their flexibility in facilitating work across knowledge systems in Indigenous spaces (Watson and Huntington, 2008).

Among this cross-disciplinary posthuman work, ANT is relatively distinct for its grounding in empirical and applied approaches, focussed on tracing the associations among heterogenous actors, often through case studies. ANT and other similar approaches have now been applied in a wide variety of disciplinary and research contexts, from livestock regulatory policy (Donaldson et al., 2002) to financial risk in Australian housing markets (Palmer, 2014), to low-carbon commercial development (Rydin, 2013). Over the past several decades, it has become a particularly popular theoretical foundation in the fields of geography, health studies, anthropology, and tourism (Deason et al., 2022). This may be partly due to that, while ANT is often linked to the ideas of individuals scholars like Bruno Latour, ANT is unique to each researcher, and contemporary ANT approaches draw on many of the other influences discussed

within this section. Some researchers divide ANT work into two camps: a “true” ANT, grounded in the social studies of science, and often applying early ANT concepts like moments of translation, and ANT-adjacent, which borrows elements of ANT and applies them in a variety of transdisciplinary approaches (Williams, 2020). Regardless of this distinction’s accuracy or usefulness, the dichotomy demonstrates ANT’s increasingly widespread relevance outside of its field of origin. And among those suggesting the discipline-spanning value of ANT and ANT-inspired ideas are natural resource governance scholars.

In the 1990s, Freudenberg et al. wrote on the complexity of natural resources, and how they are not actually so natural after all. Rather, they are “a complex mix of social, technological, and biophysical conditions through which a given element of the natural environment, at a particular point in time, comes to be socially defined as valuable” (1995; p. 387). Later, Steins (2001), drawing on ANT, would propose that a conceptualisation of relational agency that emerges from the interactions of more-than-humans could help understand the complexity, uncertainty, and dynamism of natural resource management processes. Trosper and Parrotta (2012) have argued that ANT could be a useful perspective for understanding traditional forest knowledge, and a new ANT-inspired understanding of agency was recently recognized by both Resilience (Dwiartama and Rosin, 2014) and SES scholars (Nabavi and Daniell, 2017), for having the potential to provide new perspectives on natural resource governance. Some of these ideas are now being taken up by natural resource scholars in applied contexts. This has included using ANT to study the networks related to salmon runs in British Columbia, with the aim of improving conservation practice (Massey et al., 2021), as well as to study an Indigenous, community-based ecotourism organization in southern Mexico and its resilience to climate change (Deason et al., 2022).

An ANT-inspired methodological approach to natural resource governance, by addressing ontological pluralism in natural resource governance, appears to have the potential to help displace the central role of the human in SESs scholarship, and advance transboundary governance that is more informed, effective, and equitable. However, there are still very few examples of ANT being applied within local natural resource management and governance contexts. The studies that have been done rarely dig deeply into the ANT and posthuman

methodological toolbox, and often do not stray too far from human governance actors, including only a select few nonhumans. This is despite increasing calls for the democratic inclusion of nonhumans in governance processes (Deason et al., 2022), and the clear potential for improving governance outcomes by understanding how SESs are shaped in agential ways by nonhumans. There have also been no explorations of how ANT and related approaches could help span the ontological boundaries between knowledge systems, potentially supporting the implementation of pluralist frameworks such as Two-Eyed-Seeing.

3.5 New directions for scholarship and practice in ecosystem governance

ANT offers under-explored opportunities to facilitate transboundary collaboration and tools for advancing ontological pluralism in natural resource governance. Through relational tracing, visualization, and description, ANT has the potential to help diverse policy actors recognize that Dall sheep and rivers are not just resources, but can actively affect change on the humans who interact with them, sometimes directly, and sometimes through mediated relationships including other humans and nonhumans, thereby facilitating pluralistic understandings of governance in complex SESs. Collaborative governance arrangements like co-management are already working across spatial and jurisdictional boundaries (Cash et al., 2006), and methods like the multiple-evidence-based approach are meant to help integrate knowledge systems (Pyke et al., 2021). However, despite recognition of the need to address nonhuman agencies and the spaces between worldviews in governance (Norman, 2015), there are still few practical tools for practitioners to draw on when seeking to span ontological boundaries. ANT could help fill this gap, facilitating the shared learning and knowledge co-production crucial to transboundary networks (Agranoff and McGuire, 2001), and drawing in actors and perspectives from across the diverse disciplinary and bureaucratic spheres involved in natural resource governance. One of the manners in which ANT could be applied is as a complement to research on network governance.

ANT offers inspiration for a new analytical network approach because of its synergies with existing network governance research methods, and its deep grounding in empiricism, focussed on the careful tracing of associations among human and nonhuman actors using case

studies or ethnography (Law, 2009). Most ANT studies use methods like interviews, participant observation, or document analysis to understand how networks function (Deason et al., 2022). Employing a wide variety of methods both directly with human participants (interviewing, focus groups) and without (document analysis, participant observation) can help illuminate these associations. For example, in a recent study of lobster fishing areas in Atlantic Canada, researchers utilized archival research, participant observation, interviews, and focus groups to understand how the boundaries of fishing areas interacted with changing lobster species' distributions, new technologies, licensing procedures, and competition with other marine industries (Wiber and Barnett, 2021). The researchers found that the fishing areas acted almost as social actors, controlling where and when fishing could take place. These kinds of insights into the impact of nonhumans could benefit governance within complex SESs, helping policy actors to untangle the relationships between interwoven social and natural components, as well as how these lead to emergent patterns and feedbacks.

Common network governance research methods, such as social network analysis, also have the potential to be used with ANT, helping to qualify the links between governance network structures and outcomes, and identifying obstacles and opportunities within the network for enhancing collective action (Palmer, 2016). Network analysis in SESs is a growing body of work, but a lack of methodological pluralism, especially in analysing social and ecological data together, has been noted as a barrier to the advancement of this approach (Eider et al., 2021). While there are theoretical obstacles to combining ANT with social network analysis (Latour, 2005)—differences in understandings of the relationship between network structure and agency, for instance (Stevenson and Greenberg, 2000)—there could also be some benefit to applying social network analysis to a posthuman network elaborated through ANT. In a study of Australian urban development, Palmer (2014) used ANT to explore the role of human actors like "property developers", as well as nonhuman actors like "market value" and "tax legislation", in determining what kinds of buildings get built. They then applied social network analysis measures like betweenness and centrality to their network to help identify important components like focal actors, mediators, and obligatory passage points, or features of the network which force actors to conform to certain goals or perspectives (Callon, 1984; Figure 3-

1). These were then used to help identify obstacles and opportunities for more sustainable development, for instance, properties of the network which prevented the building of higher-density housing developments. This is an area that would benefit from future participatory research in different governance contexts.

Figure 3-1. An example of an actor-network from an analysis of urban development processes in Australia.

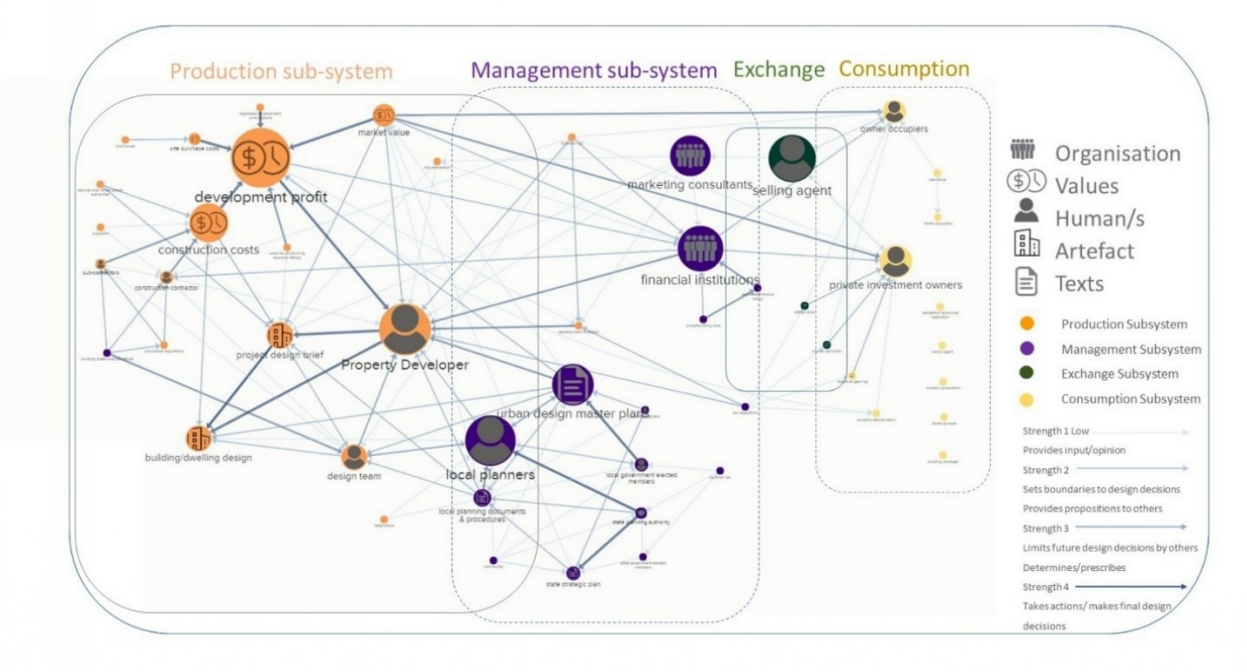

Figure 3-1 depicts the development of medium-density housing in Australia as an actor-network, with key actors and relationships identified using social network analysis tools (Palmer, 2016).

However, maybe the application of ANT with the most potential for facilitating collaborative governance outcomes is as a boundary object. Boundary objects are tools which facilitate collaboration in the absence of consensus (Star, 2010). They exist in the space between social groups (Star and Griesemer, 1989), creating common ground for collaboration (Enqvist et al., 2018), while still being flexible enough for each group to interpret and understand the object in their own way (Amundsen and Hermansen, 2020). These objects are not necessarily physical things, but can be abstract concepts like Resilience (Brand and Jax, 2007), Ecosystem Services (Abson et al., 2014), Stewardship (Enqvist et al., 2018), or Green

Transformations (Amundsen and Hermansen, 2020). Boundary objects make it easier for actors to act collectively across boundaries, for example, by translating co-learning into evidence-based decision making. In natural resource governance, pluralities of actors, knowledges systems, and ontologies make collaboration challenging, but actors often have broadly shared conservation or sustainability goals, despite not necessarily agreeing on how to meet those goals. In this context, boundary-spanning objects that can act as intermediaries are extremely valuable (Cash et al., 2006).

Applying ANT as a boundary object may help researchers and practitioners to incorporate ontological pluralism when working across knowledge systems (Adade Williams et al., 2020; Molnár and Babai, 2021), and better address existing power imbalances within governance networks (DePuy et al., 2021). By allowing space for multiple understandings of the social roles of Dall sheep, or rivers, or even Mother Earth, ontological frictions in governance networks could perhaps be navigated, and trust and knowledge sharing/co-production enhanced, without necessarily requiring agreement on, or the imposition of, a single worldview. This could also help to move beyond critiques of participatory governance practices, which see some of these processes as being tokenistic and serving only to reproduce existing power imbalances within governance networks (Guibrunet et al., 2021).

An example of these possible applications is offered by the case of the orca Tsu-xiit (Norman, 2015). A lone juvenile orca in British Columbia, Canada, famous for approaching boats, he became known as Luna to the general public, L98 to scientists, and Tsu-xiit to the Mowachaht/Muchalaht First Nation, who believed he embodied the spirit of their recently deceased chief. Due to concerns about Tsu-xiit's behaviour leading to unsafe conditions, and driven by political pressures, a plan to relocate him was developed. This plan was opposed by the Mowachaht/Muchalaht First Nation who did not want him removed from the traditional waters where he had chosen to reside. Tsu-xiit's multiple identities "as an animal and a human, a whale and a chief, and a victim and a victor" (Norman, 2015, p. 171), created ontological frictions which prevented this transboundary governance challenge from being resolved quickly and equitably. Tsu-xiit would eventually be struck by a tugboat and killed.

Although there are similarities in how more-than-humans are conceptualised according to posthumanism and TEK, ANT has yet to be regularly applied to the transboundary governance of natural resources in Indigenous contexts. That may be partly due to the well-founded concern that translating TEK through ANT, itself a Western academic construct, would only exacerbate the existing problems with knowledge integration (Todd, 2016). Conception of nonhuman agency can differ between ANT (agency within webs of moderating relationships) and Indigenous ontologies (agency that is often tied to spirituality). ANT, and especially Latour's ANT, has also faced criticism for ignoring inequalities and power relations at the expense of maintaining the status quo, and privileging scientists and bureaucrats over marginalised peoples (Holifield, 2009). Two-Eyed Seeing offers insights for weaving Indigenous and non-Indigenous knowledges and guiding co-learning, but it lacks specific tools for addressing ontological frictions and communicating across ontological spaces in practice. By adding a boundary object like ANT to the methodological toolbox of frameworks like Two-Eyed Seeing, these criticisms of ANT might be better addressed, and the pluralist goals of these frameworks advanced. This is an area that requires further empirical exploration. ANT has always been "a diaspora that overlaps with other intellectual traditions" (Law, 2009, p. 142) and future work developing methodological discourses in which the voices of Indigenous scholars play a much more prominent role is needed if ANT is to meaningfully inform new approaches in natural resource governance. This would further ANT's goal of understanding the messy and multiple interwoven realities at play in society, and perhaps better realise the benefits of collaboration in transboundary natural resource governance.

It should be noted that the term natural resources is itself problematic. It does not evoke agency, but instead the exact boundaries between natural and social that posthumanism seeks to confront. Natural resources are generally treated as inert biophysical units, perceived to hold economic value. They are acted upon or acted with, but are not actors themselves. The term is also indelibly linked to extractivism, dispossession, and colonization. In that sense, a turn towards the posthuman in natural resource governance is perhaps contradictory. While new language is likely needed to replace that of natural resource discourses, we leave that important work to others for now. Governance methods and discourses have, however,

evolved in other ways: from primarily state-led and hierarchical models to ones which are more inclusive, decentralised, networked, and collaborative. Drawing on insights from Indigenous scholars, ANT, and posthumanism scholarship more broadly, these governance perspectives have the potential to be productively decentralised further still, to include the nonhuman, and in ways which can further realise pluralist objectives within ecosystem governance.

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PREFACE TO CHAPTER 4

Chapter 3 theorises that ontological pluralism poses a major challenge to effective knowledge weaving, which in turn poses obstacles for collective action in natural resource management systems. Chapter 4 builds on these findings by empirically exploring the knowledge weaving challenges facing collaborative moose and forestry governance in Eeyou Istchee, northern Quebec. The results show that knowledge pluralism can present important methodological challenges when using participatory network analysis methods like fuzzy cognitive mapping, particularly regarding the roles and significance of non-human actors. The findings align with the conclusion of Chapter 3, which identified that further development of network methods would likely be necessary to fully address knowledge weaving obstacles in natural resource management and governance research.

CHAPTER 4. BOUNDARY SPANNING METHODOLOGICAL APPROACHES FOR COLLABORATIVE MOOSE GOVERNANCE IN EEYOU ISTCHEE

Nathan A. Badry[1], Gwyneth A. MacMillan[1], Eleanor R. Stern[1], Manuelle Landry-Cuerrier[1], Gordon M. Hickey[1], & Murray M. Humphries[1]

[1]*Department of Natural Resource Sciences, McGill University, Canada*

Keywords: Knowledge weaving, Indigenous and local knowledge, Co-management, Wildlife, Ontological pluralism

Abstract

Natural resource governance challenges are often highly complex, particularly in Indigenous contexts. These challenges involve numerous landscape-level interactions, spanning jurisdictional, disciplinary, social, and ecological boundaries. In Eeyou Istchee, the James Bay Cree Territory of northern Quebec, Canada, traditional livelihoods depend on wild food species like moose. However, these species are increasingly being impacted by forestry and other resource development projects. The complex relationships between moose, resource development, and Cree livelihoods can limit shared understandings and the ability of diverse actors to respond to these pressures. Contributing to this complexity are the different knowledge systems held by governance actors who, while not always aligned, have broadly shared species conservation and sustainable development goals. This paper presents fuzzy cognitive mapping (FCM) as a methodological approach used to help elicit and interpret the knowledge of land-users concerning the impacts of forest management on moose habitat in Eeyou Istchee. We explore the difficulties of weaving this knowledge together with the results of moose GPS collar analysis and the knowledges of scientists and government agencies. The ways in which participatory, relational mapping approaches can be applied in practice, and what they offer to pluralistic natural resource governance research more widely, are then addressed.

4.1 Introduction

> "We live in a world in which nations govern through science. Indigenous peoples are no exception" (Tallbear, 2014, p. 189).

Knowledge pluralism and weaving is an ongoing challenge for natural resource governance researchers and practitioners. There is increasing recognition that natural resources are part of a wider fabric of landscape-level interactions that go beyond disciplinary understandings of social and ecological systems (Reed et al., 2016), and that these interactions involve diverse actors subscribing to diverse knowledge systems (Badry and Hickey, 2022). Integrated Landscape Approaches (ILA)–which are "governance strategies that attempt to reconcile multiple and conflicting land-use claims to harmonize the needs of people and the environment and establish more sustainable and equitable multi-functional landscapes" (Reed et al., 2020, p. 1)–are one strategy for addressing the boundaries and complexity of natural resource systems. ILAs attempt to do this by bringing together a wide variety of actors from across spatial, jurisdictional, and knowledge systems boundaries, and finding common ground between them (Reed et al., 2020). Such strategies mark a departure from top-down and state-led understandings of governance, and a movement towards more decentralised understandings, involving multiple levels of government, private-sector actors, and local peoples (DePuy et al., 2021). This departure could be attributed to a variety of drivers, ranging from the broader neo-liberalization of natural resource governance (Turnhout et al., 2014), to the advancement of land claims agreements that enshrine rights to decision-making by Indigenous Peoples (Saku et al., 1998).

While ILAs are explicit about the need to bring together diverse actors, reconciling their multiple and sometimes conflicting knowledge systems and ways of knowing is often a corequisite. This weaving of knowledges is considered a key objective of ILAs, and is thought to increase trust and collaboration (Dressel et al., 2020), as well as enhance evidence-based decision-making through the inclusion of more and different knowledges (Berkes et al., 2000). The inclusion of more and different knowledges, beyond reasons of epistemic justice and representation (Toncheva and Fletcher, 2021), means a more complete understanding of the natural world, with the capacity to make better management and policy decisions, and perhaps

better achieve shared sustainable-use and conservation goals (Tengö et al., 2017). These knowledges are also not necessarily restricted to the natural world, but can extend to a range of subjects, from environmental ethics to philosophy (Peltier, 2018). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is one example of institutional support for knowledge weaving. The IPBES has a working group on Indigenous and local knowledge (ILK) systems, with deliverables focussed on "recognizing and working with ILK" within the context of the IPBES and introducing more participatory approaches with knowledge holders (IPBES Secretariat, 2019). Within academia, some ecologists have long argued for the inclusion of ILK in applied ecosystem research. They make the case that science and ILK are complementary (Huntington, 2000), arguing that different knowledge systems have different strengths and weaknesses, and that by bringing them together, a more holistic approach can emerge. ILK has been noted as being particularly useful for addressing complexity in natural resource systems, and for conducting long-term monitoring (Folke, 2004; Bohensky and Maru, 2011).

However, in practice, knowledge weaving can be extremely challenging. Obstacles arise because weaving together different knowledge systems requires more than just pooling data, or adapting individual ethical principles (Badry and Hickey, 2022). Fikret Berkes, in his work on traditional ecological knowledge, describes knowledge systems as knowledge-practice-belief complexes, which, in addition to specific knowledge of plants and animals, includes management systems, social institutions, and worldviews (Berkes, 2018a). Often, during knowledge integration with scientific and bureaucratic knowledges, only the easily integrated elements of ILKs are included (Shaffer et al., 2022).

Knowledge integration is a term commonly used in the applied fields of natural resource management and sustainability. However, it has been argued that "integration" implies a hierarchy of knowledge, in which ILK is only considered reliable if validated by science, and that terms like knowledge co-production, which call for collaboration at every stage of a research project, better describes equitable processes of bringing together different knowledges (Tengö et al., 2014). In this paper, we adopt the term weaving (Popp et al., 2020), and while co-production is crucial, we use weaving specifically to refer to the combining of knowledges,

occurring within processes of participation and co-production. We follow Bohensky and Maru by framing weaving "as a process in which the originality and core identity of each individual knowledge system remains valuable in itself, and is not diluted through its combination with other types of knowledge" (2011, p. 10).

