Received: 23 July 2021 | Accepted: 30 November 2022

DOI: 10.1002/2688-8319.12211

Ecological Solutions and Evidence | BRITISH ECOLOGICAL SOCIETY

REGISTERED REPORT STAGE 1

Setting a foundation for Indigenous knowledge systems-guided boreal caribou (tǫdzı) conservation planning in the Western Boreal Region of Canada: A systematic map protocol

Jacquelyn Saturno[1] | Matthew Boeckner[2] | Samuel Haché[3] | James Hodson[4] | Emily McAuley[5] | Eliot McIntire[6,7] | Tatiane Micheletti[7] | Jean Polfus[8] | Sophie Sliwa[9] | Trevor Teed[10] | Alana R. Westwood[1]

[1]School of Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia, Canada

[2]Landscape Science & Technology Division, Environment & Climate Change Canada, Ottawa, Ontario, Canada

[3]Canadian Wildlife Service, Environment and Climate Change Canada, Yellowknife, NorthWest Territories, Canada

[4]Wildlife and Fish Division, Department of Environment and Natural Resources, Yellowknife, NorthWest Territories, Canada

[5]Indigenous Science Liaison Office, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada

[6]Pacific Forestry Centre, Canadian Forest Service, Natural Resources Canada, Victoria, British Columbia, Canada

[7]Faculty of Forestry, University of British Columbia, Vancouver, British Columbia, Canada

[8]Canadian Wildlife Service, Environment and Climate Change Canada, Kelowna, Canada

[9]Natural Resources Canada, Ottawa, Ontario, Canada

[10]Dene Nation, Assembly of First Nations Regional Office, Yellowknife, NorthWest Territories, Canada

Correspondence
Jacquelyn Saturno
Email: j.saturno@dal.ca

Funding information
Dalhousie Belong Research Fellowship Awards; Environment and Climate Change Canada, Grant/Award Number: 3000719349

Handling Editor: Maria Beger

Abstract

1. In recent years, researchers have increasingly recognized the need to bridge Western and Indigenous knowledge systems to strengthen research in wildlife conservation. Historically, this arena has not made space for Indigenous knowledge holders to share components of their knowledge systems with agency and to support their own self-determination as equal partners.
2. Since time immemorial, Indigenous Peoples have been developing, maintaining and refining their own knowledge systems, based on intimate knowledge and relationships with the lands, airs, and waterways. There remains enormous potential for Western scientists to engage in equitable knowledge exchange and co-production with Indigenous Peoples. This applies to species such as boreal caribou *Rangifer tarandus caribou*, known by the Dene name, tǫdzı; which hold ecological value and cultural importance for both Indigenous and non-Indigenous people in the boreal region of Canada.
3. To gain an overarching perspective of this species, we will create a systematic literature map that will examine peer-reviewed and grey literature involving spatial mapping of all species of caribou *Rangifer tarandus* based on Indigenous knowledge. This map will (a) characterize available data and previously engaged knowledge holders and (b) identify positive experiences that exemplify best practices for knowledge co-production.
4. Searches will be conducted in English in selected databases. Search strings will be tested against a collection of benchmark papers of documents previously chosen to determine strings with maximum sensitivity and specificity. Results will be reviewed through the: (1) title and abstract; and (2) full text.
5. All screening decisions will be recorded in a database, with 10% of full-text screening decisions validated. Items retained for inclusion in the systematic map will be coded using a list of coding questions. Ten percent of coding outcomes will be validated by a second reviewer.

6. The systematic map will employ a narrative synthesis approach that will compare retained studies against a list of best practices from the current proposal. It will examine case studies that performed well according to the list and contribute to a repository of previously documented Indigenous knowledge about caribou to support projects involving Indigenous and Western knowledge co-production.