During problematic knowledge integration processes, contestations, like whether nonhumans like orcas (Norman, 2015) or spirits (Theriault, 2017) have agential relationships with people and other nonhumans, and whether these are relevant to governance, can be left out by scientific and bureaucratic knowledge holders. This can lead not only to poor outcomes, but when integrated uncritically, the inclusion of local knowledges might only reinforce existing hierarchies between knowledge systems (Bridel, 2022). Other models of bringing together knowledge systems have sought to respond to these criticisms. Two-Eyed Seeing is a prominent example. Developed by Mi'kmaq elder Albert Marshall, Two-Eyed Seeing means to see with both eyes: from one eye seeing and learning with Indigenous knowledge, and from the other, seeing and learning with Western knowledge (Bartlett et al., 2012). But while these models provide frameworks and guidance for bringing knowledge systems together, there are still few specific tools for addressing the contestations between them in a way that supports collective action by diverse governance actors (Badry and Hickey, 2022).

Contestations between knowledge systems can be framed in ontological terms. Ontology is a branch of philosophy that deals with questions of 'what is', and ontological assumptions are assumptions held about what things exist in the world and how they relate to each other. Is an orca a respected, reincarnated chief who should be allowed to remain close to their community, or a wild animal which poses a danger to boat traffic and needs to be relocated (Norman, 2015)? Ontological pluralism describes contexts in which actors hold different ontological assumptions and commitments (DePuy et al., 2021). Sometimes these ontological differences are inconsequential to collaboration. Other times, they can challenge knowledge weaving and collective action, as well as the existing hierarchies between knowledge systems and dominant paradigms of governance. Understandings of environmental "management", for example, are based on a foundation of ontological commitments often not shared by Indigenous Peoples (Howitt and Suchet-Pearson, 2006). Indigenous Peoples (and

many others) may not agree philosophically that aspects of the environment should or can be managed by people, or that the "environment" exists as a meaningful category separate from humans.

Researchers and practitioners in these contexts often apply pluralistic frameworks such as ILAs and Two-Eyed Seeing, and are increasingly adapting specific methods to work within them (Reed et al., 2016; Peltier 2018). One such method is Fuzzy Cognitive Mapping (FCM). In this paper, we ask: to what extent can participatory methods like FCM help bridge the ontological gaps inherent to knowledge weaving processes in landscape management, and better support diverse governance actors when they work together towards shared goals? We seek to understand whether FCM represents a meaningful advancement for knowledge weaving and to what extent it can help meet the goals of pluralistic governance actors.

4.2 Fuzzy Cognitive Mapping as a Tool for Knowledge Co-production and Weaving

FCM is a semi-quantitative method of mental modelling, often applied in multi-stakeholder and rightsholder governance contexts. Data for FCM can be collected in a variety of ways, including surveys, interviews, and document analysis (Özesmi and Özesmi, 2004). These data are used to identify different nodes, and the relationships, or causal links between them. FCM has been used across a wide variety of fields, including ecology, where the nodes are typically ecological variables (Hobbs et al., 2002; Özesmi and Özesmi, 2004). Nodes and relationships are established qualitatively, creating a simplified model of causal relationships (Kosko, 1986).

Quantitative weights can then be assigned to each relationship. Adding to the qualitative positive or negative relationship described between each node, a number is assigned, standardized to represent a value ranging from −1 to 1. Much of FCM is rooted in graph theory, similar to other network methods like Social Network Analysis (Poczeta et al., 2019). FCM is a matrix-vector calculation, and measures like eigenvalues and eigenvectors can be used to analyse the adjacency matrices, and give further insights into the roles and importance of different variables (Kok, 2009). The fuzzy quantitative values of each relationship can also be worked out collaboratively with participants during data collection, with final values

developed through back-and-forth discussion, potentially enhancing the trustworthiness of the approach.

The 'fuzziness' in FCM describes the combination of subjective, qualitative knowledge with approximate quantitative values (Alizadeh and Jetter, 2017), leading to a fuzzy model. The fuzzy logic of this sort of model potentially makes it more useful for decision-making in systems characterised by complexity and uncertainty (Kok, 2009). Fuzzy logic models, similar to ILK systems, allow for more flexible and holistic understandings of the world (Peloquin and Berkes, 2009). They deal in large numbers of qualitative variables interrelated by fuzzy relationships. The gaps between different knowledges and approaches can then be bridged by identifying the differences between maps of different knowledge systems subscribers (Hobbs et al., 2002; Sarmiento et al., 2020). FCM can be used descriptively, but, because it is semi-quantitative, it can also be used to develop 'what if' scenarios (Voinov et al., 2018). FCM has also been recognised for its usefulness in bringing local and non-academic knowledges into analyses (Gray et al., 2014), including ILK.

However, the effectiveness of FCM for weaving together knowledges in pluralistic natural resource governance contexts, and in particular, for addressing the ontological contestations between knowledge systems, is unclear. FCM offers an interesting method for knowledge weaving because it is semi-quantitative. Semi-quantitative methods have previously been used to bridge gaps and communicate knowledge between different actors, such as between stakeholder and modellers (van Vliet et al., 2010). In what follows, we consider how participatory FCM can be used to support knowledge weaving, as well as consider the opportunities and challenges arising from this approach, using the case of a collaborative moose habitat research project in Eeyou Istchee.

4.3 Research Setting

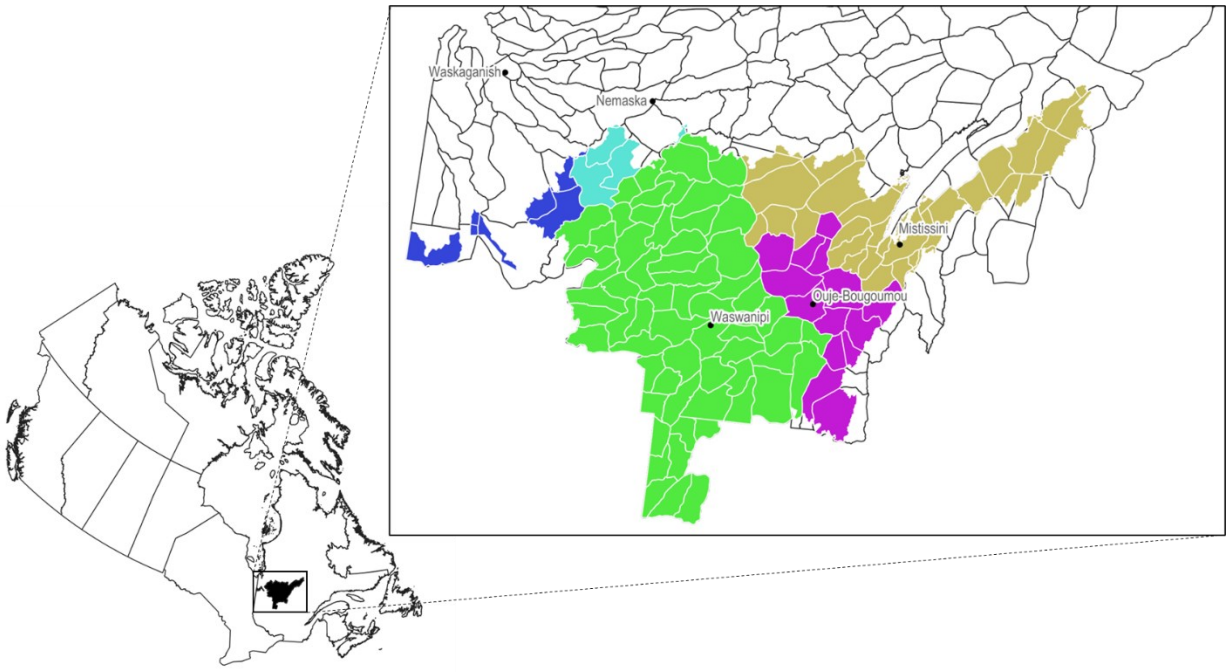
Eeyou Istchee (ᐄᔨᔫ ᐊᐢᒋ), in northern Quebec, Canada, is the traditional territory of the Eastern James Bay Cree. Beginning in the 1950s, the Quebec government increasingly planned development of the northern part of the province, culminating in 1971 with the announcement of the James Bay Hydroelectric Complex. This project was a large-scale development project

that would greatly alter the landscape, and it faced organised opposition from Indigenous Peoples in the territory, including the Crees. Following extensive negotiations, in 1975, the James Bay and Northern Quebec Agreement (JBNQA) was signed by the Government of Quebec, the James Bay Energy Corporation, the James Bay Development Corporation, Hydro-Québec, the Grand Council of the Crees (of Quebec), the Northern Quebec Inuit Association, and the Government of Canada. This agreement is widely considered to be one of the first modern land claims agreements with Indigenous Peoples in Canada (Saku et al., 1998). Among other things, the JBNQA was meant to enshrine Cree rights and decision-making within natural resource development processes (Cyr et al., 2022). Notably, Section 24 of the JBNQA establishes a wildlife co-management regime where the Province of Quebec and the Cree Nation share responsibilities for wildlife management.

In 2002, amid concerns by the Crees that the processes and institutions established under the JBNQA did not give them the promised decision-making powers, a new agreement was negotiated. This was the Agreement concerning a new Relationship between the Government of Quebec and the Cree of Quebec, or the "Paix des Braves". The Paix des Braves was meant to establish a nation-to-nation relationship between the Crees and Quebec, with more collaborative natural resource governance arrangements. In particular, Chapter 3 of the agreement called for an Adapted Forestry Regime (AFR). The AFR covers the southern parts of Eeyou Istchee directly impacted by forestry, and is meant to better account for Cree livelihoods in forestry planning, as well as improve Cree participation and input (Figure 4-1). The Paix des Braves also established the Cree-Québec Forestry Board to oversee the AFR, with members nominated by both the Cree Nation Government and the Ministère des Forêts, de la Faune et des Parcs[2].

[2] In 2022, partway through this research, the Ministère des Forêts, de la Faune et des Parcs was reorganised, with forestry being placed under the purview of the Ministère des Ressources naturelles et des Forêts, and wildlife under the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs. For clarity we will use the former name throughout.

Figure 4-1. A map of the Adapted Forestry Regime (AFR) within Eeyou Istchee, northern Quebec.



This map depicts the Adapted Forestry Regime territory, situated within Quebec, Canada, with the individual hunting territories of Mistissini in brown, Nemaska in light blue, Oujé-Bougoumou in purple, Waswanipi in green, and Waskaganish in dark blue (Waskaganish did not participate in the collaborative moose research project)

The Moose Habitat Quality in Eeyou Istchee Under the Adapted Forestry Regime (MHQ) Project, which began in 2020 and is ongoing, aims to understand and model the various factors influencing moose habitat quality in Eeyou Istchee. The results of this project are considered particularly urgent following 2021 aerial surveys which identified substantial moose population declines in the southern parts of the AFR (Brodeur et al., 2022). The Crees–for whom moose is a wild food species with significant nutritional, economic, social, and cultural value (Bearskin and Berkes, 1984)–have expressed strong concerns over these declines. Non-Crees in the territory have also expressed frustrations, as non-Indigenous hunting allowances in some areas were eliminated following the results of the survey (Cree Nation Government, 2022). A driving force of the MHQ project is to produce tools that could help guide moose management decisions in

the AFR. One of the primary outcomes was a Habitat Suitability Index (HSI) for moose habitat in the AFR, informed by both scientific and Cree knowledges. HSI models are often used in natural resource management to assess the quality of wildlife habitat in a landscape (Brooks, 1997). Moose habitat quality and availability is believed by biologists to be a primary driver of moose population dynamics in Eeyou Istchee, and an HSI was especially desired by the provincial government to help guide management and land-use decision-making. Beginning in 2020, a steering committee of local rightsholder and stakeholder organizations was assembled to help guide the MHQ project, including representatives of the Cree Nation Government, the Cree Trappers' Association, the Ministère des Forêts, de la Faune et des Parcs, the Cree-Québec Forestry Board, and the Cree communities of Mistissini, Nemaska, Oujé-Bougoumou, and Waswanipi, all four of which have territory within the AFR. Fourteen of these steering committee members were interviewed by study coauthor Gwyneth MacMillan at the beginning of the project to help understand their different goals and priorities for the research.

4.4 Methods

The MHQ Project offers an instrumental case study (Denzin and Lincoln, 2005) of knowledge weaving in natural resource management research in Eeyou Istchee. The MHQ Project is an interdisciplinary and collaborative research effort developing understandings of and modeling the different factors affecting moose habitat. The choice of FCM as a method was driven by the need to bring together Cree and ecological knowledges within a joint project. This need had scientific and technical justifications, but also political ones. The objective of project researchers and steering committee members was that moose collar data, together with Cree expert knowledge, would provide a more complete understanding of the variables affecting moose habitat in Eeyou Istchee, and the effectiveness of the special forestry measures introduced with the AFR:

> "It's going to be important to talk about what [Cree] people know and to understand moose habitat and behaviour from whatever knowledge our people have here. Biologists will have their understanding of all of this, and I know that's a big part of this project, but it's going to be important to look at both knowledge types to get a better

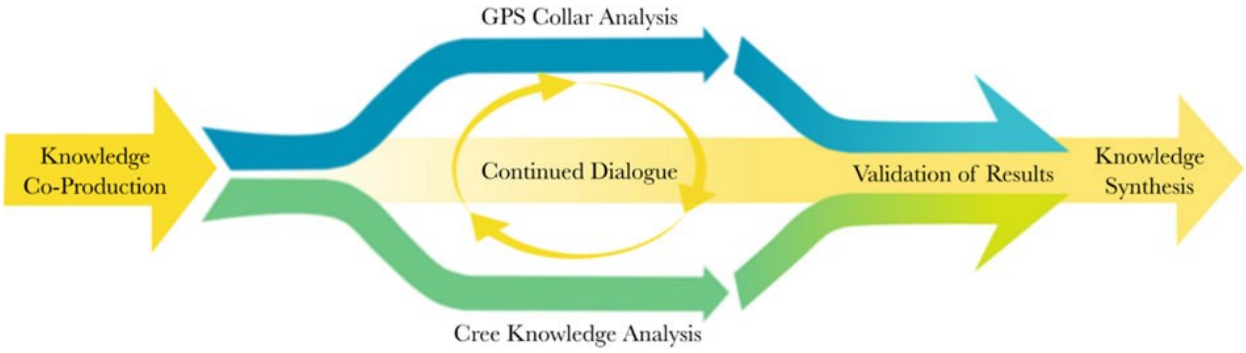
understanding of the health of the moose population as well as their habitat." - Steering committee representative

Cree knowledge was significant for its potential ecological and biological contributions. However, politically, it was also important that Cree knowledge informed the model, and that tallymen were actively involved in the project, beyond just having Cree representatives on the project steering committee. Cree knowledge and input was a source of legitimacy and a means to exert decision-making power:

"Our Tallyman and our land users are scientists in their own way, you know!" - Steering committee representative

There were two primary streams of data collection and analysis involved in this project (Figure 4-2). One was focussed on the spatial and quantitative analysis of data collected from moose collars, including GPS location and video data. The other focussed on Cree knowledge of moose and moose habitat, and was based mainly on qualitative interviews and semi-quantitative FCM.

Figure 4-2. MHQ knowledge weaving model.



This flow diagram depicts the model of knowledge weaving applied in the MHQ Project. The approach began with developing a Knowledge Co-Production framework, guided by project-scoping interviews, and ended with a phase of Knowledge Synthesis. Primary streams of data analysis, including analysis of GPS collars and of Cree Knowledge interviews, are represented by blue and green arrows respectively.

We presented our objectives and methods to Chiefs and Councils in each community to inform them of our approach and seek their approval for carrying out our proposed research activities. Band council resolutions in support of the research were obtained in each community prior to data collection, and data collection protocols were reviewed and approved by the McGill University Research Ethics Board (#21-08-034).

4.5 Data Collection and Analysis

4.5.1 Habitat selection analysis and moose collar data

Animals have specific habitat requirements related to their need for food, shelter, and safety. Most landscapes consist of a few common habitat types and many rare habitat types. How animals situate themselves within a landscape of contrasting habitat types communicates their individual and species-specific habitat preferences (assuming the animals are free to occupy the habitats most conducive to their own fitness and have the information necessary to make well informed choices; Fretwell and Lucas, 1969). Wildlife habitat selection analyses quantify the habitats used and selected by free-ranging individuals. Habitat use is then often compared to a measure of habitat availability to derive an estimate of habitat selection. Animal habitat use and movement patterns are typically documented by biologists using GPS-equipped biologging devices attached to animals fitted with radio collars. The distribution of animal locations is then compared to the distribution of habitat types. If most animal locations are situated in the common habitats and few in the rare habitats, then use is approximately proportional to availability and habitat selection is considered to be weak or absent. Alternatively, if many, most, or all use locations are clustered in a few uncommon habitat types, then use is disproportionate to availability and these rare but heavily used habitats are considered to be strongly selected or preferred. A simple measure of habitat selection can be obtained by dividing proportional use into proportional availability (Manly et al., 2002).

To develop an HSI for moose within the AFR area of Eeyou Istchee, an understanding of moose habitat selection on the landscape was needed, and this was informed by GPS data and GIS-based land covariate data obtained from the Ministère des Forêts, de la Faune et des Parcs and the Cree Nation Government. Thirty-eight moose collars were employed in the AFR, all

affixed to female moose, as female contributions to population productivity were identified as a conservation priority. Moose location data were collected from 2018‑2021, recorded every two hours. These data were then used to develop the HSI. Manly selection ratios (proportional habitat use over proportional availability) were calculated for a number of important moose habitat variables, at the scale of the AFR and within each moose's home range, during both winter and summer (Stern, 2022). These variables were partially informed by key quantifiable environmental drivers to habitat use that were frequently mentioned in interviews with Cree land-users, including land cover, elevation, road density, and distance to water. Winter and summer were identified as highly dichotomous seasons in which differing habitat preferences could be clearly identified. These seasons correspond to the Cree seasons of Niipin, or 'time for gatherings' (July to August), and Pipun, or 'best time to trap' (January to February; Stern, 2022). Home range polygons were created for each moose in winter and summer for each year the collars were on, using Kernel Density analyses to determine home range size and locations.

It should be noted that the collaring of moose began prior to the beginning of the MHQ project and continued throughout, performed by biologists of the Ministère des Forêts, de la Faune et des Parcs. Collaring of animals, and their related capturing and handling, can be controversial, including in Eeyou Istchee and among other Indigenous Peoples (Byers, 1999). Concerns often relate to whether the proper respect has been given to the animal, and whether it is safe to consume the animal after it has been tranquilised. Researchers carrying out interviews were informed of the collaring process and health and safety protocols related to the consumption of previously anaesthetised moose.

4.5.2 FCM and Cree Knowledge

Members of the research team held 37 interviews with a total of 56 participants in the four communities involved in the project: Mistissini, Nemaska, Oujé-Bougoumou, and Waswanipi (Table 4-1). We reached out first to the tallymen, or Kaanoowapmaakinch in Cree, in each community. These are the stewards of family hunting territoryin each community, and were contacted due to their depth of knowledge of forestry and moose habitat in Eeyou Istchee. These family hunting territories are called traplines, or Indoh-hoh Istchee, and all of Eeyou

Istchee is divided into them. Tallymen are responsible for the land and animals on their trapline, and can exercise control over things like the number of moose that can be harvested during a season. We also contacted land-users, or Indoh-hoh Eeyou, who were known in each community for being particularly knowledgeable about moose. We attempted to organise each interview around a single trapline, with the tallymen and land-users all being from the same hunting territory. However, in some cases this was not possible, with some interviews covering several traplines, and some traplines being split into separate interviews. In communities on the edge of the AFR, traplines affected by forestry were prioritised.

Table 4-1. Number of interviews and participants in each community.

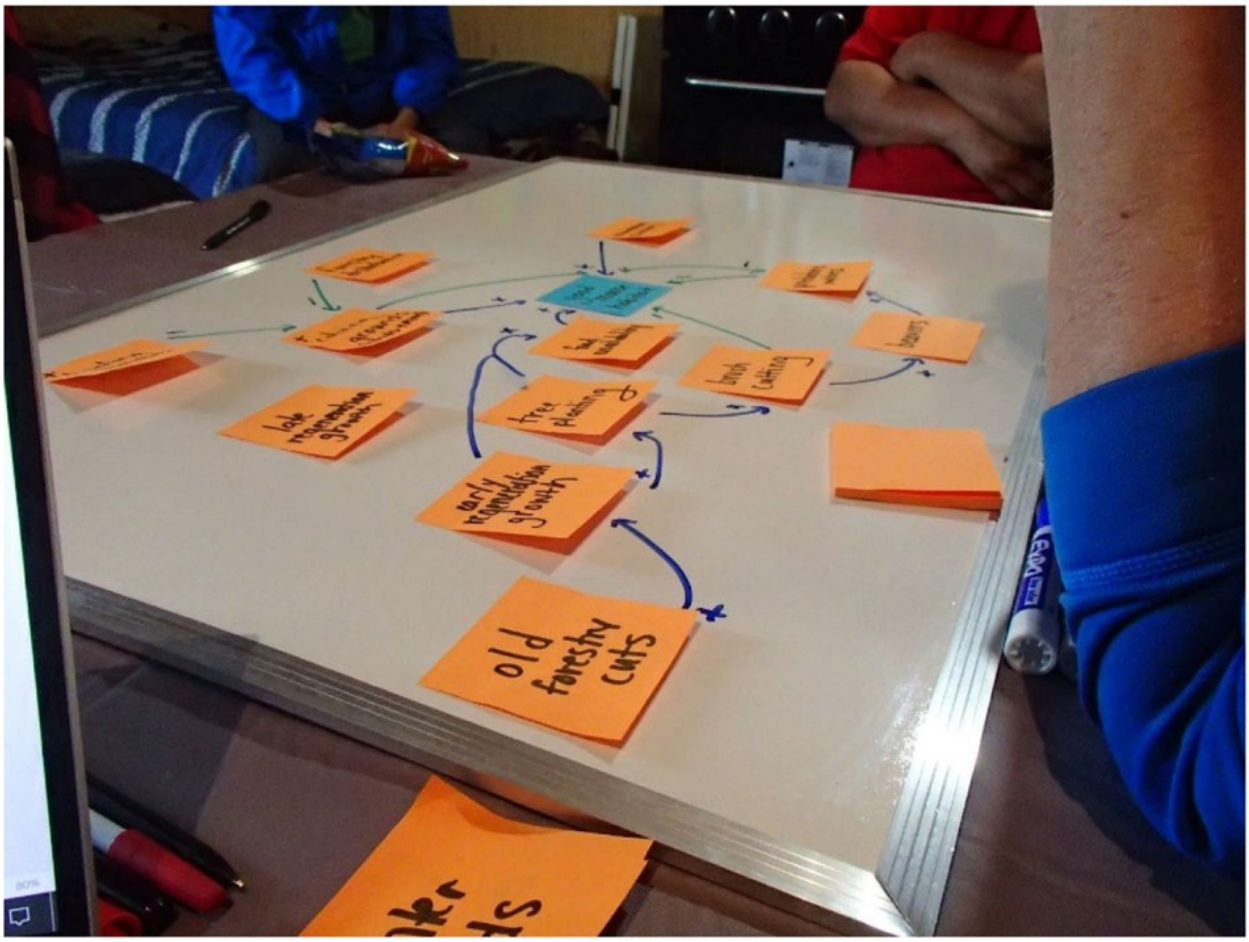
Community	Number of interviews	Number of participants
Mistissini	6	8
Nemaska	8	16
Oujé-Bougoumou	8	11
Waswanipi	15	21
Total	37	56

We conducted interviews between October 12th and November 7th, 2021. There were still COVID-19 protocols in place in Eeyou Istchee during this time, so the research team worked with local Health and Safety Coordinators in each community to ensure compliance with all public health directives. We organised a one-week quarantine for the research team, followed by COVID-19 screening tests at the hospital, prior to travelling to communities. We also followed masking and sanitation protocols during data collection. Interviews were split between two different teams of researchers which each visited different communities.

The majority of each interview was dedicated to FCM, although some questions on local forestry and forestry consultations were also asked. FCM data were captured using white boards, markers, and sticky notes. Mapping was done collaboratively with participants during interviews, which lasted for approximately two to three hours (Andersson and Silver, 2019). Mapping began with the placing of a central node of “good moose habitat” on a sticky note in

the center of the white board. After discussing what “good moose habitat” meant to the participants, the researcher then worked with them to establish the different variables that affect “good moose habitat” on their trapline. These were also written down on sticky notes and placed on the board as nodes. When the participants could not think of any more variables affecting moose habitat on their traplines, the researcher began working with the participants to draw the positive and negative relationships linking these nodes together, and back to “good moose habitat”. Any additional variables that did not arise during the initial discussion, but became evident during the relationship drawing stage, were added at this stage, while existing variables could be reorganised or combined if equivalent. Once all the nodes were linked together by relational arrows, if there was time, the researcher would work with the participants to rank the relative importance of each arrow. The relationships represented by these arrows were ranked from one to five, with a five signifying the most important relationships defining “good moose habitat” on that trapline (Figure 4-3).

Figure 4-3. A participatory fuzzy cognitive mapping interview.



This picture depicts an FCM exercise and interview in progress. Variables affecting moose habitat (orange notes) are linked to each other and to the "good moose habitat" (blue note). These linkages are directional, and either positive (blue arrows), or negative (green arrows).

In each community, research teams worked with local research assistants who helped to reach out to participants, arrange interviews, and translate between Cree and English. Many participants preferred to conduct their interviews in Cree, in which case the research assistant would translate the questions and answers back and forth. Participants received honoraria for participating in the interviews.

Maps were digitised using the software yEd (yWorks). A list of possible variables affecting "good moose habitat" was not established ahead of data collection, allowing the important variables in each interview to emerge inductively in the participants' own language.

However, this necessitated synchronising variables between maps and between research teams. The result was 144 unique variables across 35 maps (two interviews did not result in maps). Fuzzy transitive closure was calculated between each node to account for indirect relationships between nodes (Sarmiento et al., 2020, 2022). Due to the complexity of the data, and to facilitate analysis and communication of the results, thematic analysis was used to group the 144 unique variables into 20 categories (Sarmiento et al., 2020). An adjacency matrix was then developed for the categorised data. Because weights had not been assigned to every map, relationships were weighted according to frequency instead (Sarmiento et al., 2022). Results of participatory relationship weighting, and weighting according to frequency in the data, are typically consistent (Alizadeh and Jetter, 2017).

Member-checking workshops were held in each of the four communities in July 2022. Preliminary results from the moose collar and Cree knowledge analyses were presented to previous interview participants and any other interested community members for their impressions and input. The variable categories, in particular, were discussed and validated.

4.6 Limitations and Assumptions

The outcomes of a scientific habitat selection analyses depend on three key analytical decisions: the habitat variables and categories used as a basis for the analysis, the habitats considered to be available to the animal, and the time periods that are included in the analysis. Habitat and landscape classifications, together with other spatial data layers, form the foundation of all habitat analyses. Thus, the reliability of any habitat selection analysis depends on the accuracy, resolution, recency, and relevancy of habitat variables and categories (Fieberg et al., 2021). Commonly deployed GPS satellite collars record precise animal locations (e.g., <15 m of true location) at high fix rates throughout multi-annual sampling periods. Accordingly, habitat use data tends to be highly accurate. Comparatively, characterizing the habitats at each animal's location is complicated by classification data that can be spatially imprecise, outdated, or incorrect. In our analyses of the GPS collar data, we assume that the classification data are reliable.

The question of which additional habitats are available to an animal–in other words, where the animal is choosing not to be–is an even more complex and scale-dependent issue. Wildlife species, populations, and individuals can be interpreted as selecting habitats at multiple scales, and some of these scales of comparison and choice are more meaningful and relevant than others. A classic contribution to habitat selection analysis classifies three scales of selection as first, second, and third-order selection (Manly et al., 2002), and suggests that analyses of habitat selection should consider available locations across multiple spatial extents to assess multi-scale habitat selection (Fieberg et al., 2021). In our case, the analysis incorporates two scales of selection, at the level of the moose home range, and at the scale of the AFR.

Another key consideration in habitat selection analyses is the temporal extent and seasonal specificity of analyses. If individuals express seasonally divergent patterns of habitat selection, including multiple seasons in a year-round habitat selection analysis may average out and obscure those seasonal differences. We chose to focus on mid-winter and mid-summer in our analysis, as these are time periods where we would expect significant differences in habitat selection. Other seasons have not yet been included in the analysis.

We also made several assumptions during the FCM process. We strove to involve research participants throughout the data collection and analysis process, but the research team still led the process of categorising individual variables. The choice of categories, and how variables were divided among them, was inevitably coloured by researcher positionality and will likely have deviated from how many of our participants would have approached categorization (Sarmiento et al., 2020). To limit this, we focussed on the categorization of variables in our member-checking workshops to ensure that our interpretations still resonated with participants. However, this still posed a challenge for our efforts towards knowledge co-production. When examining the relationships between categories, it also cannot be assumed that every individual variable within those categories reflects those same broad inter-category relationships. Maps of inter-category relationships are aggregated and simplified, and some variability and detail within those categories will have been lost (Johnson et al., 2022). These

data and intra-category relationships can still be explored by tracing specific paths within the transitive closure maps and changing the focus and resolution of the map. We also generated qualitive data through the interviews we conducted with participants during the FCM process, and these data were used to guide interpretations of the maps and variables, and reintroduce some of the nuance that could have been lost. A further limitation is that mapping was only conducted with Cree participants. Mapping was not conducted with other potentially interested participants, such as sport hunters, foresters, or government biologists. Therefore, there was no opportunity to contrast the FCMs produced by Cree participants with those produced by the subscribers of different knowledge systems.

Finally, interpretation, and the developing of shared understandings between English and Cree, was sometimes a barrier throughout the interview process. For example, in some interviews, it was difficult to agree on what the concept of "good moose habitat" actually meant, as there was no simple translation to Cree, and the concept is so grounded in scientific knowledge systems. Similarly, later interviews revealed that some participants would assume that when the research team asked questions about moose, they were asking only about male moose. This relates to a broader limitation of this study, in that all the GPS collar data was collected on female moose, but the interviews and FCM included both females and males. The difference could represent an important discrepancy between the two approaches, as female and male moose may behave and select habitat different, for instance, if a cow moose is calving.

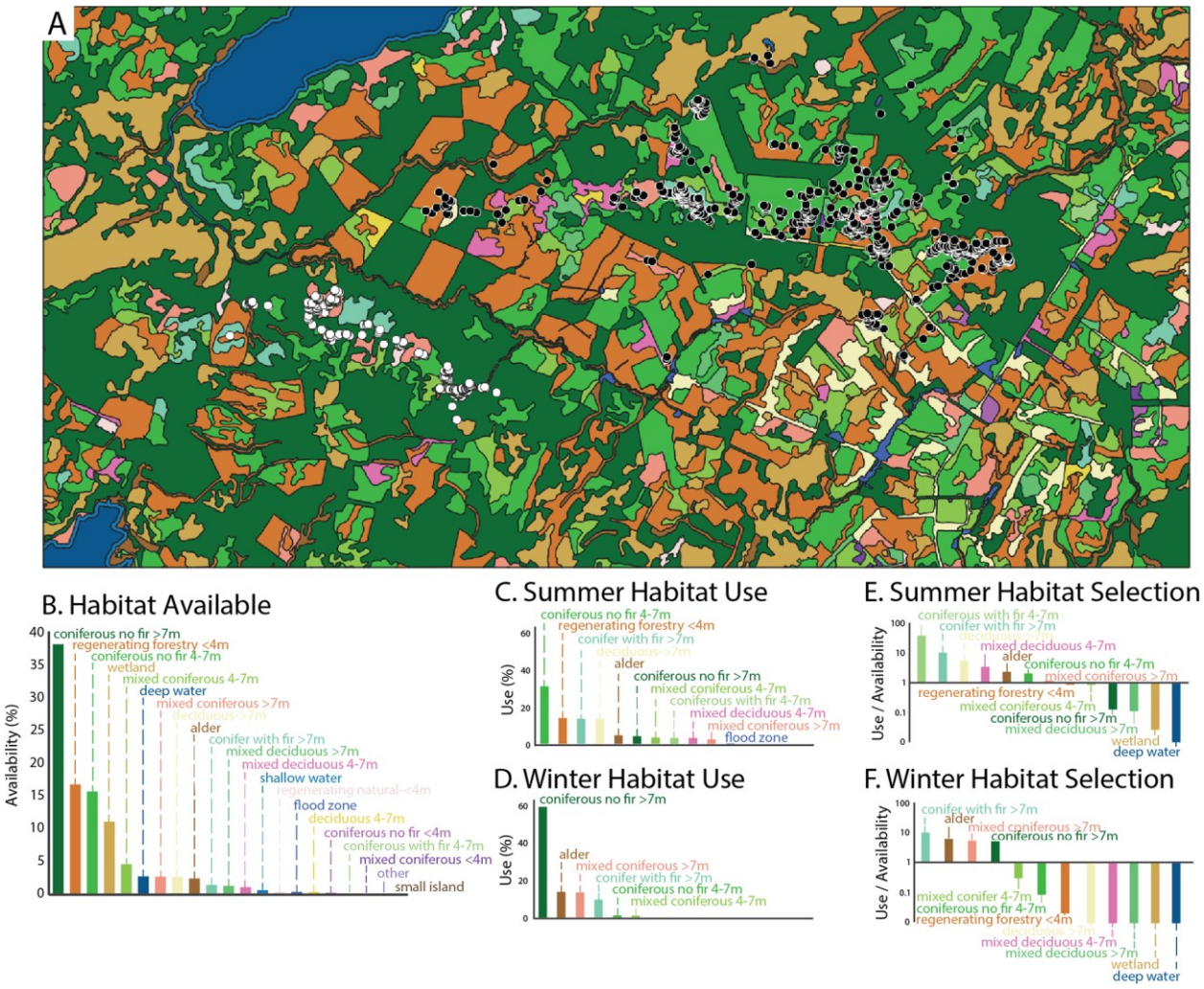
4.7 Results

In what follows, we draw on the data collection and analyses conducted through the MHQ project, our own involvement in this project as researchers, and data from available reports and meeting notes. We focus on the process of project development, delivery, and analysis, and conclude with a discussion of future opportunities, challenges, and needs for working across knowledge system boundaries in pluralistic natural resource governance contexts.

4.7.1 Moose Collar Data

Results of the moose collar data analysis show that moose strongly selected for some habitat types, like mixed wood forests, while avoiding others (Stern, 2022). An example of a habitat selection analysis, simplified from protocols developed by Stern (2022), including consideration of habitats used in winter and summer relative to habitats available, is presented in Figure 4-4. This example focuses on a single female moose, whereas the complete habitat selection analysis considered patterns of selection expressed by 38 females across multiple years and scales (Stern, 2022). Further, this example assesses available habitat at a single scale, not corresponding to the scales studied in the full HSI. It uses the spatial extent of a rectangular map as a simple but arbitrary example of how available habitat might be considered, whereas the complete analysis considered two scales of analysis based on random locations distributed within estimated moose home ranges (third order selection) and across the AFR region (second order selection). Accordingly, the results of this simple analysis are illustrative and not necessarily representative of results of the full analysis.

Figure 4-4. An example of moose habitat availability, use, and selection in Eeyou Istchee's Adapted Forestry Regime.



A. *GPS collar locations of a female moose within the Adapted Forestry Regime, including summer (July-August; black points) and winter (January-February; white points) locations, overlaid on coloured polygons reflective of habitat types derived from Quebec's ecoforestry maps, which include forested areas classified by stand composition and height and additional non-forested habitat types.* ***B.*** *Habitat availability, calculated as [(habitat area/total area)x100], with habitat area and total area calculated across the spatial extent included in panel A.* ***C.*** *Summer habitat use by the representative female moose, based on July-August GPS collar locations.* ***D.*** *Winter habitat use by the representative female moose, based on January-February GPS collar locations.* ***E.*** *Summer habitat selection, expressed as use relative*

availability, with availability based on the spatial extent included in panel A. ***F.*** *Winter habitat selection, expressed as use relative availability, with availability based on the spatial extent included in panel A.*

In this example, the predominate available habitats are tall (>7 m) coniferous stands without fir present (38% of total area), regenerating stands following forestry disturbance (16%), medium height (4–7 m) coniferous stands without fir present (16%), and wetlands (10%). These four habitat types collectively account for 80% of land area, whereas 17 different habitat types make up the remaining 20% of land area. Like many other landscapes, this area is composed of a few common habitat types and many rare habitat types. The habitats used by this female moose–determined by overlaying GPS collar locations on habitat categories classified and mapped by the Ministère des Forêts, de la Faune et des Parcs du Québec–indicate use concentrated in a few habitat types and non-use across many habitats in both seasons, although a wider variety of habitat types were used in summer (11 habitat categories; Figure 4-4C) than in winter (6 habitat categories; Figure 4-4D).

In this single-moose example, combining metrics of use and availability into a selection ratio indicates strong summer preference for tall and medium conifer stands with fir, tall deciduous stands, medium-height mixed stands, and alder stands, combined with strong summer avoidance of deep water, wetland, tall mixed deciduous stands, and tall coniferous stands without fir present, which is the most widely available habitat. Winter selection ratios for this moose indicate a strong selection of alder stands and three tall forest types (mixed coniferous and coniferous with and without fir present) and complete avoidance of deep water (covered by ice in winter), wetlands, tall deciduous stands, and two medium-height stand types.

As stated above, these illustrative results reflect the locations of only one female moose, for a restricted set of predictor variables focused primarily on a forest-focused landcover classification, and do not represent the full habitat selection found in the HSI. A more complete assessment of female moose habitat selection within the AFR, including results from 38 other collared females, two spatial scales of analysis, and additional predictor variables is presented separately (Stern, 2022). The example presented here should not be interpreted as

results or conclusions about moose habitat selection in the AFR, but rather as an example of the logics and analytical steps involved in the process of habitat selection analyses, and a demonstration of how animals situating themselves within a landscape of contrasting habitat types can help to communicate their individual and species-specific habitat preferences.

4.7.2 Cree Knowledge Interviews

The results of the FCM show the relative influence of each habitat variable category (Table 4-2). Five of the most influential categories on "good moose habitat" were "Hunting and Predation", "Habitat Features", "Forestry & Access", "Noise & Disturbance", and "Moose Forage". Each category comprised social and ecological variables. "Hunting & Predation" included variables such as hunting pressure, Indigenous and non-Indigenous hunters on the landscape, poaching, safety while hunting, and nonhuman predators like wolves. "Habitat Features" includes the various habitats that moose use at different times of year, like moose yards, which are moose wintering areas, "typically described as elevated terrain, intersected by valleys, with mature mixed or deciduous stands used for food and mature coniferous stands for cover" (Jacqmain et al. 2005, p. 153). The "Forestry & Access" category included forestry activities more widely, as well as different kinds of cuts and related impacts like debris and increased road access. "Noise and Disturbance" encompassed both natural disturbances like forest fires and windthrow, as well as human disturbances like camps and noisy snowmobiles. "Moose Forage" included a variety of plants that moose feed on seasonally, as well as other broader variables like regrowth and aquatic plants.

Table 4-2. Categories of variables identified affecting moose habitat in Eeyou Istchee and applied in our analyses, not including the central node of "good moose habitat".

Climate & Weather	Habitat Features	Moose Population
Cree Culture	Human Health	Noise & Disturbance
Education & Knowledge	Hunting & Predation	Other Resource Development
Forest Fire	Land Stewardship	Other Wildlife
Forest Management	Moose Forage	Pollution
Forestry & Access	Moose Movement	Protected Areas

The most influential categories varied somewhat between communities. In Oujé-Bougoumou and Waswanipi, the impacts of "Forestry & Access" and "Forest Management" on moose habitat were more clearly reflected in the maps. This is unsurprising, as these communities are further south and have more traplines affected by forestry. Forestry and forestry management was much less relevant in Nemaska, for example, which is at the northern limit of the AFR and has fewer traplines affected by forestry. In Nemaska maps, "Cree Culture" and "Education & Knowledge" had higher relative influence. The "Cree Culture" category includes values like respect and reciprocity, as well as practices like sharing wild foods, preparing moose hides, and practicing the "Cree way of life". "Education & Knowledge" comprised variables related to knowledge of moose and being on the land, as well the elders and family who passed these teachings on. It should be emphasized that these are measures of relative influence on moose habitat, and not a statement on a category's overall importance to any community. A more complete assessment of the FCM analysis is presented separately (MacMillan et al., 2024).

4.7.3 Knowledge weaving in FCM

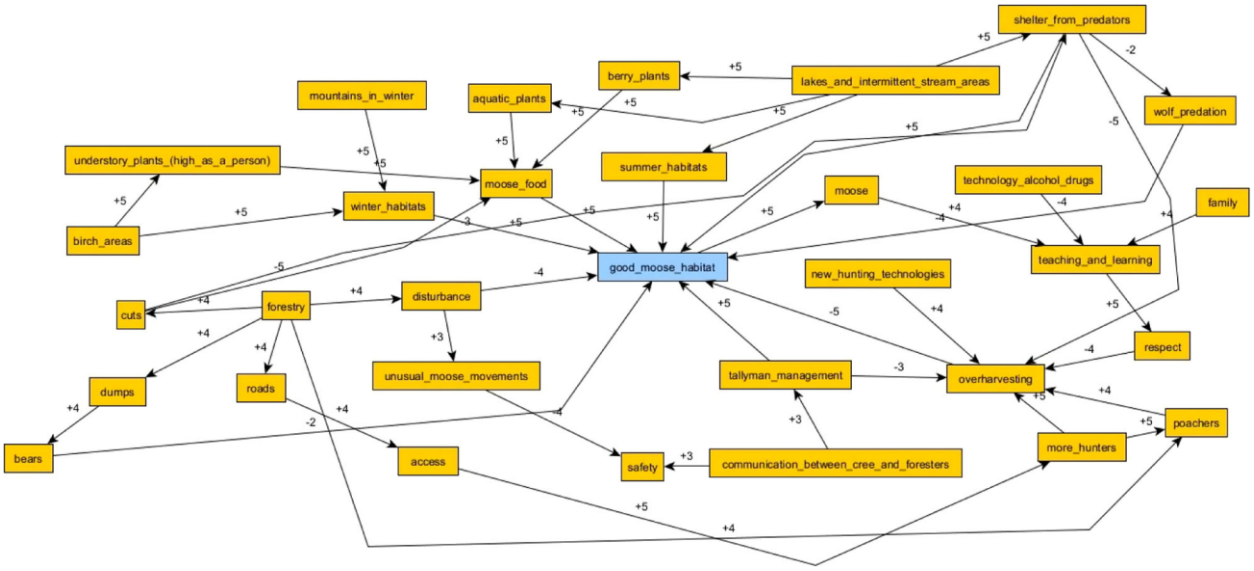
FCM as a method helped to illustrate some of the differences between these knowledge systems. By taking an inductive approach in the participatory mapping, and placing nodes in the participants' own words, we were able to identify a number of new variables affecting moose

habitat. The interviews emphasized variables that did not or were unable to emerge from the analysis of habitat suitability. Namely, “Hunting & Predation” and “Other Resource Development”[3] played important roles in the FCMs, in ways which were not captured in the habitat suitability analysis. “Cree Culture”, “Education & Knowledge”, “Human Health”, and “Forest Management” played smaller but still notable roles in many of the FCMs, and similarly were not captured in the moose collar data analysis.