KEYWORDS
boreal caribou, conservation, co-production, indigenous knowledge, indigenous knowledge systems, *Rangifer tarandus caribou*, species-at-risk, tǫdzı, traditional ecological knowledge

1 | INTRODUCTION

The boreal forest in what is now known as North America is experiencing an intensification of natural resource extraction and some of the most extreme impacts of climate change (Carlson et al., 2015; IPCC, 2018; Park et al., 2014). In response, there has been increasing interest in research to maintain and enhance conservation measures for biodiversity, particularly of key indicator species like boreal caribou in the boreal region (Environment and Climate Change Canada, 2018). Indigenous knowledge is encoded in the cultural norms, traditions, and regional dialects of practitioners; therefore, we refer to boreal caribou by one of their Dene names, tǫdzı[1] (Burgar et al., 2018; Stewart et al., 2020; Winder et al., 2020) throughout this manuscript. Western scientific and political approaches have identified 51 ranges of tǫdzı to facilitate federal-level conservation and management through the Species at Risk Act (SARA), 33 of which occur in the western region of the boreal forest in the northern part of North America. The Western Boreal Forest include the present-day Canadian territorial and provincial boundaries of the Yukon, Northwest Territories, British Columbia, Alberta, Saskatchewan, and Manitoba (Figure 1). As of 2017, seven ranges are thought to have a stable tǫdzı population, nine are in decline, and 17 do not have enough data available to assess population trends (Environment and Climate Change Canada, 2019). For the 16 ranges for which population data are available, seven have less than 100 individuals remaining, and the nationally recognized status of boreal subpopulation of tǫdzı is Threatened (Environment and Climate Change Canada, 2019). These ranges are also home to the territories of Indigenous Peoples, including the Dene Nation which cover most of the Northwest Territories. The territory of the Dene Nation consists of five regions: Gwich'in, Sahtú, Dehcho, Tłı̨chǫ, and Akaitcho regions. There are approximately 15,000 Dene people in the northern region of the Western Boreal Forest, also known as Denendeh, with signatories under Treaty 8 (1899), and Treaty 11 (1921), in addition to modern treaties (comprehensive land claim agreements) with the Government of Canada (Westaway & Reiss, 2019; Figure 2; Table 1).

[1]Though there are many Indigenous words used for boreal caribou, we use tǫdzı which is predominantly used by speakers in the Sahtú and Tlicho regions of Denendeh which comprises a large portion of our area of interest (Western Boreal Forest) and is sometimes used by coauthors and advisors on the present project.

Presently, both Indigenous governments and communities and Western governments are interested in coproduced research and co-management practices for tǫdzı (Environment and Climate Change Canada, 2021). There is an ongoing range-planning processes for tǫdzı (e.g. Government of the Northwest Territories, 2019), which involves engagement between the Government of the Northwest Territories and Indigenous governments and rights holders, as well as interest from a research perspective in developing an interactive ecological forecasting workflow for the Western Boreal Forest to predict the impacts of climate change, fire, and natural resource management on ecological systems and species, known as the Western Boreal Initiative (Environment and Climate Change Canada, 2021; Western Boreal Initiative, 2022; Wiebe, 2021). Such large-scale modelling initiatives, which can include ecological and socioeconomic considerations, require tools for addressing environmental challenges and incorporating multiple ways of knowing when considering various courses of action for conservation or management on the landscape (Council of Canadian Academies, 2019).

Western research has often excluded, marginalized, or resulted in harm to Indigenous Peoples (Ball & Janyst, 2008; Brunet et al., 2016; Castleden et al., 2012). It is not uncommon for research projects led by Western scientists to involve Indigenous partners without properly building relationships or supporting self-determination of knowledge-holders and communities (Castleden et al., 2012). This failure to properly include, credit and empower Indigenous partners in research can result in distrust between parties and diminished conservation outcomes (Young et al., 2020).

To reconcile this well-documented history of Western science failures, it has been long proposed by Indigenous Peoples and recently by Western scientists to co-develop research together as a way forward (Adams et al., 2014; Kothari et al., 2013; Westwood et al., 2020). The Council of Canadian Academies, in gathering an expert panel to address ways for managing modern environmental and natural resource challenges, recommended that institutions in Canada adopt principles of integrated natural resource management (Council of Canadian Academies, 2019). This includes bridging Western science and Indigenous and local knowledge systems in a respectful manner.