Outside of these categories, specific variables like values of respect towards moose, other wildlife, and the land; the importance of familial and inter-generational relationships for transmitting knowledge of moose; and even the effects of social media, drugs, and alcohol on youth, were all raised in mapping exercises (Figure 4-5). This provided qualitive insights into how Cree tallymen and land-users understood the relational networks governing moose on their traplines.

[3] This category did not include forestry, which was categorised separately, but included development activities like mining and hydroelectric development.

Figure 4-5. An FCM that includes diverse social and ecological variables affecting moose habitat.



This figure depicts an initial FCM, prior to categorization, developed from an interview with a Mistissini participant. It includes nonhuman actors like technologies, alcohol, and drugs, and teachings and learning, as well as human actors like family members.

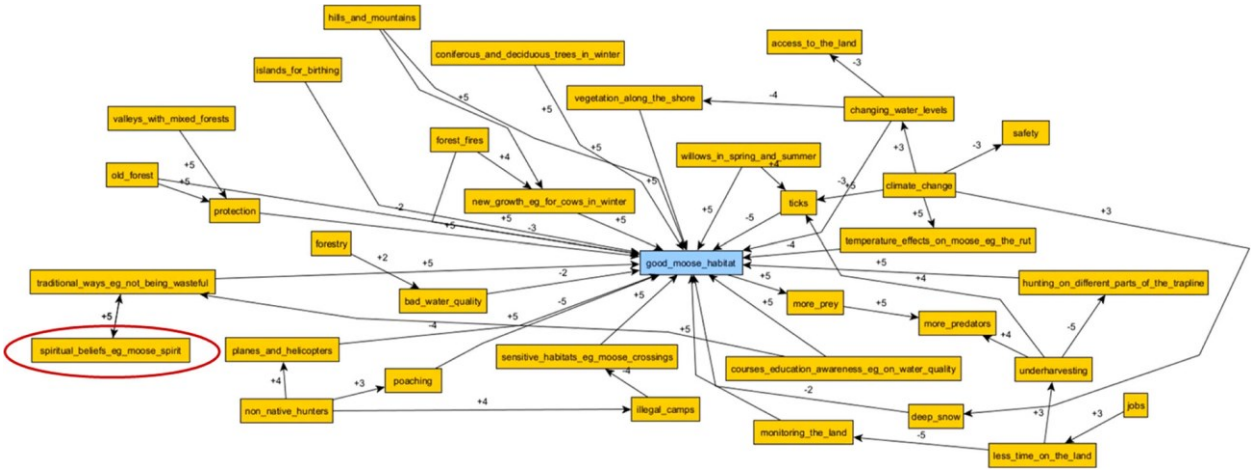
The FCMs also showed how important these new variables were quantitatively, either from ranking them with participants during data collection, or through relative frequency after aggregation. The results allowed us to, as Kok describes it, bridge the gap between narrative storytelling and mathematical scenarios (2009). The maps included holistic Cree knowledge of moose habitat, and the importance of many relationships between variables, while also communicating the importance of certain variables in ways that resonated with many of our non-Cree steering committee members. The fuzzy quantitativeness of the relationships allowed for more complex comparisons, like, for example, comparing the relative impacts of poaching between different communities. Poaching is commonly used in Eeyou Istchee to refer to any hunting practices, by Crees or non-Crees, which do not align with traditional Cree hunting law, or Eeyou Indoh-hoh Weeshou-Wehwun.

For the Crees, the identified variables, like respect and knowledge sharing, are critically important for moose habitat. They shape Cree and non-Cree relationships on traplines.

Disrespect towards moose and “hunting the wrong way” could lead to excess moose mortality or disturb moose and drive them from the area. This “hunting the wrong way” included poaching and overharvesting, which participants often described as negatively affecting their traplines. Qualities like safety, quiet, and shelter, were very important to Cree understandings of “good moose habitat”. Disturbances come not just from resource development like forestry, but also from more people, both Cree and non-Cree, not practicing land-based activities respectfully. This was in contrast to some of our steering committee members, and particularly non-Cree members, for whom the concept of moose habitat did not necessarily include things like hunters, or quiet, or respect.

However, the role these variables will play in project outcomes is still being determined. Much of the moose GPS data and Cree knowledge data is incommensurable, making any integration of FCM data into the HSI extremely difficult. Spatial and temporal specificity vary considerably between the data sets. The GPS location and habitat data were much more specific than the data from Cree knowledge interviews, which generally applied to the individual participants trapline at its most specific. The complex interactions between FCM variables could be further drawn out, but may appear to some researchers and steering committee members as being outside the boundaries of the research question or priority at hand. Conversely, not drawing them out risks ignoring large elements of expressed knowledge, and missing key connections and relationships. Engagement continues with members of the project steering committee to determine what the HSI should ultimately include to help address positionality biases, as well as what other outcomes should emerge from the project. Nevertheless, it remains likely that due to this incommensurability, some variables like “moose spirit” will remain underrepresented in project outcomes (Figure 4-6).

Figure 4-6. An FCM that includes "moose spirit" as a variable in "good moose habitat".



This figure depicts an initial FCM, prior to categorization, from a Nemaska participant which included moose spirit (circled), a nonhuman actor which did not fit neatly with the GPS collar analysis.

4.8 Discussion

Within the MHQ project, the 'messy' work of knowledge weaving is ongoing. Although the HSI model is still in development in collaboration with the project steering committee, the process has progressed far enough to provide some insights for knowledge weaving. In practice, each approach–Moose collars and Cree knowledge–generated data that were unique to the other but also often overlapped. Data from the moose collars provided precise GPS location data, allowing for insights into moose movement and habitat use. Cree knowledge interviews provided more qualitative data on preferred moose food species and moose behaviours related to specific habitats and seasons. These data on food preference and behaviours are further nuanced by video from the moose collars, which show these activities first-hand, albeit mediated by the cameras. One example is moose winter habitat. Analysis of the GPS collar data showed that moose strongly selected for mixed woods forests in winter, and typically moved around less than in summer (Stern, 2022). These analyses largely aligned with the analysis of the FCM and interviews, which indicated that winter habitats, which the Cree call moose yards, were typically characterised by a diversity of tree species that moose feed on, like alder and birch, and that these were often areas on hills and mountains which could provide shelter from

predators and the elements. These layers of overlapping data have enhanced the trustworthiness of the conclusions drawn from the two approaches (Lincoln and Guba, 1985).

The increased trustworthiness of results, and introduction of new variables and directions, supports the claim that FCM is an effective and practical tool for bringing together scientific and ILK systems (Hobbs et al., 2002; Sarmiento et al., 2020). During data collection, the method was flexible. It went at the participants' own pace, and because it was done physically on a white board, the participant could monitor interview progress, and make corrections and adjustments if they felt something was misrepresented. The method also allowed participants, if they desired, to take more control over the interview, and tell researchers what was important, challenging somewhat the power imbalance between researcher and participant. The data collection dynamic felt well-suited to research in Indigenous contexts, where there can often be distrust towards researchers, and a perception that researchers are just there to ask their questions, extract their data, and leave (Castleden et al., 2012). The participatory nature and duration of the method provided room for rapport and trust to develop.

However, the moose collar and Cree knowledge approaches did not always align. Understanding moose habitat selection related to specific management strategies–like mosaic cutting and the Cree Sites of Special Wildlife Interest, or "25% areas"–was a priority for many of our project steering committee members, who wanted to understand whether these special AFR forestry measures had been effective for preserving and creating moose habitat. 25% areas are the parts of a trapline, adding up to a quarter of the total productive forestry area, that a tallyman can earmark as important wildlife habitat. In these areas there are unique requirements the forestry industry must follow, namely conserving higher proportions of mature forest and leaving more time for regeneration between cuts. Theoretically, these forestry measures would create diversified habitat with both mature and regenerating patches of forest, providing food and cover to moose (Jacqmain et al., 2012). The MHQ Project's HSI analysis found similar results, showing that moose spent more time in the 25% areas than in habitats outside the 25% areas (Stern, 2022). This could be due to the success of the 25% areas,

or potentially to other factors, such as tallymen having originally selected the 25% areas because they were naturally better moose habitat than the surrounding trapline. Nevertheless, in our interviews, tallymen and land users often felt strongly that the 25% areas had been ineffective at preserving and creating moose habitat:

> "The 25%? It's just another fancy word." - Waswanipi research participant

Some participants were skeptical that the special forestry measures were effective enough to offset the impacts of development and disturbance on the traplines. Many participants also expressed dissatisfaction with the AFR consultation process. In particular, some tallymen had believed that the trapline areas they had initially chosen to protect wildlife habitat would be free of forestry altogether, rather than subject to a different kind of forestry. The Cree Nation Government and the Government of Quebec, responding to these and other concerns, have been working with tallymen to relocate their 25% areas and improve communication.

According to the accepted forestry and wildlife science informing forest management in Eeyou Istchee, AFR forestry strategies are a key component in the efforts to maintain the proportion of mature and regenerating mixed woods stands, which in turn support moose populations and biodiversity in the territory (Brodeur et al., 2022). Moose use of regrowing stands for food is somewhat supported by our HSI analysis, which found that moose mildly selected regrowing stands post-logging at some scales and in some seasons, although mildly avoided them at others (Stern, 2022). For many Cree participants, though, these relationships were more complicated. Some of the complicating variables–like forestry increasing road access and decreasing cover, leading to increased hunting pressure–are also well recognised in the scientific literature (Rempel et al., 1997). Others, like noise disturbance, are not as often acknowledged and would be challenging to quantify for HSI analysis, at least in the holistic sense identified by Cree participants. They identified a range of sources, from landusers, to traffic, to heavy machinery from resource development and construction. Nonetheless, while these two different knowledge systems in this example sometimes reached different conclusions, this is not necessarily a problem or barrier. A lack of agreement is a key element of the knowledge weaving process, and should represent a jumping-off point for further inquiry,

rather than an obstacle. But this pluralism can create sticking points when it comes to collaboration and decision-making, as in this example, where the right action to preserve moose populations could vary greatly depending on the knowledge and worldview that is drawn on. Even the project's focus on moose and moose habitat is grounded in a particular worldview, and has the potential to conflict with Indigenous worldviews, many of which are more holistic (Salomon et al., 2023).

In their work with the Kluane First Nation in the Yukon, Nadasdy refers to knowledge weaving obstacles as "distillation" and "compartmentalization" (1999). When Indigenous knowledge is integrated with science it is often distilled down into its narrowest sense, focussing on specific knowledge of things like plants and animals. By only integrating this most basic level of knowledge, management systems, social institutions, and worldviews are excluded (Berkes, 2018a). Things like spiritual values related to moose, or even the role of tallymen on the trapline, are often put aside. But if moose spirit was to be included in an integrated model, how would non-Indigenous decisionmakers, or even non-Cree ones, make sense of that? These are ontological obstacles to knowledge weaving. All methods, from interviewing to moose collar analysis, have their own ontological underpinnings and assumptions, and this is an area that requires further exploration in future empirical research. The need was clearly identified by our participants (in this example, speaking in reference to non-Cree hunters):

> "If we see their way and they see our way, maybe there could be a better balance" - Oujé-Bougoumou research participant

While FCM is effective at identifying a wide variety of actors, variables, and relationships from across knowledge systems, many of these things may become de-emphasized, de-contextualised, or eliminated completely as maps are aggregated, variables are categorised, and results taken up by decision-makers.

Bringing together science and ILK is a key priority for governance actors in Eeyou Istchee and in many other jurisdictions. However, ontological pluralism and complexity may pose a challenge to knowledge weaving. While some elements of ILK integrate easily with scientific

frameworks, like the food species that moose prefer, others, like the role of respect in moose governance, are more challenging to weave together. FCM is a promising method for advancing knowledge weaving in pluralistic contexts like ILAs. It can effectively bring together different knowledge systems to explain complex phenomena. FCM is also semi-quantitative, which facilitates the ability to communicate results to decision-makers, and to incorporate the data into quantitative models. But researchers and practitioners applying FCM are likely to still face challenges in the form of ontological contestations between knowledge systems. We acknowledge too that even if ontological boundaries can be overcome, knowledge weaving in most contexts will still face political challenges (Nadasdy, 1999). In Eeyou Istchee, many of the political conflicts have been ongoing since the construction of the James Bay Hydroelectric Project, only now situated in boardrooms and conference calls (Scott, 2003).

Within the context of academic research in Eeyou Istchee, this research study builds on several past efforts to bridge gaps between Cree and scientific knowledges. For example, work by Fikret Berkes on Cree knowledge of species like cisco (Berkes, 1977) and caribou (Berkes, 2018b), which illustrated the value of Cree contributions to ecology and wildlife management. Anthropologist Harvey Feit worked with Cree land-users and tallymen in Waswanipi directly on moose (1987), and demonstrated how Cree practices related to moose were the foundations of traditional management strategies. Hugo Jacqmain et al. complement GPS data from moose collars in Eeyou Istchee with Cree knowledge interviews, contrasting the results between them (2005, 2008). Our research builds on this body of work by assessing the effectiveness of a specific forestry regime, the AFR, which allows Cree tallymen to specify areas within their territories with high wildlife value, and institute specialized forestry practices within these areas intended to maintain wildlife habitats and support Cree ways of life. Additionally, our research is novel in its detailed documentation of two knowledge approaches, one focused on habitat selection analysis of collared moose and the other on FCM of Cree knowledge, conducted within a thorough and explicit knowledge co-production framework. This has allowed us to move towards a model that brings knowledges together in a way in which both inform project results and outcomes equally, without positioning one knowledge above the other. We also sought to be collaborative in our approach, and in doing so brought together a diversity of key

governance actors in the territory to have control over the project direction and outcomes, a crucial step, also recognised by Feit, who wrote:

> "Native people can no longer use or manage the resources without extensive and effective means of participating in the decisions taken in the wider society which profoundly affect the future of the resources and their use. And government wildlife managers cannot protect or manage the wildlife resources without effective means of participating in the decisions taken in Native society which profoundly affect the future of the wildlife resources and their use" (Feit, 1987, p. 40).

Future research on knowledge weaving could focus on assessing the potential of complementary boundary-spanning methods to help navigate some of the obstacles facing researchers working across ontological boundaries. Inspiration could be taken from, for example, recent work on actor-network theory and analytical posthumanism, which may hold insights for addressing boundary-spanning relationships like the ones between "moose spirit" and "good moose habitat" (Badry and Hickey, 2022). Such directions have the potential to make the results of transdisciplinary research more responsive to contestations in pluralistic landscapes, better addressing the "landscape of tension" (Parker and Crona, 2012) between diverse actors.

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PREFACE TO CHAPTER 5

Chapter 4 provided empirical evidence that ontological pluralism and complexity can pose challenges for social-ecological network analysis methods in collaborative natural resource governance contexts. Chapter 5 builds on this finding by experimenting with actor-network theory to assess the potential for post-humanist network methods to assist with spanning ontological boundaries, including those between humans, and between humans and nonhumans. It presents a case study of lake sturgeon governance in the Cree community of Nemaska and applies actor-network theory to illustrate and trace the complex relationships governing sturgeon there.

CHAPTER 5. USING ACTOR-NETWORK THEORY TO UNTANGLE COMPLEXITY IN THE ANALYSIS OF PLURALISTIC SOCIAL-ECOLOGICAL SYSTEMS: THE CASE OF TRANSBOUNDARY LAKE STURGEON GOVERNANCE IN NEMASKA, EEYOU ISTCHEE, CANADA

Nathan A. Badry[1], Murray M. Humphries[1], & Gordon M. Hickey[1]

[1]*Department of Natural Resource Sciences, McGill University, Canada*

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Abstract

Social-ecological systems are complex and the product of numerous interwoven human and nonhuman relationships. Methods and frameworks for analysing these systems are characteristically inclusive of social and ecological things and relationships, but they can struggle to address the in-between spaces. They also prioritize particular worldviews, which can exclude local understandings. We argue that recent and diverse scholarship on actor-network theory, new materialism, and posthumanism could hold inspiration for new network methods in social-ecological systems governance. We demonstrate this through an instrumental case study of lake sturgeon governance in the Indigenous community of Nemaska, Eeyou Istchee, Quebec. Lake sturgeon is a key wild food species in Nemaska, holding significant nutritional, economic, social, and cultural value. But sturgeon is also facing pressures and uncertainties, particularly related to hydroelectric development. Drawing on interviews and participant observation, we illustrate the relational networks of human and nonhuman actors that influence lake sturgeon governance in Nemaska. The ability of these methods to capture relationships that might otherwise be missed, like a past relocation of the community now limiting intergenerational knowledge transfer, is highlighted.

5.1 Introduction

> Fish and fishermen [*sic*] do not face one another like 'natural' and 'social', 'object' and 'subject', 'material' and 'symbolic' (Latour, 2005, p. 109).

Governance is a key consideration for natural resource managers and practitioners. It is the wider architecture of social relationships and institutions in which management decisions get made. Natural resource governance specifically has been defined by Graham et al. as "the interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens or other stakeholders have their say" (2003, p. ii). However, despite the importance of governance to collective action and management outcomes, there are still many obstacles to understanding governance, especially in transboundary social-ecological systems (SESs).

SESs are complex adaptive systems comprising both social and natural elements and processes (Biggs et al., 2021). However, in most cases, they include more than just boundaries between social and natural. They often encompass a wide variety of social groups, cultures, ecosystems, knowledge systems, and more. SES theory brings together these different SES dimensions by drawing on a variety of diverse interdisciplinary perspectives and approaches, such as institutional analysis (McGinnis, 2011), ecology (Berkes et al., 1998), ecosystem services (Ban et al., 2015), and sustainability (Partelow & Winkler, 2016). These efforts are driven by a recognition that phenomena in these systems are complex, determined by complex relationships among humans and nonhumans, and that traditional siloed disciplinary approaches have struggled to fully address these challenges (Schoon & van der Leeuw, 2015). In many SES frameworks, governance plays an integral role, such as in Elinor Ostrom's frequently cited SES framework (2009), where governance is a core subsystem, alongside resource units, resource systems, and users.

Governance, as a subset of an SES, is often studied as a relationship network, with researchers drawing on the rich history of network approaches in sociology to describe and analyse it (Borgatti et al., 2009). This approach has allowed researchers to describe governance as a structure of nodes (actors) and links (relationships and interactions among actors), based

on connections as diverse as knowledge sharing, influence, affinity, or trust. Social network analysis specifically has contributed to the understanding of natural resource governance by demonstrating: there are interdependencies between actors, network structures, and network functions; that different network connections and patterns affect governance differently; that different network structure characteristics are predictive of certain governance outcomes; and that governance operates across scales (Salpeteur et al., 2017). Network methods like social network analysis can also be used to describe governance networks qualitatively or quantitively, and to identify potential solutions for improving social linkages between actors. The overarching objective is often to improve collective action, an outcome that can be facilitated through knowledge creation, acquisition, and transfer; resource mobilization and acquisition; commitment to shared rules; and conflict resolution (Bodin & Crona, 2009).

However, SES frameworks—made up of social and natural subsystems and components, including governance—can be universalising, and tend to be exclusive of local perspectives and other ways of knowing (Bohensky & Maru, 2011; Martinez et al., 2023). In the pluralistic governance contexts characteristic of natural resource systems, applying SES frameworks can be problematic, as not every rightsholder and stakeholder may subscribe to the worldview laid out in an individual framework (Holzer et al., 2022). Diverse peoples holding diverse knowledges within these systems have equally diverse understandings of natural and social worlds. In Indigenous contexts, for example, some ontological assumptions about the relationships between humans and the natural world fit poorly in SES frameworks (Badry et al., 2024; Badry & Hickey, 2022). The challenges this raises have been well illustrated in the case of traditional ecological knowledge (Klenk et al., 2017): the elements and outputs of these knowledge systems which fit within scientific frameworks, like abundance counts and wildlife habitat preferences, are often extracted and used, but the rest, like traditional management systems based on reciprocity between humans and nonhumans, are ignored, leading to knowledge co-production in-name-only (Nadasdy, 2007). The inflexibility of frameworks like the SES can thus limit the scope of cooperation among governance actors in pluralistic contexts.

Further, SES scholars, and frameworks like the SES Framework (Ostrom, 2009), tend to promote different perspectives on who (or what) the important actors are and are not. These

perspectives can shape every stage of the research process, from initial research questions and project scoping, to the interpretation of results. For example, in a study of consumptive wildlife use and policy in Kenya, landowners and markets were foregrounded (Brehony et al., 2020). Whereas in a study of Indigenous kelp fishing in Canada, markets were externalized, while harvesters, traditional managers, and intertidal ecology were foregrounded (Kobluk et al., 2021). And in a study of dryland ecosystem services in China using agent-based modelling, household income and behavior were foregrounded alongside landscape dynamics (Miyasaka et al., 2017). In each of these cases, a wide variety of actors and processes were included, spanning both social-natural and human-nonhuman boundaries. However, the starring cast of actors which gets foregrounded, and the supporting cast which does not, are often pre-determined by the individual researchers, frameworks, and methods. This could be considered a fundamental constraint of all research, but in the case of natural resource governance networks, this constraint may be mediatable.

Outside of SES scholarship, there are bodies of work like critical posthumanism (Braidotti, 2016) and new materialisms (Thorpe et al., 2022) which seek to make sense of the transboundary linkages between different actors in these complex systems. There are also approaches and tools, like actor-network theory (ANT), which operationalise these ideas to help untangle the relationships between natural and social, human and nonhuman. ANT is a collection of tools and sensibilities for empirically tracing the associations among human and nonhuman actors. Popularised through the works of Bruno Latour (2005), John Law (1984), and Michel Callon (1984) in the field of science and technology studies, ANT has since been taken up and contributed to by numerous scholars across various disciplines (Kanger, 2017). Nonetheless, few studies have applied ANT to natural resource governance networks, or, in particular, explored its boundary spanning potential in pluralistic networks. In this paper we ask the question: can an ANT-inspired approach to analyzing natural resource governance networks help improve pluralistic understandings of complex transboundary SESs? SESs which are more inclusive of, for example, Indigenous knowledge and stewardship, could improve collective action and help empower Indigenous governance actors and systems.

5.2 Conceptual Framework

5.2.1 Actor-Network Theory

ANT was partly positioned as a response to orthodox sociological research (Latour, 2005), with researchers attempting to shift focus away from broader sociological theories and explanations, and towards approaches that could illuminate the humans and nonhumans responsible for particular scientific and technological developments under study. According to ANT, the social world is best understood through the careful tracing of these humans, nonhumans, and relationships (Latour, 2005).

Such an understanding could be considered incongruent with how natural resource governance is typically understood in SES theory. However, several studies have proposed that ANT could help further natural resource governance research by helping to explain the roles nonhumans play in natural resource governance processes and structures. In an example of applied ANT, Massey et al., studying salmon run networks in British Columbia (2021), used ANT to identify opportunities for improving salmon conservation. Dwiartama and Rosin (2014) and Nabavi and Daniell (2017) have suggested that ANT could offer important new insights for resilience theory and SESs, respectively. But additional study is needed to fully explore the potential of ANT to help span boundaries and expand network governance to include a broader range of human and nonhuman actors. The rise in transdisciplinary ANT applications provides numerous insights and avenues for how to do so. Thus, rather than draw on any one particular understanding of ANT, in this study we draw from a number of influences and perspectives that have built on and advanced ANT, including ANT-adjacent research (Ampumuza & Driessen, 2021), material semiotics (Law, 2009) more-than-human agency (Li & von Essen, 2020), posthumanism (Theriault, 2017), socio-materialism, (Fox & Alldred, 2021), feminist theory (Leonardelli et al., 2022), and Indigenous scholarship (Engman & Hermes, 2021).

ANT and other related work aid in exploring how social worlds are enacted through social practices (Law, 2009). According to ANT, practices and worlds are woven from heterogenous associations of human and nonhuman actors, or actor-networks, which are constantly evolving and being negotiated and renegotiated. However, in ANT, no *a priori* assumptions are made about whether the human and nonhuman actors in the network have

agency, what their roles are, and what other things they may relate to (Holifield, 2009). Instead, it is the work of the researcher to carefully trace the networked relationships among actors, and let the data 'speak for itself' (Latour, 2005).

In ANT, agency is a key concept (Sayes, 2014). Agency within an actor-network is understood as the ability to affect change on other actors, and can be potentially held by anyone or anything, human or nonhuman (Toncheva & Fletcher, 2021). ANT agency is considered separately from the conscious thought or intentionality of an actor. This is sometimes described as symmetry or a flat ontology (Höppner, 2021): the actors with starring roles and the actors with supporting ones are not predetermined by the analyst. The researcher then represents the results of their analysis using a common language so as to not privilege any single perspective, describing all actors in the same terms. Such a strategy serves to decenter the human from the social, highlighting the role of material and collective agencies.

5.2.2 Food Value Chains

Food systems are frequently cited examples of SESs (Hodbod & Eakin, 2015). These examples range from large scale agriculture (Kopainsky et al., 2015) to local and Indigenous food systems (Galicia-Gallardo et al., 2023). SES theories and frameworks are applied to these systems to help answer questions like how to improve sustainable-use (Bloom & Hinrichs, 2011). One tool used in this research is food value chains (Marshall, 2015; Bloom & Hinrichs, 2011). A value chain is a form of relational multi-actor network, often conceptualized as a sequence of steps through which something is transformed into a product or service (Lowitt et al., 2015). Value chains in food systems are used to help interrogate the different actors throughout the chain, their relationships, and how these influence the system. However, like other SES models and frameworks, value chains can be exclusive of other ways of knowing, and foreground some actors and processes while obscuring others. A more fundamental problem might be their inability to respond to radically different ontological positions, including considerations of different kinds of relationships between humans and nonhumans.

Wild food systems are one type of SES that can be described and analysed as a value chain (Thompson et al., 2020). Wild foods, sometimes called country foods or traditional foods,

are plants and animals obtained from the land through subsistence activities and consumed locally (Kuhnlein & Receveur, 1996). Wild food value chains are often made up of diverse actors and practices. Insights from ANT could potentially help explore 'hidden' or marginalized actors and processes in these value chains, and provide novel insights for researchers or managers seeking to enhance collective action in pluralistic wild food contexts (Badry & Hickey, 2022).

5.3 Methods

We conducted an instrumental case study of lake sturgeon governance in the Cree community of Nemaska, Eeyou Istchee. Case studies are considered a useful approach for addressing explanatory questions of how, why, and what (Yin, 2018). Instrumental case studies specifically can provide insight into a particular issue or phenomenon (Denzin & Lincoln, 2005). In our research, the issue was whether applying ANT as an analytical method could provide pluralistic insights for natural resource governance actors in complex SESs, by recasting actors and their relationships to better reveal the complexity of SESs. Further, ANT is typically applied through case study approaches (Law, 2009).

For our case, we investigated the interrelated steps through which transboundary lake sturgeon come to represent nutritional, social, cultural, and economic value for Crees. We used a wild food value chain to structure our approach to data collection, analysis, and representation, which allowed us to explore the everyday practices of sturgeon governance from different vantages. We sought to understand the human and nonhuman actors that were influential throughout the value chain, spanning bureaucratic, local Indigenous, and scientific ontologies. Using ANT, we aimed to trace the associations among 'starring' actors at each stage of the sturgeon value chain, and followed the entangled relationships wherever possible.

5.3.1 Research Setting

Eeyou Istchee, or "Land of the People", has been the home of the James Bay Cree since time immemorial. It lies within the borders of Quebec, Canada, and encompasses a northern territory over 400,000 km^2, an area more than two thirds the size of France. Over the past several decades, and especially since major hydroelectric developments proposed in the 1970s, Cree communities have transitioned from subsistence economies to mixed economies, which

include both traditional, land-based activities and wage labour. However, wild foods have remained hugely important (Berkes & Farkas, 1978).

Wild food forms the basis of a Cree traditional diet, and many Crees use their territory to access a wide variety of plants and animals. Lake sturgeon (*Acipenser fulvescens*) is one such wild food species. Sturgeon comprises a significant portion of the diet in several of the Cree communities of Eeyou Istchee (CBHSSJB, 2013), where it is also known as nameo, némèw, or namew (Berkes & Mackenzie, 1978), or nameu (ᓇᒉᐤ) and nimaau (ᓂᒪᐤ; Badry & Dunn, 2022).[4] Eeyou Istchee is home to a portion of the federally designated Southern Hudson Bay-James Bay populations of lake sturgeon, whose range stretches into the provinces of Ontario and Manitoba (COSEWIC, 2006). Sturgeon can be found throughout most of Eeyou Istchee, including all the major watersheds draining into James Bay, ranging from the La Grande River in the north to the Harricana River in the south. While sturgeon is an important wild food in many Cree communities, Nemaska is one community in which they are particularly important. Nemaska in Cree means 'the fishing place'. The historical community site, prior to being relocated, was on Nemaska Lake, a summer gathering place on the Rupert River at which several species were fished, including sturgeon.

Unfortunately, sturgeon in Nemaska, and continued access to sturgeon by the Cree, is being threatened. As in many jurisdictions throughout North America, lake sturgeon in Eeyou Istchee have faced a number of pressures, but the impacts of hydroelectric development in the territory are of particular concern (COSEWIC, 2017). Among other effects, hydroelectric development has degraded spawning habitat territory and decreased habitat connectivity (Badry & Dunn, 2022). In 2009, the Rupert River, where Nemaska is located, was partially diverted upstream of Nemaska Lake as part of the Eastmain-1-A and Rupert diversion project, hereafter the Rupert Diversion. The Rupert Diversion had significant impacts on the people of Nemaska. Many family hunting areas, or traplines, were affected. Other cumulative effects, like forestry and climate change, are likely impacting lake sturgeon in other parts of the territory as

[4] The Cree language in Eeyou Istchee includes multiple dialects and had no written form prior to the introduction of syllabics, so words often have many spellings.

well (Che & Hickey, 2021), but little research has been conducted to assess their magnitude. Rising temperatures may, for example, negatively affect metabolic processes at specific life-stages (Bugg et al., 2020). Population rise and increasing demand for wild foods is also likely playing a role. Consequently, lake sturgeon has recently been listed as a species of Special Concern by the Committee on the Status of Endangered Wildlife in Canada, and is considered to be At Risk by the Convention for International Trade in Endangered Species of Wild Fauna and Flora (COSEWIC, 2017). Efforts are currently underway to develop a lake sturgeon threat management plan in the territory to address these concerns and sustain Cree use of sturgeon, led by the Cree Nation Government, the Cree Trappers' Association, and the Cree communities of Eeyou Istchee, with support from Fisheries and Oceans Canada, as well as several rightsholder and stakeholder organisations.

5.3.2 Data collection and analysis

We drew on community-based participatory research to develop our approach (Castleden et al., 2012), seeking to engage with community members at every stage of the research process and share decision-making power over project directions and outcomes. Before we began, we reached out to the Cree Nation Government, the regional government entity, to ensure that our project aligned with research goals in the territory. We also presented our proposed project to the Nemaska Chief and Council to make them aware of our work and obtain their consent to proceed. At the time of data collection, there was no formal research ethics approval process in Eeyou Istchee for this type of research, although efforts are currently underway to establish one. We received approval from McGill's research ethics board to undertake this project (File #:393-0319).

Data collection consisted of a qualitative, multiple methods approach combining overt participant observation and unstructured interviews. Unstructured interviews were chosen because they were appropriate for an exploratory case study in which we did not yet know the exact questions to ask, and they could help create more equitable relationships between researcher and participant (Corbin & Morse, 2003). Unstructured interviews are also recognised as an effective method in Indigenous contexts because they resonate with the orality of

knowledge transmission in many Indigenous cultures (Bessarab & Ng'andu, 2010; Kovach, 2010). Participant observation provided access to data and insights that were unavailable to us as outsiders, and allowed us to triangulate between the two data-collection methods, and helped identify additional key informants (Jorgensen, 2015).

Participants included both community participants, Crees of Nemaska with close relationships to sturgeon at any stage of the value chain, and other informants, Cree and non-Cree individuals involved in the wider governance of sturgeon stewardship, conservation, and management. Twenty-three interviews were conducted with twenty-six Cree land-users (several couples preferred to be interviewed together). Eight of the participants identified as women, and several were elders. Interviews were conducted within the community and in the surrounding area in 2019, including at Old Nemaska. Interviews were between one and two hours in length. Participant observation was conducted with land-users in 2019. We went out with fishermen while they set and checked their nets. We also sat with men, women, and youth while they cleaned and prepared sturgeon, and ate sturgeon at community gatherings. Through the interviews and observation, the important actors and relationships at each step of the value chain were traced. Since 2020, the lead author has been involved in efforts by the Cree Nation Government to develop a management plan for lake sturgeon in the territory, and this has also informed our analyses.

Honoraria were provided to participants to compensate them for their contributions, as is standard in Eeyou Istchee. Honoraria can help build reciprocal relationships and reduce barriers to participation. Land-users in Eeyou Istchee are frequently contacted to participate in an array of research activities, and there are many demands on their time and attention. We also hired a local research assistant who could help make contact with participants, organise interview logistics, and translate between Cree and English. Many elders in the community do not speak English comfortably, or prefer to speak in Cree, and so an assistant who could translate between English and Cree interviews was invaluable.

An iterative approach to qualitative data analysis was used, with coding beginning during data collection and informing the questions being asked (Saldana, 2016). Open coding

was used for the initial transcripts, after which a code list was established, and a constant comparison approach was adopted for the remaining transcripts. Coding was used to identify important actors and the relationships between them, and these relationships were traced as far as they could be, with new actors and relationships identified iteratively. Results of this analysis are presented below in both thick qualitative description and a network diagram.

The strategy for maintaining the trustworthiness of our research was informed by Lincoln & Guba's four criteria (1985), and Baxter & Eyles' corresponding strategies (1997). Credibility was maintained through purposive sampling, prolonged engagement, persistent observation, and triangulation between methods. Transferability was maintained through the thick qualitative descriptions generated by participant observation and unstructured interviewing. Dependability was maintained through triangulation between methods, peer debriefing with research assistants, and low inference descriptors from interviews and focus groups. Confirmability was maintained through journaling and by creating an audit trail.

5.4 Results and discussion: the value chain

In the following subsections, we describe the 'starring' humans and nonhumans and their relationships identified at each stage of the sturgeon value chain (Figure 5-1). The majority of these data are drawn from the interviews conducted with Cree land-users, but complemented and contextualised by document analysis and participant observation conducted with Crees and non-Crees. To help make sense of the sturgeon actor-network in Nemaska, we divide the value chain into six steps, each of which have feedbacks and interactions with each other, as well as contribute to the 'value' of wild food. The structure of the value chain emerged partly from the data collection process, but also from other collaborative and ongoing research programs in the territory, including a climate change forum in the Cree community of Eastmain in 2018.

Figure 5-1. The wild food value chain.

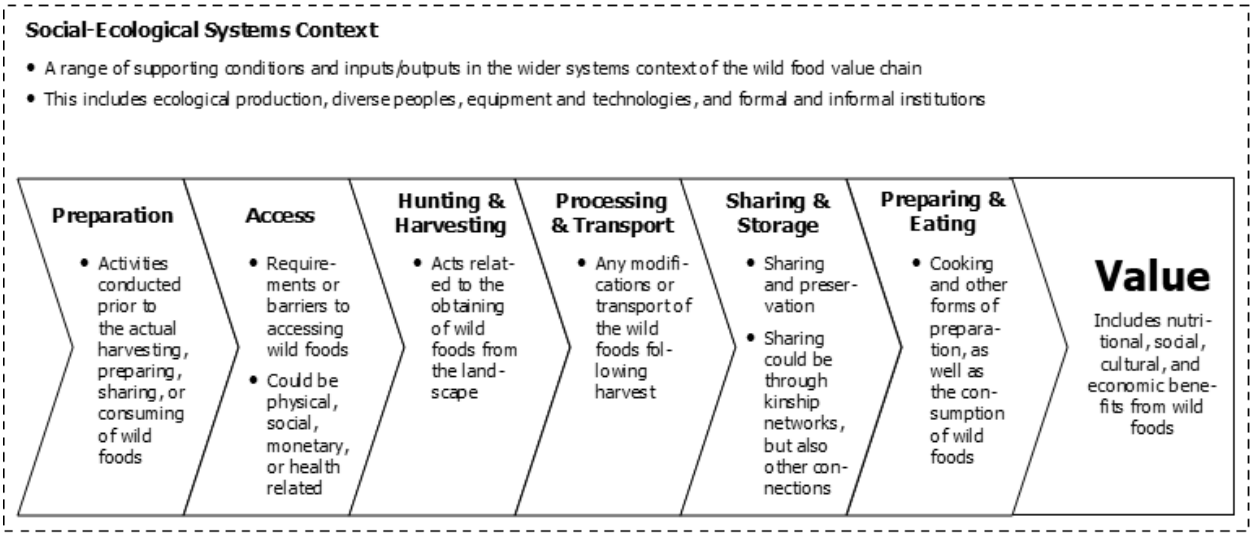

Figure 5-1 illustrates the steps through which nutritional, social, cultural, and economic benefits are created through relationships and practices related to wild foods in Eeyou Istchee. It should be noted that the 6 steps, while illustrated here as discrete boxes, have considerable overlap. Further, not every step is necessarily involved in each case of wild food use. There are also often reciprocal relationships between the value generated and many steps of the value chain.

5.4.1 Social-ecological context

Lake sturgeon governance in Nemaska exists within a broader social-ecological systems context that influences, and is influenced by, every step of the sturgeon value chain.

Lake sturgeon in the Rupert River rely on certain habitat conditions, including deep waters with muddy substrates for feeding habitat, and eddies below fast-moving waters with rocky substrate for spawning—often found at the base of rapids and falls. Many sturgeon make the journey to spawning grounds at the end of each spring thaw, although not every individual spawns each year. Around Nemaska, sturgeon will typically spawn in the first week of June. Sturgeon are capable of travelling great distances between habitat types, sometimes even crossing into other watersheds.

In Nemaska, sturgeon feature prominently in the stories and artwork. A painting of a woman smoking sturgeon by the lakeside hangs in the principal's office of the school. Stained

glass art of two sturgeon swimming along the riverbed can be found in the waiting room of the health clinic. Every fisher has a story about "the Big One"; one giant sturgeon, almost unbelievably large, that they caught a glimpse of from the boat, or that just managed to escape the net as it was pulled in.

Sturgeon is one of several wild food species reserved exclusively for the Indigenous Peoples in northern Quebec. This was mandated in the 1975 James Bay and Northern Quebec Agreement (JBNQA), considered one of the first modern lands claim agreements in Canada. This agreement came about through negotiations and protests over planned hydroelectric development by Hydro-Québec, specifically the La-Grande Project in the north of the territory. The JBNQA guarantees that Cree harvesting rights are protected to a certain extent even if stocks are shown to decrease, with allowances for conservation principles and significant population declines. Despite this, there have been several efforts to commercially fish lake sturgeon in Eeyou Istchee, beginning since at least the 1920s, and continuing until 1994, when it was determined that lake sturgeon stocks were likely declining and thus unable to support the fishery (La Haye & Beaudet, 2004).

The Rupert River was diverted in 2009 following the negotiation of a new agreement: the Paix des Braves, in 2002[5]. The Rupert was only a partial diversion, with approximately 70% of the river's flow at the Rupert dam diverted towards older hydroelectric infrastructure in watersheds further north. Unique within Eeyou Istchee, there is a regulated flow regime on the Rupert River which controls flows and water levels, designed in part to minimize impacts on lake sturgeon. There are also several weirs located throughout the lower reaches of the river, built to maintain water levels. Some of the spawning grounds which had been damaged by the diversion have undergone restoration work to promote spawning activity. Hatchery raised sturgeon have also been released above the dam in the Paix-des-Braves Reservoir to help re-establish the population, although it is unclear how effective this was (Badry & Dunn, 2022). As

[5] While an agreement was reached, support for the project was not universal. Approximately 70% of Crees voted for the agreement in a referendum. Support for the project since will likely have changed as the outcomes of the project have become more clear.

a result of scientific monitoring following the diversion and subsequent mitigation activities, sturgeon in the Rupert River are among the most studied in the territory. Monitoring has shown that spawning and recruitment levels have largely stayed consistent following the diversions. However, there are still concerns that the habitat has become fragmented, and that this is impacting lake sturgeon (Badry & Dunn, 2022). Since the diversion, Hydro-Québec, through the Niskamoon Corporation[6], has funded a number of programs, including some which pay people to fish sturgeon and teach others about fishing.