Indigenous knowledge systems are wholistic and involve communally held and transmitted knowledge, cultural norms, practices,

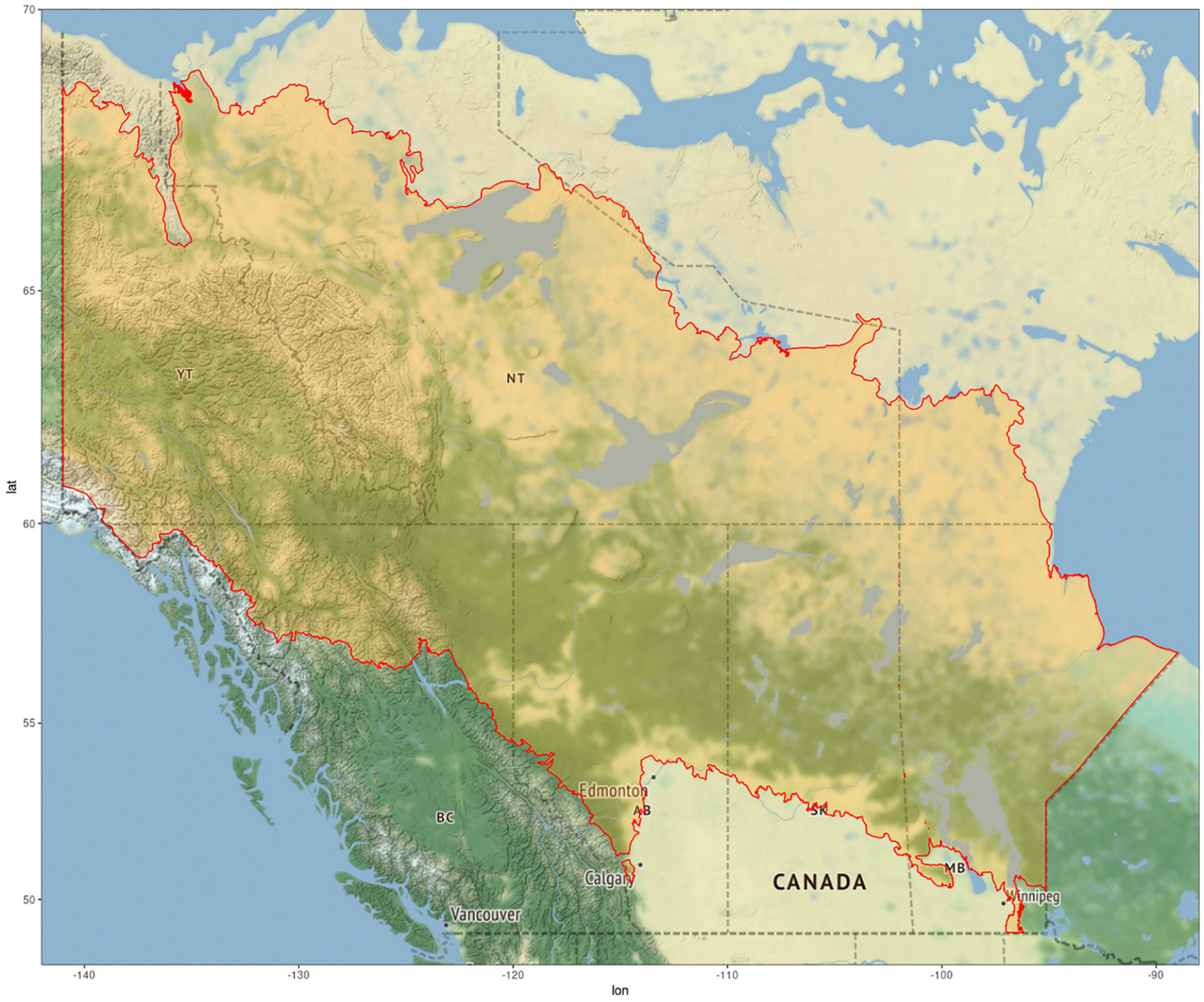

FIGURE 1 Map showing the Western Boreal Forest region (polygon outlined in red) of what is now known as Canada.

and beliefs that span generations. They are also based on long-term relationships with local ecosystems and human and non-human animal and plant relations and can improve quality and actionability of wildlife research (Ban et al., 2018; Kutz & Tomaselli, 2019). Indigenous knowledge is informed by data and information collected using Indigenous methodologies (e.g., discrete data like meat quality, ice thickness, migration pathways) and these data have often been used in academic research exercises for the purpose of informing wildlife management. Indigenous knowledge, like Western scientific knowledge, cannot be extracted and interpreted outside of its knowledge system - Indigenous scientists (i.e., Elders and Knowledge Keepers) and practitioners (hunters, gatherers, fishers, etc.) are required to interpret the data. As such, bridging of knowledge systems requires full participation of Indigenous Peoples as integral components of their knowledge systems. In doing so, we do stress that Western scientists should be specific and deliberate when seeking to collaborate with Indigenous partners about whether they are interested in bridging knowledge systems, or simply collecting specific discrete data gathered by Indigenous Peoples or scientists.

Ideally, for future research to predict ecological outcomes for environments and species in the Western Boreal Forest, it would be fully coproduced between Indigenous and Western partners. While scientists in disciplines like wildlife conservation are often well-intentioned and aim to enhance protection practices for threatened species and populations, many scientists lack training, resources, and awareness of different Indigenous methodologies and the relationships required for effective and respectful co-development with Indigenous communities.

The basic building blocks of such co-production, from the perspective of Western scientists, must begin with understanding the historical and present context of Indigenous Peoples in the Western Boreal Forest, their interests and aims, their relationship to tǫdzı, the legal frameworks that shape the institutional context, and the past work and relationships between Western scientists and Indigenous knowledge holders.

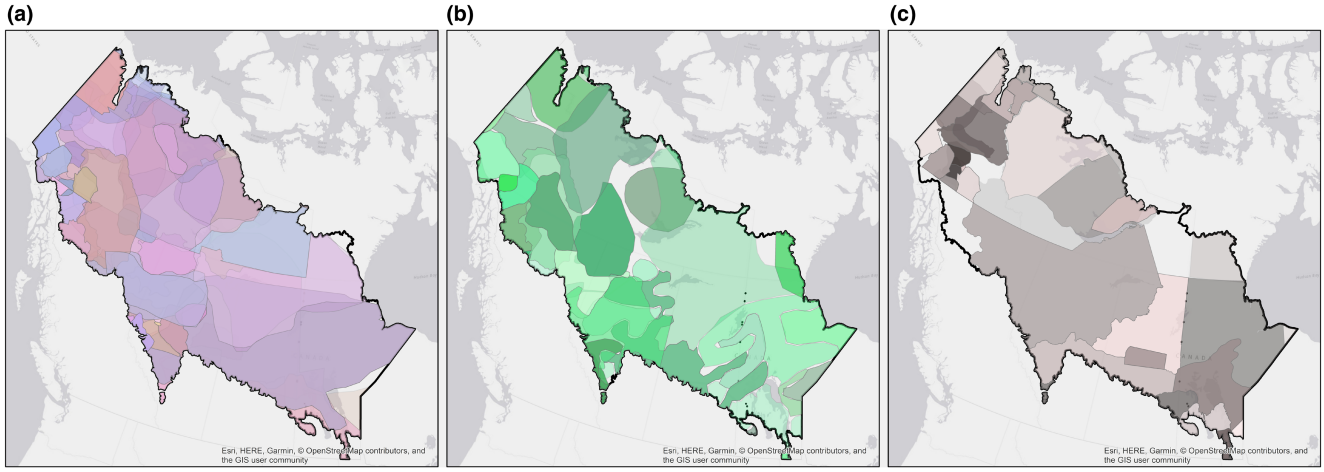

FIGURE 2 Maps of the Western Boreal Forest region (black outline) detailing the overlapping coverage of (a) territories of Indigenous Peoples, (b) Indigenous languages and (c) treaties between the Government of Canada and Indigenous Peoples, both historical and modern. Basemap provided by (Esri Inc., 2015) and data obtained from (Native Land Digital, 2021).

With the bridging of knowledge systems having been previously attempted across disciplines, systematic reviews have been conducted to better understand the methodologies and identify best practices through existing published literature. By observing past case studies of success and failures, future research can build on improving the practice of co-production and continuing to learn from past experiences. Several recent systematic reviews have outlined both challenges and solutions with practical applications for improvement. For instance, Alexander et al. (2021) and Stern and Humphries (2022), both identified various types of methodology approaches taken that have been emphasized to be pivotal in the succession of the co-production arrangement. Alexander et al. (2021) highlighted that the occurrence of community-based participatory research was common, while Stern and Humphries (2022) highlighted the importance of community consent from Indigenous Peoples and regular communication throughout the duration of the project. While these past studies have looked at case studies of bridging Indigenous knowledge and Western science together in their own respective disciplines, it is to our knowledge that there has not been a systematic map done for co-production in caribou conservation.