Following these resource developments, much of Eeyou Istchee has now become accessible by road, changing the way Crees travel across the landscape, as well as opening up the territory to further development and increasing cultural exchange. Responsibilities for sturgeon governance in this evolving context are spread across a number of jurisdictions and spatial scales. There are traditional institutions like the tallymen, as well as the local and regional Cree Trappers' Associations that work to preserve them. Tallymen are stewards of traditional family hunting territories, or traplines, which cover the entirety of Eeyou Istchee. Tallymen are responsible for their traplines, managing access and harvesting on their land. There is the Cree Nation Government, as well the Cree Nation of Nemaska with their own elected chief and council. There is also the Hunting, Fishing and Trapping Coordinating Committee—comprising representatives of the Cree and other northern Quebec Indigenous Peoples, as well as the governments of Quebec and Canada—which is given responsibilities for managing hunting and fishing on the territory by the JBNQA.

5.4.2 Preparation

> "Well, to me, for me personally, the best way to transfer knowledge is by practice. Hands on learning experience, especially Cree culture, Cree traditions. Because, um, it's easy to read a piece of paper. It's easy to watch a video. And it's easy to forget what you watched with your eyes. But if you do it by hand, then you are really experiencing it in

[6] Niskamoon is a majority Cree organization created to manage Impact-Benefit Agreements signed with Hydro-Québec.

real life. You feel. There is a spirit that comes with the culture, and our language. That's how it works. It all connects."

'Preparation' was identified as the first step of the wild food value chain, and includes all the initial work needed to perform traditional activities related to lake sturgeon.

A key component of 'Preparation' is knowledge and knowledge sharing. Older, experienced fishers know when and where to set their nets. They know how to clean the fish afterwards, and how to smoke it or cook it. They have an understanding of how many fish they can take before an area can no longer support their activities. They know the sizes of fish that should be taken, as sturgeon that are 'too small' are difficult to clean, and taking them before they are spawning-age can have a huge impact on populations. Lessons like these have ethical dimensions too. Teachings on how many sturgeon can be taken in a season relate to the maintaining of collective access to an important resource/interspecies relationship. These sturgeon lessons are often passed down through family members, or sometimes elders. Many of the lessons are conveyed with stories.

Sturgeon-related knowledge also applies to equipment and logistics. Those who are going fishing for sturgeon need to prepare their boats, obtain fuel, and charge batteries. They need to clean their nets and make sure that they are properly stowed so that they can be deployed efficiently. They might need to harvest wood for smoking the sturgeon. Fishers also need to make plans, and often take time off work, to get out on the land.

5.4.3 Access

"Everybody wants wild food, but not everybody hunts."

Sturgeon was never present and accessible in all communities in Eeyou Istchee, and sturgeon densities tended to be higher in watersheds in the south of the territory, including in the Rupert River:

"A whole lot of people in Mistissini say they don't get sturgeon so… We're very lucky. We're the luckiest people because we get sturgeon."

However, resource development, particularly hydroelectric, has impacted 'Access' even further. Some affected watersheds are no longer able to support the same levels of sturgeon harvesting that they once did. Members of other communities where sturgeon are not as readily available are known to come to Nemaska to obtain sturgeon. Even in Nemaska, where sturgeon is relatively abundant, not every community-member has a boat to fish in, or even a net to fish with. Not everyone can afford to take time off of work, or purchase the fuel and other supplies needed to go out on the land.

Money and the wage economy play a huge role in controlling 'Access' to the land and to sturgeon. Since the beginning of large-scale natural resource development in the 1970s, increasing numbers of Crees have become enrolled in the wage economy. This has led to less time being spent on the land or learning traditional practices:

> "They have jobs [participant laughs]. And the only time they can go is on weekends, or if they have a holiday, or a cultural break."

However, that income has become indispensable for affording things like boats, fuel, and nets—necessary items now for carrying out traditional practices. Further complicating the relationship between money and wild foods, the JBNQA included provisions for a hunter income security program. This program provides an income to those who spend a certain amount of time each year conducting harvesting or harvesting-related activities. The Paix des Braves Agreement also included a fund for cultural and land-based training education programs. Although funding has recently ended, many in the community used these funds for education programs, including ones that taught youth about sturgeon.

As in 'Preparation', a lack of knowledge and experience is a major obstacle to 'Access'. Younger fishers often reflected on a gap between their knowledge and that of older, more experienced fishers. When family members or elders did not possess knowledge of sturgeon and sturgeon-related practices, or were unable to pass that knowledge down, it created obstacles to knowledge transmission in the community, and younger generations were unable to take part in traditional practices in the same way. Past events like the relocation of the community were often cited. In 1970 the Hudson Bay Company Store at Old Nemaska was

abandoned. The reasons for this are debated, but it is often attributed to concerns that a planned hydroelectric project (the ultimately unrealized Nottaway-Broadback-Rupert Project) would flood the community. The closing of the store forced the people of Nemaska to leave as well, and settle in either Waskaganish or Mistissini, two neighbouring Cree communities. The relocation severed connections to the land and made practicing sturgeon-related activities more difficult. As one participant described it:

> "Ever since we've left Old Nemaska, he says, the generation now, they were never exposed to the way the sturgeon used to be."

Residential school programs similarly affected knowledge transmission in Nemaska. Many participants spoke of being taken away from their homes, and only much later returning and being taught about being on the land. Others did not return at all, or did not have the opportunity to be taught after returning:

> "One of the reasons might be because the children were sent away to school. And he says he thinks that it's one of the causes. And that they grow up not seeing that. Because they were away from their parents, away at school. They never saw that being done."

These factors prevented older generations from passing down knowledge. Drugs and alcohol, as well as social media, were also brought up in interviews as outside influences which created obstacles to youth being on the land.

Other obstacles to 'Access' are more physical. Health problems can prevent people from traveling to camps and traplines. Their health problems may then be compounded, as a diet primarily made up of store-bought items available in Nemaska is much less healthy than a diet of traditional foods, and access to medicines from the land would be limited. Some traplines are more difficult to reach, being further away from the community, or not as accessible by road. Some traplines are only accessible via float plane, or canoe and portage in summer and snowmobile in winter.

5.4.4 Hunting & Harvesting

In Nemaska, much of the sturgeon harvesting now occurs during the Gathering, a one- or two-week celebration at Old Nemaska, the previous community site. The Gathering is located several hours from Nemaska by road and by boat, and is typically held in July when sturgeon can be found feeding in the muddy bays and drop-offs of the lake. Many people will take this time as a cultural break from work, spending at least a couple of days staying in cabins at Old Nemaska. Many set nets for sturgeon. However, outside of the Gathering, harvesting still occurs throughout the year on various traplines.

Netting is the primary method of sturgeon harvesting in Nemaska today. Nets are often set from a boat, usually during summer, although some sturgeon harvesting is done throughout the year. Fishers will frequently set their nets in the same spots from year to year, focussing on the areas where they know sturgeon like to be. The nets are anchored with weights, with floats marking their location. Net size is an important consideration for fishers. Net mesh sizes range from 3 inches to 9 inches and above, and help determine the sizes of fish that are caught. A small net will capture a wide range of fish species and sturgeon of varying sizes. A net with larger mesh will allow smaller fish to swim through, and will only catch larger sturgeon. Apart from concerns that a large sturgeon will destroy a small (and costly) net while trying to escape, sturgeon below a certain size are considered less desirable. Being more difficult to clean and prepare, these sturgeon represent a much smaller return on a fishers' investment of time and resources. Crees also prefer to let smaller and younger sturgeon grow and reproduce before harvesting them. This is similar to Berkes' observation that Crees in Chisasibi managed their coastal fishery using different mesh sizes (Berkes, 1977). While fishers who routinely bring in small sturgeon are rarely explicitly called out, they tend to be collectively judged by other community members.

Nets, once set, are left out for several days. They might stay out for five or six days if there is low current, or three to four days if currents are faster and debris needs to be cleaned out of the net. Nets are checked for fish at least once every day, usually early in the morning. However, it is considered best practice to check at least twice, once in the morning and again in the evening. Sturgeon, if left too long, could die, tear the net trying to escape, or get so entangled they would need to be cut out. When fish are brought back to shore, there is a

community monitoring program, funded by the Niskamoon Corporation, that is responsible for counting and weighing the sturgeon. Some in the community are skeptical of any attempt to count wild food harvests however, and there are concerns that any observed declines could lead to harvest restrictions. The program is applied unevenly, and although the data could potentially offer some insight into long-term population and harvesting trends, the results are not consistently used in decision-making.

Prior to the signing of the JBNQA, the primary method of sturgeon harvesting in the territory was spearing, but spearing is no longer regularly practiced in Nemaska. Spearing in Nemaska would traditionally be done during spawning, with fishers identifying spawning times by seasonal changes:

> "Once that pops out to a leaf and comes to the size of a beaver's ear. That's one sign. And then you'll hear the difference in sound of the rapids. Cause they're swimming or approaching the area. You listen carefully. You'll know the sound of the rapids has changed. Then you'll hear some frogs [participant laughs]. Then all the ice will dissipate or go. Then they'll spawn."

Care was taken not to disturb the sturgeon during spearing. Camps would be set well back from the spawning site while waiting for the fish to arrive, as noise or even smoke could disrupt the sturgeon. It would be the responsibility of one person, typically an experienced fisher, to check to see if the fish had arrived. Once they had, sturgeon would be speared from the back, starting downstream of the spawning group. Sturgeon are highly sensitive, and if they sense any blood in the water, they might abandon the spawning site. Many participants had stories of young and overeager fishers disturbing spawning sturgeon in their haste and ruining the harvest. To avoid this, some fishers would, out of an abundance of caution, clean their spears after each use, or bloodlessly hook sturgeon through the gill instead. Once captured, sturgeon would be hauled onto shore. The spearing would end when it was determined that enough sturgeon had been harvested, often ending after a single day. This would typically be most or all of the sturgeon harvested during the year, although throughout the summer sturgeon might be encountered in shallow waters and speared from boats. There were three main spawning sites

where spearing was practiced at Nemaska: the Genawmee Rapids, where the Rupert River flows into Nemaska Lake; Kilometer Point 281 or Kaiapshemshii, upstream of the lake in the upper reaches of the Rupert River, now located below the Rupert Dam; and Mesgouez Lake, now located above the dam. Use of these sites would be rotated on a yearly basis.

5.4.5 Processing & Transport

After the sturgeon have been harvested, they are cleaned. This is typically done differently according to the size of the sturgeon and the fish's eventual use. One reason smaller sturgeon are more difficult to clean is their spines. Sturgeon have five rows of scutes running the length of their bodies. On older, larger sturgeon these become worn down and spread out as the fish grows. On smaller sturgeon, the scutes are still sharp and large relative to the size of the fish. Cuts can be common, especially among less experienced cleaners. Many participants warned that a cut could leave people with symptoms of fatigue and fever.

Larger sturgeon are often saved for smoking, which is the favourite preparation method for most people in Nemaska. Smoking serves to both preserve and cook the sturgeon, and is traditionally done in smoke huts. However, the process is both complicated and time intensive. One participant explained:

> "Yeah, she was showing me how to dry it and smoke it, and the right wood, and the moss that's needed. All of that. But I don't think I would be able to do it myself. I still need to learn more."

Firstly, a smoke hut is needed. These are typically small outdoor buildings made from wood, tarps, sheet metal, and chicken wire. Then materials are needed for the actual smoking process. Different plants have different properties required for smoking:

> "Black spruce and poplar is the best wood for smoking. It burns slowly, and the smoke isn't acrid."

At Old Nemaska, the wood is often obtained from forest stands that have been previously burned by forest fires. The dead trees are easy to fell and burn easily, and the species can be

identified by the crown of the tree. Mosses are also sometimes used in the smoking process, with red sphagnum moss being preferred.

Cleaning and smoking is done predominantly by women, while men are responsible for bringing the fish and wood:

> "Cleaning is done by family members, by elderly women. Experienced. We provide them with wood, and anything else they need."

The cleaning and smoking requires knowledge and experience, and these lessons were not always passed down to men in Nemaska. However, based on our observations, this division of labor is seemingly becoming less common, as younger Crees are eager to participate in every aspect of wild food harvesting. In fishing programs at Old Nemaska, both boys and girls typically participating in all activities together, from fishing to smoking.

5.4.6 Sharing & Storage

Sharing is a key element of the sturgeon harvest in Nemaska. Sturgeon is commonly shared with elders and family members. Many participants expressed that the first thing one should do after harvesting a sturgeon is to share it with elders:

> "Ever since, I dunno, time immemorial, you give the first one to an elder. Usually, in turn, that elder blesses you… in return, prays for you."

Many elders are no longer able to get out on the land themselves, and sharing networks provide them with continued access to traditional foods:

> "I like to share when I can with people. Not specifically sturgeon though, but anything I harvest, with people that, uh, elders mainly, that I know that they're not as active as they used to be."

Sturgeon is highly sought after, both in Nemaska, and more widely throughout Eeyou Istchee. It is frequently requested at feasts and meetings. But it is also shared with Crees who are currently outside of Eeyou Istchee. Crees who travel to the city of Montréal, Québec to seek

medical treatments are sometimes sent sturgeon by fishers in Nemaska, so that they can enjoy traditional foods while they are in hospital.

However, sturgeon is not only shared; it is also sold. Selling wild foods between Crees is a controversial practice in Eeyou Istchee, despite being a protected right in the JBNQA. It is generally considered contradictory to the shared values of respect and reciprocity that govern relationships in Cree cosmologies, and could potentially lead to unsustainable harvesting. Nonetheless, as the costs of being on the land rise, the practice of selling wild foods like sturgeon increases too. People who sell sturgeon argue that being able to exchange sturgeon for money allows them to continue harvesting sturgeon, passing down knowledge, and providing sturgeon to Crees who would otherwise be unable to access it. Social media, especially Facebook, accessed via smartphone, has become a platform for both selling and sharing traditional foods, including sturgeon.

When it comes to wild food storage, freezers have become the primary method of preservation. This is in contrast to more traditional methods like drying and smoking. Freezers allow people to stockpile wild foods throughout the year, with less time invested in preparation time. However, there are some concerns in the community that having freezers available could encourage people to harvest more than they need.

5.4.7 Preparing & Eating

There is great variety in how people like to eat their sturgeon. Most people expressed a preference for smoking sturgeon, but another common traditional preparation is boiling. Sturgeon heads, for example, are typically boiled, and the flesh and broth consumed. This dish is well known for relaxing its consumers, and can be used as a sleep aid. Along with the head, the notochord and some organs can be boiled as well. Baking and frying sturgeon is also relatively common:

"I like smoked, boiled, fried. [I have] tasted almost every part of the sturgeon."

Sturgeon is sometimes dried and mixed with berries to make a trail food, although this is rarely practiced today. Another part of the sturgeon that is consumed is the caviar, or roe, although

this is an acquired taste. Some people seek out the caviar, while others avoid it entirely. Caviar is most often consumed as an ingredient baked into bannock. There are also some culinary innovations and experimentation when it comes to sturgeon and other wild foods. Traditional foods in Eeyou Istchee are not usually heavily seasoned, outside of some sprinkling of salt. However, one fisher's preferred way to have sturgeon was breaded and deep-fried.

Finally, participants also raised concerns about the sturgeon they had been eating. Many people claim that since the Rupert Diversion, sturgeon has changed:

> "And even when you cook it, when you boil it, it's not the same. When you put it in the oven, it's not the same. It's not as fatty."

To many community members, sturgeon appear to be less healthy. They are skinnier. Their flesh has changed colour, becoming less vibrant and less fatty. Sturgeon also reportedly taste different than they used to.

5.4.8 Value

Value is created at each step of the wild food value chain, and grows cumulatively. This value contributes to the Cree way of life, or Eeyou Pimaatisiiwin, in a variety of ways. Eating sturgeon provides nutritional and financial benefits that come from avoiding store-bought foods that can be nutritionally poor and expensive. Practicing sturgeon harvesting and preparation helps maintain cultural traditions and pass them down to subsequent generations of Crees. Sharing sturgeon reinforces social and kinship ties, with both humans and nonhumans. And collectively, this value flows back into and reinforces the practices and relationships within the steps of the value chain.

5.5 Results and discussion: the materiality of lake sturgeon governance

We were looking out over a large and scenic expanse of water when a research participant told us:

> "This is why they call it a dead river."

We had been directed to this lookout following a visit to the participant's trapline. To us, the waterbody looked far from dead. But the participant explained that this—the Rupert River—was not the river they, or their ancestors, grew up with. We were over an area immediately above the Rupert Dam, where the diverted water has flooded the riverbanks, and the ice in winter is now unpredictable and unsafe to travel on. Behind us, and downstream of the dam, was Nemaska Lake and the old community site. A description of the Rupert as a "dead river" could be interpreted as metaphor or hyperbole. However, for many Crees in Nemaska, the Rupert River died a literal death when it was diverted. In the Cree cosmology, things like rivers are part of the social world, and have agency. This is true for other nonhumans in the Cree cosmology as well, like caribou (Berkes, 2018) and bear (Scott, 2006). Lake sturgeon too demonstrates agency, as when it chooses to leave a spawning ground after being disturbed.

Lake sturgeon in Nemaska are inherently transboundary. They span knowledge systems and worldviews, from Cree, to scientific, to bureaucratic. Sturgeon span jurisdictional boundaries, oscillating between local, regional, and federal government structures and processes. They span geographic boundaries, travelling between and within different watersheds in Eeyou Istchee. Sturgeon span ecological boundaries, filling different ecological roles at different life stages. They even span boundaries of meaning; to different people, sturgeon could be a fish, food, commodity, or scientific object.

Our relational analysis of the sturgeon value chain in Nemaska highlights the many ways in which the governance of this transboundary species can be influenced by a complex web of human and nonhuman actors (Figure 5-2). Agreements like the JBNQA and the Paix des Braves intersect with dams and hydroelectric companies and governments, which interact with sturgeon habitat conditions and sturgeon themselves. Family members and elders, their stories of sturgeon, as well as jobs, money, and equipment like boats and nets, decide whether an individual is prepared to go out on the land and fish for sturgeon. Trauma from residential schools and the relocation of the communities may limit access further still. Leaves, frogs, ice, sturgeon, and fishermen previously all interacted to determine when sturgeon spawn and when sturgeon get harvested. Then the Rupert Diversion led to a shift in sturgeon harvesting practices. Now nets and boats shape how people interact with sturgeon, and the choice of net

size affects the size of the sturgeon that will be caught. Smoke huts, black spruce, and poplar are needed to smoke sturgeon, and this reinforces and challenges gender roles in Nemaska. Facebook and social media moderate efforts to share and sell sturgeon. While sturgeon fat helps determine reactions to the Rupert Diversion and impacts nutritional outcomes.

Figure 5-2. A map of the lake sturgeon governance actor-network in Nemaska

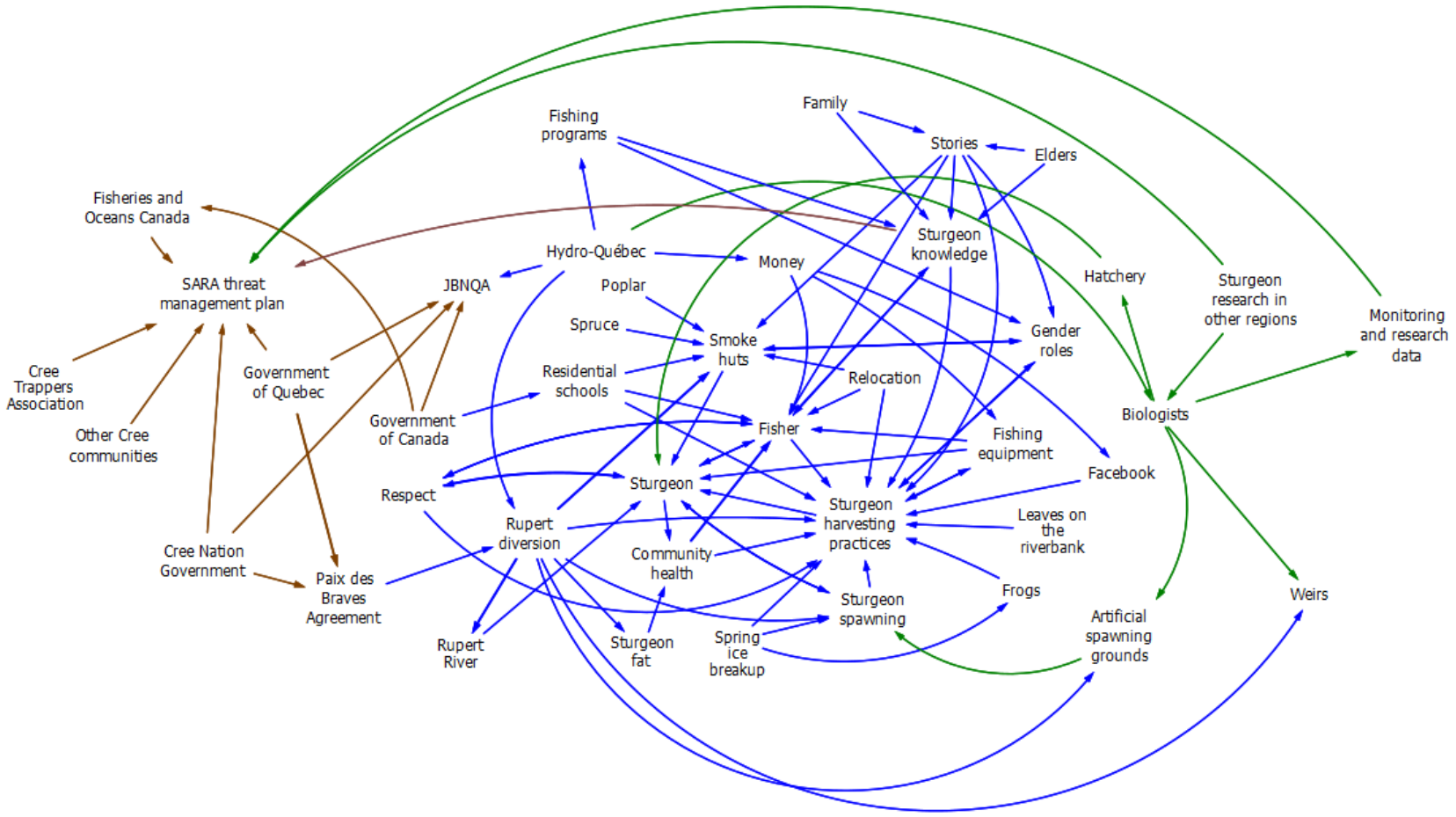

Figure 5-2 illustrates the influential actors and agential relationships identified in the lake sturgeon value chain in Nemaska, Eeyou Istchee, with overlapping spheres informed by Cree land-user knowledges (blue), bureaucratic knowledges (brown), and scientific knowledges (green). Actors, relationships, and spheres were identified through interviews and participant observation.