A systematic map of existing literature around spatial mapping of tǫdzı (i) allows Western scientists to identify potential Indigenous organizations, governments, or communities who may be interested in future co-production of ecological research for tǫdzı, (ii) identifies examples of best practices where spatial mapping or modelling produced with data or knowledge collected by Indigenous Peoples about tǫdzı support the agency of Indigenous communities and rights holders, and (iii) limits engagement fatigue by maximizing discovery of existing work.

1.1 | Objective

The proposed systematic map will examine the published peer-reviewed and grey literature to quantify and qualitatively describe the techniques and approaches used to bridge Indigenous knowledge with Western science systems about caribou *Rangifer tarandus* for the purpose of spatial mapping or modelling. We will be looking at all species of caribou to inform the current Western Boreal Initiative project on tǫdzı in the Western Boreal Forest by the Government of the Northwest Territories and the Indigenous governments (Western Boreal Initiative, 2022). To avoid the possibility of not obtaining enough literature on tǫdzı, and subsequently, limiting our research scope, we will conduct a literature search for literature on all caribou species. We aim to describe the type of theoretical and applied methods and approaches, their distribution within and among institutions, and lastly, report evidence of their effectiveness.

1.2 | Primary questions

The questions guiding the systematic map are: What methods and approaches have been taken in the past to bridge Indigenous and Western science knowledge systems pertaining to caribou *Rangifer tarandus* for the purposes of spatial mapping, modelling, or land-use planning for this species?

The primary question relates to a *population of interest*, which includes the topic of caribou *Rangifer tarandus* and Indigenous knowledge and *item content*, which are items that use spatial mapping, modelling or representation on the landscape related to caribou. Although the current report is intended to inform work focussed on tǫdzı (boreal caribou), we included literature related to caribou generally as their entire range co-occurs with territories of Indigenous Peoples, and to broaden our search to maximize the relevant results returned.

Specifically, we are using methods for a systematic map prescribed by the Collaboration for Environmental Evidence (Collaboration for Environmental Evidence, 2018) and to synthesize:

- Evidence about how past research involving Indigenous knowledge related to caribou were developed, including who was engaged, when, how often, by whom, and using what methods.

TABLE 1 Lists (in alphabetical order) of Indigenous territories, languages, and treaties in the Western Boreal Forest region of what is now known as Canada. Rows do not read left to right, each list is independent of the others. Information compiled from data from Native-Land.ca (Native Land Digital, 2021).

Territories	Languages	Treaties
Acho Dene Koe	Ahtna	Carcross/Tagish
Ahtna Nenn’	Dakota	Champagne & Aishihik
Akaitcho	Dän k'è (S Tutchone)	Gwitch'in Comprehensive Land Claims Agreement
Anishinabewaki ᐊᓂᔑᓈᐯᐗᑭ	Dän k'í (N Tutchone)	Inuvialuit Final Agreement
Aseniwuche Winewak (Rocky Mountain)	Dane-Zaa (ᑕᓀ ᖚ)	James Bay Treaty No.9 (Adhesions in 1929 and 1930)
Beaver	Danezāgé’	Kwanlin Dun
Beaver	Den k'e	Little Salmon/Carmacks
Beaver Lake Cree	Dene K'e	Na-cho Nyak Dun
Big Stone Cree	Dëne Sųłıné Yatıé (Chipewyan)	Nunavut Land Claims Agreement
Carcross/Tagish First Nation (BC)	Dinjii Zhu’ Ginjik (Gwich'in)	Sahtu Dene and Metis Comprehensive Agreement
Carcross/Tagish First Nation (Yukon)	Eastern Swampy Cree	Selkirk
Champagne & Aishihik	Gitsenimx̱	Ta’an KwÃ¤ch’Ã¤n
Cree	Han	Teslin Tlingit Council Final Agreements
Dehcho Dene	Inland Łingít	Tetlit Gwitch'in
Dene Tha'	Inuinnaqtun	Tlicho Agreement
Dënéndeh	Inuktitut	Tr'ondëk Hwëch'in
Denendeh (Dënësųłinë́ Nëné)	Inupiatun	Treaty 1
Gitx̱ san Lax̱ yip	Kaska	Treaty 10
Gwich'in Nành	Kivallirmiutut	Treaty 11
Gwitch'in Settlement Region	Ktunaxa	Treaty 2
Hän	Łingít	Treaty 3
Inuit	Nakota	Treaty 4
Inupiat	Nisg a'a	Treaty 5, 1875
Inuvialuit	Northwestern Anishinaabe (Ojibwa)	Treaty 5, 1908
K'áálǫ Got'ine	Plains Cree	Treaty 6, 1876
K'asho Got'ine	Rocky Cree	Treaty 6, 1889
Kaska Dena Kayeh	Sahtúot'ı̨nę Yatı̨́	Treaty 7
Kelly Lake Metis Settlement Society	Severn Anishinaabe Oji-Cree	Treaty 8
Kluane	Siglitun	Vuntut Gwitchin
Ktunaxa ʔamakʔis	Southern Anishinaabe (Ojibwa)	White River-Kluane
Kwanlin Dün	Swampy Cree	YKDFN: Chief Drygeese Territories (1900 & 1920, Treaty 8)
Lheidli T'enneh	Tāłtān	
Lingít Aaní (Tlingit)	Tłı̨chǫ Yatıì	
Michif Piyii (Métis)	Tse'khene	
Na-cho Nyak Dun	Tsúūt'ínà Gūnáhà	
Niitsítpiis-stahkoii ᓱᖽᐧᖿ ᓴᐦᖳ (Blackfoot/Niitsítapi ᓱᖽᐧᒣᑯ)	Upper Tanana	
NWT Métis Nation	Western Anishinaabe (Ojibwe)	
Očhéthi Šakówiŋ	Woods and Rocky Cree	
Sahtu Dene and Metis	ᓀᐦᐃᔭᐍᐏᣉ (Nēhiyawēwin)	
Sahtú Got'ine		

(Continues)

TABLE 1 (Continued)

Territories	Languages	Treaties
Selkirk		
Shita Got'ine		
Stoney		
Sturgeon Lake Cree		
Ta'an Kwäch'än		
Tagé Cho Hudän (Little Salmon/Carmacks)		
Tagish		
Takla		
Taku River Tlingit		
Tāłtān Konelīne (Tahltan)		
Teslin Tlingit Council (BC)		
Teslin Tlingit Council (Yukon)		
Tetlit Gwich'in		
Tłı̨chǫ Ndè		
Tr'ondëk Hwëch'in		
Tse'khene		
Tsuu T'ina		
Upper Tanana		
Vuntut Gwitchin		
White River-Kluane		
Woodland Cree		
ᓀᐦᐃᔭᐤ ᐊᐢᑭᕀ Nêhiyaw-Askiy (Plains Cree)		

- An estimation of if or how past research contributed to the self-determination of Indigenous knowledge holders (e.g. was the study Indigenous-led or co-led? Who published the documents?) Did Indigenous knowledge holders receive credit for the work, for example, co-authorship? Was co-development done as a continuum (identification of research priorities and questions, methods, data collection, analysis, interpretation, writing, dissemination)? Was retention of data by Indigenous Peoples explicitly identified? What recommendations or suggestions does the item make about co-production of knowledge or co-production between Indigenous and non-Indigenous Peoples.
- If and how caribou Indigenous knowledge was used in spatially explicit modelling or land-use plan mapping projects; as well as a list of contacts involved (to ensure communities are asked for consent before their data or information are re-used).
- Spatial and temporal gaps relating to publicly discoverable data informed by Indigenous knowledge about caribou in the study region.

This review will be helpful for Western researchers, Indigenous Peoples, and Indigenous scientists seeking to conduct tǫdzı research in the Western Boreal Forest or wishing to replicate our approach for other regions or taxa. Western researchers would especially gain clearer insight on the appropriate steps to build meaningful relationships with Indigenous Peoples prior to and throughout the life of a research project and beyond. In turn, Indigenous Peoples and Indigenous scientists are interested in learning from past success stories that resulted in benefits to communities and having a road map to replicate or enhance work that effectively bridges knowledge systems should they wish to do so. Our overall goal is to contribute to improving the co-development experience for Indigenous Peoples and to promote good relations and limit engagement fatigue by guiding Western researchers working with holders of Indigenous knowledge.