Sturgeon, fishers, as well as many of the other actors in Nemaska, are more-than-human assemblages whose actions are the product of multiple networked relationships and agencies (Ampumuza & Driessen, 2021). It is arguably impossible to understand sturgeon without understanding their associations with specific practices, habitat features, other species, hydroelectric infrastructure, institutions, and Crees. Likewise, a fisher cannot be understood without considering values of respect and reciprocity, which, along with cost and other considerations, determines the size of net used, or informs a fisher's decision to leave sturgeon viscera on an exposed rock in the lake as an offering.

Many of the individual actors discussed here are themselves actor-networks. The Rupert Diversion in our local, sturgeon governance actor-network is actually made up of three dams spanning three different rivers, diversion bays, a larger hydroelectric complex, weirs, road infrastructure, monitoring programs, restored spawning grounds, and a flow management regime. Sometimes it is more helpful to consider the Rupert Diversion as a single actor. Other times, treating an actor-network as a singular whole can obscure important relationships. In ANT parlance, these networks within networks are called punctualisations or black boxes (Donaldson et al., 2002). In our case, the black box of the Rupert Diversion was hiding important relationships. The flow management regime on the Rupert River involves regularly increasing and decreasing flows through the dam to mimic natural variations. This is to improve conditions for fish, particularly sturgeon. One of these increases happens in the spring, mimicking spring melt, and is timed to coincide with sturgeon spawning. However, this is also shortly before goose break, and the timing means that goose feeding habitats below the dam get flooded just as geese begin to arrive. This drives the geese away from this area, making the traditional goose hunt more difficult. Artificial goose ponds have been built as compensation, but these ponds are difficult to construct, and many are not currently used by geese.

The relationships absent from the network are also of note. The Cree Trappers' Association was marginalised within the actor-network. While they have a mandate to protect and promote the interests and values of land-users, they rarely emerged in the analysis. This could indicate an opportunity for a stronger assertion of the rights of Cree land-users. The network also omits tallymen, which is discussed in more detail in Section 5.5.1. This too could

represent an opportunity to bring Cree knowledge and values to the governance network. Likewise, there are few direct links between Cree sturgeon knowledge and scientific and bureaucratic actors. While the network describes the system at a point in time, things are rapidly changing, and Cree knowledge is becoming increasingly relevant to all formal governance processes in Eeyou Istchee.

5.5.1 Governance actors and relationships foregrounded in the actor-network

Through this analysis, change emerged as a defining characteristic of lake sturgeon governance networks in Nemaska. Environmental changes, changes to traditional practices, generational changes, and changes to sturgeon themselves are all having an impact. Widely discussed environmental changes include water quality, depth, and temperature, all of which are thought to affect sturgeon and other fish, as well as people:

> "Like, before the Rupert Diversion, he says, you could clearly see. The water was really clear. You could clearly see where the water was shallow, where it was deep, where there were rocks. You clearly see that on a sunny day, he said. And now you can't. You can't see any of that, and the water's dark."

> "50-60 km up the river. That's where the big change is. Sturgeon are less healthy there. The water is warmer. Water temperature is very important. The trapline near the spillway. That's where you can see the deformed fish. Eyes changed. Certain part of the river are more impacted than others."

Concerns in the community continue, despite the reports showing little impact on sturgeon spawning success and juvenile recruitment in the Rupert River downstream of the diversion. This perhaps illustrates a lack of trust between human and organisational actors, particularly between the Crees and Hydro Québec, as well as a more holistic understanding by the Crees of impacts that go beyond any individual species, and which affect Eeyou Pimaatisiiwin in numerous ways.

There have also been widespread changes to sturgeon traditional practices over the past decades. Changes in fishing techniques, from spearing to netting, are the most evident, but

there have also been generational shifts in knowledge sharing and values. Residential schools and the relocation of the community, as well as other negative impacts related to resource development, have created obstacles to people spending time on the land, maintaining relationships with sturgeon, and passing down knowledge to future generations. Fishing programs and other structured teachings, many of them funded by Hydro-Québec through Niskamoon, represent attempts to fill that gap. This has marked a shift in gender roles and expectations, as roles typically filled by either men or women are now being taught to any young person willing to learn. Values related to selling sturgeon are also changing. While many in the community condemn the selling of sturgeon and other wild foods, there is increasing recognition of the complex relationships between money, being on the land, and values:

> "So, the only thing that he knew to do, how to raise money, was to catch sturgeon and sell it."

Indeed, the importance of land was described more than once to us through analogies with banks. Protecting and maintaining wild foods were described as an investment, and this investment could be drawn on when income for purchasing other foods was not available. These changes continue to develop and create new challenges and opportunities for sturgeon governance.

There are many concerns over the health of sturgeon populations in Eeyou Istchee and the continued sustainability of the sturgeon harvest. In addition to changes to the waters, there are threats like disturbance from increased boat traffic and fishing derbies which can drive away the sensitive sturgeon, and isolated overharvesting in habitats that have become fragmented and can no longer support it. Many people have observed that sturgeon are less healthy than they were prior to the diversion:

> "We can go to the doctor when we are sick. Where do the fish go?"

This is in contrast to reports from scientific monitoring in the Rupert River, which have concluded that the effects of the diversion on sturgeon and sturgeon spawning have largely been mitigated (Badry & Dunn, 2022). There are similar tensions over hatchery-raised sturgeon. Many Crees have expressed concerns that the hatchery fish are not as healthy as wild fish,

despite this not having been observed during monitoring. This raises questions of what is a "wild" fish, and reflects similar findings from other jurisdictions—that relationships to and perceptions of things like hatcheries affect individual understandings of what makes a fish (Berseth & Matthews, 2021; Law & Lien, 2013). These tensions extend to habitat restoration as well. Many participants believe that the blast rock that was used to restore spawning grounds after the diversion was unsuitable. Blast rock is sharp and jagged, whereas sturgeon prefer smooth stones for spawning. Many people felt that this has impacted spawning success, and that traditional knowledge holders should have been consulted and listened to more closely during the restoration process.

There are also concerns that changes to traditional harvesting practices have led to less sustainable harvesting methods:

> "When we were taught how to harvest them, we were taught this is the time you harvest, and this the time you leave them alone. So, there was only a window. Do you some people respect that window today? I don't know. Not really."

Tallyman stewardship of the land and wildlife does not typically apply to waters and fish. Whereas tallymen have the power to manage, restrict, and even eliminate the harvesting of terrestrial species on their traplines, fish have traditionally been considered more of a common-pool resource:

> "But it's the water eh? Like, it's nobody's land they say."

However, sturgeon have always been a unique case, bridging somewhat the gap between terrestrial and aquatic management, and some tallymen are known for playing a more active role in sturgeon governance on their traplines. As one participant expressed:

> "Sturgeon are the king of fish."

And as recognition of the numerous and cumulative challenges facing sturgeon increases, there are indications that tallymen are beginning to exert even more authority over lake sturgeon and sturgeon harvesting. Tallymen and organisations like the Cree Trappers' Association will likely

continue to play an important role in decision-making and management in this context of change.

Finally, now that lake sturgeon is a SARA listed species, any development that could potentially impact sturgeon habitat in the territory will be subject to much greater scrutiny by federal and local governmental bodies. The species may also become more actively managed. If ANT reveals enhanced understandings of the intricate more-than-human relationships around sturgeon, it could also, in turn, help develop more effective and culturally appropriate policies and conservation measures going forward.

5.5.2 The potential of ANT for better understanding complex and pluralistic natural resource governance systems

Through our case study, we have demonstrated that ANT can be an effective tool for untangling and making sense of the complexity and plurality within SESs. It allowed us to decenter the human from governance, and understand how governance is enacted through every-day practice, not just land claims agreements and management strategies. Governance does not only involve political and managerial actors, but a great number of others, including land users and material actors like nets, that often get overlooked. ANT helped us develop a more inclusive and bottom-up understanding of the sturgeon value chain. It could help contribute to further natural resource governance research through synergies with social network methods already common in studies of SES governance.

Adopting ANT to analyze the sturgeon value chain allowed the data to 'speak for itself'. In doing so, the actor-network began to somewhat break the bounds of the value chain framework, identifying new relationships and feedbacks. Instead of predetermining which would be the starring actors based on theory or researcher bias, this approach allowed the starring and supporting cast to be revealed as the research unfolded. Through this process, unexpected actors and relationships were identified that were nonetheless deeply related to lake sturgeon governance in Nemaska. ANT can aid in what Leonardelli et al. call obliqueness, or "cultivating attentiveness to those things and events that at first sight appear inconsequential because they do not fit with official plans or predominant (power) structures"

(2022, p. 1). In our study, ANT helped reveal the roles of residential schools, the relocation of the community, and even geese in local sturgeon governance.

By foregrounding these important human and nonhuman actors and their underlying relationships, questions like why someone would hold a funeral for a river may be answered. In our case, the answer was deep relationships of respect and reciprocity. In complex and pluralistic natural resource governance, there can be as many ontologies as there are actors, and this can create questions and contestations that impede collective action (Hein & Thomsen, 2023). For example, the question of flow management on the Rupert River, and trade-offs between lake sturgeon and geese, can be framed as an ontological dilemma for collaborative governance: is it a river for sturgeon, or a river for geese? Identifying, through ANT, the human and nonhuman relationships underlying these questions and contestations, could potentially help governance actors communicate across these gaps.

Our goal in this study was not to explain Cree beliefs and practices through the lens of ANT, but to explore the multiple and contested ecologies "of more-than-human practices, perceptions, and knowledges" (Chao, 2022, p. 3). Tensions between knowledges are common in SESs, including in our research. Participants spoke of conflicts between their own knowledges, developed through practice, and the 'expert' knowledge of biologists. These tensions emerged through contestations over whether sturgeon and waters are healthy, whether hatchery-raised sturgeon are true sturgeon, what the right way to restore spawning habitat is, and even whether a river can be alive or dead. If the onto-epistemological boundaries within SESs are not addressed, any understanding of their complexity may remain incomplete. Even terms like 'wild food' point to a human-nonhuman divide that is not reflective of Cree (and many other) cosmologies. Similarly contested terms are management, which implies human control over nature, and harvesting, which despite being common in Eeyou Istchee, comes from a problematic agricultural metaphor (Nadasdy, 2011). ANT has its own ontological assumptions, as with any other method. However, with its numerous influences from across disciplines and schools of thought, ANT appears to have the flexibility to inform tools for tracing associations across ontological boundaries in pluralistic natural resource governance settings. This is an area that would benefit from further research.

5.5.3 Limitations and Assumptions

We faced several challenges and limitations during this study. We had difficulty recruited women as participants, which can be a challenge for governance research in Indigenous contexts (Hania & Graben, 2020). We eventually found some success by holding group interviews with both women and their partners. The problem may partly have been due to perceptions in the community that knowledge of fishing is more valuable than other knowledges like cleaning and smoking more often held by women. This has likely been reinforced by past research programs in the territory which have overwhelmingly targeted male tallymen and land-users for their knowledge of the land and wildlife. The impacts of residential schools may also have played a role. This emerged through discussions with my research assistant, who is also a woman who had been taken to residential school. They posited that sitting down for an interview with me, a white man, even if done in Cree, through them, would be too uncomfortable of an experience.

This could also be related to other challenges in taking a community-based research approach. It is possible that the time spent in the community was insufficient for building the trustful relationships that lead to good data collection. There are also things that, as an outsider, I just may never have become privy to. This research was also impacted by the COVID-19 pandemic, which made returning to the community challenging.

In terms of challenges related to doing ANT, there was some question of whether interviews would be able to truly decenter the human and reveal important nonhuman actors and relationships. Climate change, for example, rarely arose as an issue in this study. There is debate in the literature whether interviews are appropriate for this kind of work, as they can prioritize human perspectives and be blind to the nonhuman (Thorpe et al., 2022). We found that combining interviews with participant observation was invaluable for illuminating some of those blind spots. For example, explicitly asking in interviews about stories related to sturgeon rarely elicited a response. Those stories only emerged after spending time with people and sturgeon. It is important to consider too that decentering the human is not always desirable. Decentering the human as a matter of course, rather than tracing the associations and letting

the data speak for which actors should be centered, humans included, could prevent the researcher from identifying hierarchies and marginalisations of people within the study context.

5.6 Conclusion

By using ANT, our value chain analysis of lake sturgeon governance in Nemaska was able to reveal important human and nonhuman actors and relationships that may otherwise have remained obscured if more traditional governance methods and frameworks had been applied. This could help make these actors and relationships legible and actionable to the diverse natural resource managers, practitioners, and scholars who work in spaces like wild foods governance, and who's success is often dependent on collective action. Insights from ANT provided the methodological flexibility to span the ontological boundaries common in SES frameworks, and helped us understand the complexity of this system. Future work could build on this exploratory study to identify what ANT can bring to other complementary methods used to study and map complexity in SESs. Some key questions include: can an ANT-inspired methodological tool be used in conjunction with methods like quantitative social network analysis or fuzzy cognitive mapping to better understand governance; can the ontological flexibility of ANT improve the weaving of different knowledge is applied research; and beyond ANT, and related work in empirical posthumanism and new materialisms, how can the growing number of Indigenous thinkers working on similar ideas improve on this kind of approach? Based on the results of this study, we suggest that ANT offers an important addition to the methodological toolbox of natural resource governance researchers and practitioners working on transboundary problems.

5.7 Acknowledgements

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CHAPTER 6. GENERAL DISCUSSION

6.1 Introduction

This dissertation considers the question: *what are the gaps and opportunities in transboundary methods for pluralistic natural resource governance in Eeyou Istchee?* My approach to this research question was informed by scholarship on collaborative natural resource governance, traditional ecological knowledge, and actor-network theory (ANT). These literatures allowed for an in-depth examination of ontological pluralism in the governance of natural resource systems, as well as related methods and approaches. Despite pluralistic governance arrangements being necessary and unavoidable structures for addressing pressing environmental problems like climate change and global biodiversity loss, there are few methods and approaches for understanding how pluralism impacts governance, and how the collective action of governance actors could be improved. Thus, the results presented here represent novel insights.

In what follows, I summarize the major findings of each previous chapter and their contributions to the overarching research question, I outline the scholarly and practical contributions of the research, and I suggest future directions to continue and expand on this work. While the insights in this section were developed through research in Eeyou Istchee, northern Quebec, they have broad relevance for network governance and knowledge weaving more widely.

6.2 Cross-Cutting Observations & Major Findings

This dissertation applied instrumental case studies, using a combination of multiple and mixed methods approaches. Both qualitative and quantitative data were collected and analyzed. Each chapter builds on, and complements previous ones, and answer specific research questions with the goal of addressing one overarching research question. Here, the major findings are summarized, while contributions to theory and practice are presented in subsequent sections.

6.2.1 Chapter 3: Opportunities for improving boundary-spanning network methods

Research question: Can natural resource governance methods be improved to help address knowledge weaving obstacles in collaborative natural resource governance spaces?

Chapter 3's synthesis, by bringing together concepts from collaborative governance and traditional ecological knowledge, identified ontological pluralism as a major obstacle to knowledge weaving in natural resource governance, and thus, to collective action. Frictions between different ontologies can prevent the governance actors who subscribe to them from coming to shared understandings of natural resource systems, leaving actors unable to agree on specific management actions. Based on these findings, Chapter 3 proposed developing new transdisciplinary approaches for understanding and operationalising governance networks. One proposed approach was ANT, which could potentially be combined with common network methods in governance research to help span boundaries in pluralistic natural resource systems.

ANT was chosen because of its synergies with network methods already being applied in natural resource systems, like social network analysis and fuzzy cognitive mapping (FCM). Human and nonhuman nodes are linked together by relationships that can be defined qualitatively or quantitatively. ANT innovates on these methods by considering that nonhuman actors, like human actors, are just as capable of being agential social actors, and are just as capable of enacting change within a network. This would have a number of implications for researchers and practitioners in natural resource systems. Namely, it would decenter the human in governance, and help bridge gaps between different ontologies and knowledge systems. ANT would help accomplish this by making the material driving forces of governance relationships legible. ANT can illustrate, for example, both the importance of a nonhuman like an orca (Norman, 2015) as a social actor, consistent with many Indigenous cosmologies, as well as the importance of something like a moose collar, which collects persuasive GPS and behavioural data. ANT can also help illustrate the importance of these nonhuman actors to diverse local, scientific, and bureaucratic knowledge holders.

The remaining chapters of the dissertation build on Chapter 3 by first demonstrating empirically how ontological pluralism challenges network analysis of natural resource governance (Chapter 4), and then by demonstrating applications of ANT as a network method in a natural resource system (Chapter 5).

6.2.2 Chapter 4: Demonstrating empirically the gaps in network governance methods

> *Research question: To what extent can the participatory mapping method, fuzzy cognitive mapping, help bridge ontological gaps inherent to knowledge weaving processes in moose and forestry governance in Eeyou Istchee, and better support diverse governance actors working together towards shared goals?*

Chapter 4 supports, with empirical evidence, the findings of Chapter 3: that network methods struggle to address ontological pluralism. The research question is addressed through a case study of moose and forestry governance in Eeyou Istchee, northern Quebec.

The findings of Chapter 4 are the product of two integrated approaches: an analysis of moose habitat–use based on GPS collar data, and an analysis of moose habitat preferences based on participatory FCM with Cree land-users, who share relationships with moose in areas of Eeyou Istchee affected by forestry. GPS collar data provided insights into where moose go and where they do not, enhancing understandings of preferred moose habitats in Eeyou Istchee, as well as how moose are being impacted by forestry. As a participatory mapping method, FCM provided insights into Cree understandings of moose habitat. It was conducted with Cree land-users in several Cree communities affected by forestry, who identified the key variables and relationships that led to good moose habitat. The focus of Chapter 4 was how FCM, as a network method, was able to address ontological frictions, as the two integrated approaches were woven together.

Some results from the two different approaches combined well, and even enhanced the trustworthiness of the combined results. For example, both approaches identified the same tree species as preferred food for moose. However, other results did not combine as well, and this can be attributed in some cases to ontological frictions. A variable like moose spirit, identified in one FCM as being an important component of good moose habitat, has no

comparative in an analysis of GPS data. Elements like these, which were not congruent with more dominant scientific and bureaucratic ontologies, prevented any complete integration of the results.

6.2.3 Chapter 5: Actor-network theory and untangling transboundary natural resource systems

> *Research question: Can an ANT-inspired approach to analyzing natural resource governance networks help improve understandings of a complex, transboundary lake sturgeon SES in Eeyou Istchee?*

Chapter 5 builds on Chapters 3 and 4 by demonstrating how ANT can help inform network governance methods in pluralistic governance contexts. Chapter 5 is a case study of lake sturgeon governance in the Cree community of Nemaska, Eeyou Istchee. It employs a transdisciplinary approach to natural resource governance by combining ANT with network governance methods, as was proposed in Chapter 3. Chapter 5 applies ANT to a natural resource system, the lake sturgeon value chain, in Nemaska. Influential human and nonhuman actors and their relationships were identified at every stage through which this important wild food species is transformed into nutritional, economic, social, and cultural value. The value chain analysis was represented through both thick, qualitative description, and a network diagram that illustrates which actors were identified through Cree, scientific, and bureaucratic knowledges.