2 | MATERIALS AND METHODS

This systematic map will follow the CEE guidelines (Collaboration for Environmental Evidence, 2018) and the ROSES (RepOrting standards for Systematic Evidence Syntheses) reporting standard (Haddaway et al., 2018).

2.1 | Search strategy

The search intends to capture all available peer-reviewed studies, reports, presentations, policy briefs, white papers, conference proceedings, book chapters, theses and other peer-reviewed and grey literature relevant to the question. We tested for English search strings. However, as the search items were geographically relevant

to North America primarily, with a few papers focusing on Europe, most of the items returned were in English.

The final search will use three databases (see below section *Databases*) focused on peer-reviewed publications and/or grey literature.

2.2 | Search strings

Our proposed search strings (Table 2) include 21 English terms based on their relevance to the research questions. The terms represent various caribou subspecies and ecotypes which occur in the Western Boreal Forest region. We also included the many present and historical terms synonymous with Indigenous knowledge. To narrow our search to items involving spatial modelling or mapping, we added relevant technical terms (Table 2).

We selected our databases based on a priori reasons: a set number of items were returned; was not behind a paywall, allowed for Boolean operators and/or returned items were not limited to only peer-reviewed literature. During initial searches of each database, we recorded the number of items returned from the search strings. For each string for each database, we calculated the specificity: the percent of items returned by the search string which are relevant to the research question. We also calculated the sensitivity of each string in each database by developing a list of benchmark papers (Table 3) of items known to be relevant to the research question and determined what proportion of items on the list of benchmark papers were returned by the search.

2.3 | Databases

We used three databases: Bielfield Academic Search Engine (BASE), Scopus, and the Canadian Conservation and Land Management (CCLM) portal created in part by the National Boreal Caribou Knowledge Consortium (NBCKC). BASE is European-focussed and returned peer-reviewed and grey literature from the European range of caribou. Scopus indexes most peer-reviewed journals in the natural sciences. The CCLM welcomes knowledge about all species of caribou in Canada and is a repository for peer-reviewed papers and grey literature, including management plans. Launched in 2020, the CCLM is in the process of building its resource library. With BASE and Scopus, we were able to use the search strings within the search bar to get a return in items, however, CCLM does not have a search bar which supports search string syntax. Upon entering the CCLM portal, we used the provided manual filters to narrow down our search as follows: we selected for projects with 'Indigenous involvement' and applied the advanced filters: 'community based', 'includes Indigenous knowledge', 'Indigenous led', and 'other'. We then selected the 'summary tab' and received a return of items, which were manually downloaded. Both BASE and the CCLM portal are publicly available, while Scopus was accessed through Dalhousie University Libraries.

TABLE 2 Proposed search strings for the execution of the search strategy.

String #	String
1	("boreal caribou" OR "woodland caribou" OR "mountain caribou" OR caribou OR "Rangifer tarandus caribou" OR "Rangifer tarandus") AND ("first nation*" OR métis OR inuit* OR aboriginal OR Indigenous OR "Indigenous Knowledge*" OR "Indigenous Ecological Knowledge*" OR "Traditional Ecological Knowledge*" OR "Traditional Knowledge*" OR "Local Ecological Knowledge*" OR "Local Knowledge*" OR "Indigenous Data") AND (map OR model OR range)

Note: *The asterisk (*) can represent any character (e.g., first nation* can be first nations to include the plural form).

TABLE 3 List of benchmark papers deemed relevant to the research question a priori based on knowledge of the research team.

#	Citation	Type
1	Boyd & Swinscoe (2018)	Grey literature
2	d'Entremont (2017)	Grey literature
3	Ferguson et al. (1998)	Peer-reviewed paper
4	Government of the Northwest Territories (2019)	Grey literature
5	Kendrick et al. (2005)	Peer-reviewed paper
6	Legat & McCreadie (n.d.)	Grey literature
7	Leroux et al. (2007)	Peer-reviewed paper
8	Polfus et al. (2014)	Peer-reviewed paper
9	Species at Risk Committee (2012)	Grey literature
10	Zalatan et al. (2006)	Peer-reviewed paper