ANT helped identify the influential actors and relationships of the network that may otherwise have been left out due to ontological contestations, a challenge that was demonstrated in Chapter 3. Some elements of lake sturgeon governance are well understood among all governance actors in Nemaska. The comparatively limited role of tallymen in managing the harvesting of lake sturgeon, although evolving, is still well understood by most Cree, scientific, and bureaucratic knowledge holders. However, the role played by values of respect, shared between Cree land-users and wildlife, or the role played by residential schools, which have prevented the passing down of sturgeon knowledge, are not as well understood by all governance actors. ANT helped reveal these key actors and relationships during the analysis and highlight their importance to governance. Perhaps just as importantly, ANT also helped

illuminate key absences of actors and relationships, providing insights for possible policy and management actions. This could be paid closer attention in future ANT studies of natural resource governance.

6.2.4 Overarching findings

> *Overarching research question: What are the gaps and opportunities in transboundary methods for pluralistic natural resource governance in Eeyou Istchee?*

This dissertation identified ontological contestations as the greatest obstacle to knowledge weaving in governance networks in complex SESs like natural resource systems. Ontological contestations often restrict knowledge weaving to surface level integrations of knowledge. For more marginalised knowledge systems, elements of worldviews, management systems, and cosmologies are left out, as they would conflict with the more dominant knowledge systems. I propose that ANT, when combined with network governance methods, could help address those ontological contestations. ANT serves to reveal material, boundary-spanning relationships, and makes clear different but overlapping understandings of complex systems. Other potential applications of ANT in natural resource governance scholarship and practice will be discussed in subsequent sections.

6.3 Contributions to Theory

This dissertation contributes to academic theories of natural resource governance, ANT, and posthumanism.

6.3.1 Natural resource governance in social-ecological systems

In the introductory chapter of this dissertation, I cited Elinor Ostrom's as a prototypical example of a social-ecological systems (SES) framework, and used it to explain the obstacles to boundary-spanning that these kinds of frameworks pose. However, Ostrom also sought to position their work, including on SESs, as an alternative to panaceas, which they described as a universal model of governance, to be applied in every case, no matter the management problem (Ostrom & Cox, 2010). We suggest that this agenda can be pushed even further

forward, towards a more posthuman understanding of governance networks, in what could be termed a posthuman turn in governance scholarship.

A posthuman governance of natural resources would consider seriously the agency of both human and nonhuman things. It would decenter the human in our disciplines (Radomska & Åsberg, 2022), refocussing models and methods away from individual human and organisational actors, and towards a cause and effect determined by messy, interwoven more-than-human relationships. Perhaps most importantly, a posthuman governance would help clarify and resolve ontological contestations, providing boundary-spanning tools to researchers and practitioners.

The marginalising of ontologies in governance networks has been described as ontological foreclosure (Burow et al., 2018; Duker et al., 2023), which, as demonstrated in Chapter 4, can limit the sorts of cooperation that can take place in pluralistic natural resource systems. A posthuman turn in governance theory would mean taking multiple ontologies seriously (Yates et al., 2017). Caribou leaving Eeyou Istchee when not treated with respect, or moose spirits being a determining factor in what is and is not good moose habitat, would be taken seriously by all governance actors.

6.3.2 Actor-network theory

There have been attempts to theorise a more posthuman governance, like with attempts to give nonhumans such as rivers legal personhood (Salmond, 2018). However, there have been few attempts to operationalise this for network governance. One potential way is through ANT, which is demonstrated in Chapter 5's case study.

The essence of ANT is in the careful tracing of associations and the trusting of participants. As Latour puts it: "the task of defining and ordering the social should be left to the actors themselves, not taken up by the analyst" (Latour, 2005, p. 23). This grounds the approach in the local research context, allowing the analyst to identify the unique peculiarities of the particular environment, and avoid generalisations like those embodied in inflexible SES models. There is no universal model that can describe every SES. Similarly, there is no model actor-network. Actor-networks are constantly collapsing and being remade (Law, 1992), and

they are always context specific. However, accumulated ANT-inspired approaches to governance can begin forming a toolkit for accounting for these more-than-human entanglements, and potentially help societies better address complex, boundary-spanning governance challenges.

According to ANT, worlds are multiple and created through practice (Law, 2009). These actor-networks can be traced similarly to other social network methods, often through case studies, with methods of data collection like interviewing, participant observation, and document analysis (Deason et al., 2022). ANT provides the tools for researchers and practitioners to help understand the human-nonhuman networks that shape environmental and natural resource governance, building on the extensive work that has already been conducted on social networks in the field (Salpeteur et al., 2017).

A key component to ANT is its "flat ontology" (N. Watts & Scales, 2015). ANT rejects hierarchical worldviews, allowing researchers to navigate freely across spatial scales in their analyses, such as tracing associations from community to regional scales. This has clear relevance to governance scholars, for whom multi-level governance has been an ongoing challenge (Emerson et al., 2012). Scales of governance often forcing researchers to artificially bound their analyses, and obscuring important cross-boundary factors like the effects of global economic drivers on local level agricultural systems (N. Watts & Scales, 2015) or responses to epidemics like foot-and-mouth disease (Donaldson et al., 2002).

6.3.3 Posthumanism

As with ANT, research that draws on posthumanist concepts and theories has become increasingly influential in the social sciences and humanities, but these concepts and theories are rarely applied in the fields of environmental and natural resource governance. This dissertation deals primarily with ANT, but, as ANT can be considered an analytical and empirical form of posthumanism (Coffey, 2021), I will address here contributions to posthumanism and other related bodies of work. Posthumanism has been described as a broad umbrella (Coffey, 2021). It could be considered to include, and overlap with, a variety of schools of thought,

including new materialisms, queer and feminist theory, material semiotics, multi-species ethnography, and the works of many Indigenous scholars.

Chapter 4 of this dissertations, as an applied case study, represents a theoretical contribution to ANT, but also to posthumanism. In this dissertation, I am not rigidly faithful to one style of ANT, but rather follow what some scholars have called an ANT-adjacent approach (Williams, 2020), drawing on a range of ideas from under the posthuman umbrella. This is partly to help tailor my approach to transdisciplinary applications with network methods in natural resource governance, and partly in response to criticism of ANT and certain elements of posthumanism, including by Indigenous scholars. They have argued that the presentation of Indigenous thought through a euro-western lens could lead to distortion and misrepresentation of that thought, particularly in cases of Indigenous "ontology", established through Indigenous stories and laws, and explored by the researcher through a western academic lens (V. Watts, 2013).

This dissertation contributes to posthumanist theory by envisioning an ANT-adjacent method for network governance, open to diverse posthuman understandings. A rigid focus on any particular ANT, often peculiar to individual researchers, can be limiting. I discuss mainly ontological conflicts in this dissertation, however, a narrow focus on ontology, as pointed out by Indigenous critics, can be similarly problematic. Posthuman scholar Karen Barad has helpfully advanced the notion of ethico-onto-epistem-ology (2007). Embedded within this notion is the idea that ethics, ontology, and epistemology are all deeply interwoven. However, there are numerous scholars working on "posthumanist" subject matter, including Indigenous ones, who can potentially be drawn upon. While we refer to ontology in this dissertation for simplicity, actor-networks must be co-produced through participatory methods and open to diverse understandings and ways of knowing.

6.4 Insights for Policy and Practice

6.4.1 Insights for collaborative governance practitioners

This dissertation identifies gaps in research methodologies and advances new approaches. The primary audience for this dissertation is academics who work with diverse actors in natural

resource governance settings. However, there are also potential insights for governance practitioners.

As demonstrated in Chapters 4 and 5, perhaps those with the most to gain from these insights are non-Indigenous practitioners who work with Indigenous Peoples in collaborative governance arrangements. In these contexts, in which collaborative activities like knowledge integration requires overcoming ontological frictions, a boundary-spanning tool like ANT could be highly relevant. ANT could help scientific and bureaucratic knowledge–holders, steeped in dominant, modernist ontologies, better understand the beliefs and practices of Indigenous knowledge holders and how they impact governance outcomes.

For Indigenous practitioners in these collaborative spaces, ANT can represent a flexible tool for communicating constitutive governance relationships, rather than a western and academic method for deciphering and dissecting Indigenous ontologies. The focus must remain local and participatory. The use of ANT, or any assemblage of posthumanist tools, should not be seen as a normative endorsement of any particular governance arrangement or social order. The delivery of Keeping the Land, a land-use plan for Whitefeather Forest developed jointly by the Pikangikum First Nations and the Ontario Ministry of Natural Resources (PFN and OMNR, 2006), as well as the Little River Band of Ottawa Indians' Nmé (Lake Sturgeon) stewardship program (Whyte et al., 2016), are both examples of ongoing pluralistic governance initiatives where these sorts of flexible tools may be beneficial.

6.4.2 Knowledge weaving

ANT is a body of approaches for understanding and analysing the world as relational webs of human and nonhuman actors. ANT could be considered akin to material semiotics or an empirical poststructuralism (Law, 2009). Nonetheless, there is no singular ANT. As ANT has become more transdisciplinary, it has increasingly become multiple, and unique to the individual researchers who apply it (Kanger, 2017; Law, 2009). However, the concept of symmetry, or a flat ontology (Höppner, 2021), is often central to these different applications. A flat ontology means that all elements of a network have the potential to be agential actors. No *a priori* judgements are made of actors by the researcher, prior to analysis. An orca has the

potential to be an honored ancestor or safety hazard, but this will be decided through careful analysis, and not decided ahead of time. A flat ontology may allow ANT to be used to investigate gaps and contestations between knowledge systems, as well as ways to communicate across them. Thinking with ANT may help communicate understandings of how hunting and predation play an important role in determining which areas are good for moose and which are not, or how spiritual beliefs related to moose encourage certain traditional practices and "hunting the right way", and thus are related to moose habitat. These variables should not necessarily be discarded because they fall outside of some individual understandings of moose habitat.

In this capacity, as a tool for knowledge weaving, ANT has much to offer natural resource governance practitioners. While it is important to recognise the risks, raised by Indigenous scholars, of coopting Indigenous stories and worldviews with western methods, that was not the intent of applying ANT in pluralistic contexts. In response to these concerns, this dissertation was aimed at an audience of collaborative governance scholars and practitioners who operate in diverse pluralistic contexts. Our argument is not that Indigenous peoples need new frameworks to understand their own worldviews. Our aim is rather to propose that ANT could have inspiration for a boundary object in natural resource governance spaces, helping to communicate ideas of nonhuman agency, largely to non-Indigenous peoples. This would have relevance outside of Indigenous contexts as well, as there are numerous ontological boundaries in natural resource governance, even just between scientific disciplines.

The place of ANT would most likely be within broader knowledge weaving frameworks like Two-Eyed Seeing (Popp et al., 2020) or ethical spaces (Greenwood et al., 2017). These frameworks advance certain best practices for actors working collectively, in this case between Indigenous and non-Indigenous Peoples. Two-Eyed Seeing has become well known both within academic scholarship and management discourse. During development of the *Species at Risk Act* management plan for lake sturgeon in Eeyou Istchee, Two-Eyed Seeing was brought up several times as an inclusion that could help shape future collaboration and research, although it ultimately was not added to the plan.

However, as identified in Chapter 3, broad frameworks like Two-Eyed Seeing still lack specific tools and approaches for dealing with ontological contestations. Finding ways of working together better are crucial. The agency of often marginalized governance actors is reliant on them being able to assert their practices and beliefs, termed by Gladfelter as ontological reclamation (2022). And as also stated in Chapter 3, this is a requirement for reasons of effective and informed decision-making, as well as ethics. Approaches that draw on ANT and other posthumanist inspirations can fill this gap, and contribute to a methodological toolbox of transboundary methods for pluralistic network governance.

6.5 Future Directions

6.5.1 Future directions for natural resource governance and network methods

ANT potentially has much to offer natural resource governance, beyond what is demonstrated in this dissertation. As shown in Chapter 5, there are gaps in network governance methods that ANT can help address. ANT can reframe understandings of governance, and reveal the roles of actors obscured by other methods. However, applications of ANT in network governance can be further explored, both qualitatively and quantitatively, and particularly for their synergies with common network methods in governance research.

FCM as a network method has become increasingly popular in studies of SESs, especially as a participatory method for engaging with local land-users (Johnson et al., 2022). Introducing ANT to FCM analyses may help avoid ontological obstacles in analysis and representation, and help actors communicate across ontological divides, and this an area that requires further exploration in future empirical research. The need was clearly identified by research participants in Chapter 4 as a priority. While FCM is effective at identifying a wide variety of actors and relationships from across knowledge systems, many of these actors may become de-emphasized, de-contextualised, or eliminated completely as maps are aggregated, variables are categorised, and results reported to decision-makers. While this is a necessary part of data reduction and analysis, ANT may offer tools to more effectively communicate these differences between different groups of governance actors, and ensure that their inclusion carries through from analyses to data representation.

Similarly, there are numerous possible applications for an approach which combines social network analysis and ANT. Social network analysis tools could be used to help identify the particularly influential actors in a network, and provide opportunities for innovative representations of ANT data through network diagrams (Palmer, 2014). In general, visual representations of ANT data is underexplored in ANT scholarship. New methods of representation could be effective for communicating ANT data to diverse audiences, and especially non-academic ones. These representations could range from new varieties of network diagrams, to vignettes and stories (Jenkins et al., 2021).

6.5.2 ANT and empirical posthumanism

Chapter 5 revealed that ANT, by foregrounding some actors and relationships and leaving out others, was able to provide some insight into governance power dynamics, as well as potential opportunities for management action. Future work could interrogate further ANT's ability and limitations for analysing power dynamics across scales and boundaries, such as local, provincial, national, regional, and global. An analysis of power may usefully draw on work by scholars like Steven Lukes (2023) to develop new avenues of inquiry.

There are also specific ANT and posthuman concepts that I did not extensively apply in this dissertation, but that may have useful applications in natural resource governance research.

One such concept is the "black box" (Shindell, 2020). Black boxes are actor-networks which have become opaque and treated as inert intermediaries (Donaldson et al., 2002). An example of a black box is the "hockey stick" study of mean global temperatures (Mann et al., 1998), which was used by the Intergovernmental Panel on Climate Change to support their arguments that global temperatures were increasing. The "hockey stick" refers to a graph of mean temperature in the northern hemisphere, which after remaining relatively steady for hundreds of years, sharply increases after 1900, creating a shape which resembles a hockey stick. This study faced criticism by opponents to the scientific consensus on climate change, and was eventually subject to a United States congressional investigation, based on doubts of its scientific validity. Defenders of the study would leverage the entire actor-network of scientists,

research, and data within the black box of this single study, to defend its merits and the merits of the wider consensus on global climate change (Besel, 2011).

Black boxes have known inputs and outputs, but their inner workings are inscrutable. In some cases, like the hockey stick study, this obscures understandings. In others, black box may stagnate and become resistant to change. The features of the black box closely parallel natural resource governance. Governance structures and processes too can become opaque and exclusive. In these systems, existing actors, practices, and processes are locked in place, preventing more desirable actor-networks from being established. Fisheries governance offers a particularly emblematic example, as not only could the models, structures, and processes of governance be described as a black box, but the central actor, the fish, is obscured from view by its aquatic environment. This can make fisheries governance a unique challenge, as with lake sturgeon in Eeyou Istchee, where scientific and Cree data on sturgeon is difficult to obtain and quickly becomes outdated. ANT can help researchers open and analyse these black boxes to understand their constituent elements and associations, and ultimately make recommendations for change.

Detours are another concept which may hold relevance for natural resource governance. Detours are a form of translation. When an actor-network is unable to fulfill its original interests, the actor-network may enroll new actors, and take a different path (Sofronievska et al., 2023). In this dissertation, we did not place a major emphasis on concepts of translation, which were fundamental to early studies of ANT (Callon, 1984). However, events such as the inclusion of lake sturgeon in the federal *Species at Risk Act* management plan process, or the advancement of the Paix-des-Braves Agreement, Adapted Forestry Regime, and special forestry management and consultation measures, could be further examined as examples of detours.

Finally, posthumanism has faced criticism for lacking clarity and analytical rigour (Hornborg, 2017). ANT offers a basis from which to start building a toolbox of analytically focussed posthuman methods for network governance. This dissertation offers one piece of that foundation.

6.5.3 ANT as a boundary object

Duker et al. (2023) observe that a lack of applicable research on and tools for addressing ontological pluralism has been a considerable obstacle to resolving governance challenges effectively and equitably (Duker et al., 2023). As I identify in this dissertation, one way in which these obstacles arise is during knowledge weaving, and I further demonstrate that ANT can be used as a network method to investigate pluralism. However, one application of ANT that was discussed in Chapter 3's literature review, but not employed in this dissertation, was applying ANT as a boundary object.

Chapter 3 proposed that ANT could be applied as a boundary object in participatory research settings, like during a workshop. Boundary objects are conceptual tools which can be used to facilitate collective action among diverse actors (Star, 2010). They work by helping to develop shared understandings and create spaces for collaboration (Enqvist et al., 2018; Star & Griesemer, 1989). One example is ecosystem services, which unites diverse scholars with shared goals, but wildly different disciplinary backgrounds and methodological approaches (Abson et al., 2014).

Applying ANT as a boundary object could help researchers and practitioners resolve obstacles to collective action like ontological pluralism (Adade Williams et al., 2020; Molnár and Babai, 2021), while allowing for flexibility in how actors' beliefs and understandings are included (Amundsen & Hermansen, 2020). ANT could allow, for example, space for multiple understandings of the social roles of caribou to co-exist, while providing insight into addressing any frictions between them. As discussed in Chapter 3, this could significantly improve knowledge weaving processes, without imposing a single dominant worldview.

6.6 References

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CHAPTER 7. CONCLUSION

As a scholar of white, settler descent, it is not my intent to explain Indigenous worldviews through Western frameworks like ANT, but instead I direct my arguments to the diverse governance scholars and practitioners working in these contexts. Accumulated ANT-inspired approaches to governance could begin filling a methodological toolkit from which to draw insights, inspiration, and potential analyses for a more inclusive governance, while working within existing Indigenous frameworks like Two-Eyed Seeing. And accounting for these more-than-human entanglements could potentially help societies better address complex, transboundary governance challenges, like working collaboratively across knowledge systems. In recent decades, governance perspectives have evolved from state-led and hierarchical models to ones which are more decentralised and collaborative, bringing in local communities and land users, private industry, NGOs, and international actors. A posthuman turn in natural resource governance would decentralise this perspective further still to include the nonhuman. This would be not just an arguably more accurate reflection of the more-than-human relationships governing SESs. It could provide novel insights for overcoming contestations and enhancing collaborations among the diverse actors within these systems, especially if combined with network governance methods like social network analysis.

As has been stated, effective boundary spanning in pluralistic contexts would be beneficial partly because it could improve the effectiveness of management strategies and decision-making by employing multiple knowledge systems and perspectives. Developing ways of improving boundary spanning is also a necessity, as pluralistic governance arrangements, involving local peoples, stakeholders, and rightsholders, has increasingly become the norm. Natural resource systems are highly complex, and in many cases, marginalised ontologies completely replacing dominant ontologies is unlikely (Duker et al., 2023), at least in the near future. It is in the best interest of governance researchers and practitioners to gain comfortability with hybrid assemblages of ontologies.

These insights strongly intersect with those offered by Indigenous philosophies of Two-Eyed Seeing or Robin Wall Kimmerer's Braiding (Kimmerer, 2013), as well as the general

aspirations of knowledge integration in governance. How can different knowledges and ways of knowing be brought together without one being subsumed by the other? Work on the more-than-human contributes to this by facilitating collaboration across the in-between spaces of governance and reducing ontological frictions. Natural resource governance scholarship has worked extensively to incorporate pluralism, developing theories and approaches for addressing and enhancing collaboration across spatial and jurisdictional scales, as well as different knowledge systems and ways of knowing. ANT, alongside other related Indigenous and posthuman works, offer tools for advancing this to the full extent of a hybrid assemblage.

In A Cyborg Manifesto, Donna Haraway's influential work on feminist technoscience, she calls for a paradigm shift in how the relationship between human and nonhuman is conceptualized, stating: "This is a dream not of a common language, but of a powerful infidel heteroglossia" (Haraway, 1991, p. 181). In literary theory a heteroglossia is the synthesis of many voices into a single text. A turn towards the posthuman in natural resource governance discourse could help the discourse move past dichotomies between TEK and Western science, and towards a powerful infidel heteroglossia, a space in which ontological differences can be discussed openly, and concrete, practical steps can be taken by both Indigenous and non-Indigenous actors. An ANT-inspired methodological approach to natural resource governance, by addressing ontological pluralism-, has the potential to help displace the central role of the human in SESs, and advance a governance that is more informed, effective, and equitable.

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