2.4 | Item screening and eligibility criteria

The screening process of the collated items from the database identifies the items returned from the searches that are relevant to the research question. Items will be screened in two steps: (1) title and abstract and (2) full text. Each of the three databases will be searched with the English search strings for Scopus and BASE, and manually collated from the CCLM portal. The collated items will then be uploaded into the reference manager Mendeley (Mendeley Desktop, Version 1.19.4), where the documents will be categorized and organized before being uploaded into the literature review program Covidence (Covidence Systematic Review Software, n.d). At this stage, the documents will be subjected to a title and abstract screening and then undergo a full-text screening review. Two reviewers will be conducting the screening process of each item, allowing for each reviewer to cross-reference each other's screening for accuracy, with 10% of total screening decisions validated. If a screener is uncertain of whether a document met the eligibility criteria for inclusion (described below), they will discuss the item with the research team. All title and abstract screening outcomes will be documented in Covidence to keep a record to determine specificity and sensitivity and compare across the three

databases. These will be cross-reference against the list of benchmark papers (Table 3), to calculate the proportion of documents returned by the database that were present in the list.

The eligibility criteria for included works must contain the following elements:

Population—Items included will concern caribou (*Rangifer tarandus*) and Indigenous knowledge, Western science, or other natural or social sciences related to caribou (*Rangifer tarandus*). Studies concerning only natural resources or environmental studies will be excluded.

Item content—Items must include spatial modelling, mapping, or representation on the landscape related to caribou (*Rangifer tarandus*), and may be oriented towards either research, management, or both.

Geographical scope—Studies will originate anywhere in the range of caribou (*Rangifer tarandus*).

Language scope—Studies will be included if written in English.

2.5 | Study validity assessment

In creating this systematic map, we intend to capture descriptive information that could be useful to others working in this area.

2.6 | Data extraction strategy

After screening and removing the items that did not match our criteria, the reviewers will use a list of data extraction coding questions (Appendix S2) to extract data from the items that have passed the full-text screening phase. These coding questions have been modelled from other systematic map protocols and modified to meet the objectives of the current proposal (Alexander et al., 2021; Henri et al., 2021; Westwood et al., 2021). These coding questions are currently in draft and will be reviewed by both Western and Indigenous project collaborators. The data extracted from the document will provide information for the following: (1) characterize available data and previously engaged organizations and knowledge holders and (2) identifying positive experiences from Western research projects that involve Indigenous knowledge.

2.7 | Study mapping and presentation

We will employ a narrative synthesis approach for the systematic map that includes descriptive statistics, tables, and figures which compare retained studies against a compiled list of best practices. The list of best practices is composed from recommendations made by Indigenous Peoples and governments, Indigenous scientists and Western scientists regarding items such as the ownership of data, approaches to co-production, relationship-building and others (Table 4). We will examine the features of case studies which performed well according to the list of best practices and contribute to the CCLM repository of publicly available Indigenous knowledge and data about tǫdzı.

To support the results of the systematic map, we used ArcMap 10.3 (Esri Inc, 2015) to intersect a polygon of the Western Boreal Initiative project area with a publicly available database, Native-Land.ca, which describes the spatial extent of Indigenous languages, territories, and treaties between Western governments and Indigenous Peoples worldwide (Native Land Digital, 2021). The information on Native-Land.ca is based on oral history, written documents, or accounts from credible sources (Native Land Digital, 2021). The database should not be used to represent official or legal boundaries related to any Indigenous Peoples or Nations (Figure 2), and the Nations or Indigenous governments

TABLE 4 Suggested best practices to engage with Indigenous Peoples and the necessary steps needed to effectively bridge Western science with Indigenous knowledge systems. The authors note that this list that has been compiled by the present study is not exhaustive and contains both our thoughts and those of others in the field.

Best practices
• Include Indigenous community participation, direction, and consent throughout the life of a research project, from the conception of the research idea, through developing methods, during data collection and interpretation, and finally as part of knowledge dissemination and exchange. Indigenous partners should have larger roles to play than the informants of the research project (Legat & McCreadie, n.d.).
• Include Indigenous Peoples in discussions about research topics that mutually benefit them. Research projects should not be imposed on Indigenous communities or knowledge holders.
• Indigenous Peoples should be given rights and ownership to knowledge they share. Researchers should, at minimum, respect the principles of OCAP® (Ownership, Control, Access, and Possession) and other Indigenous-led guidance on data governance and sovereignty (The First Nations Information Governance Centre, 2014).
• Indigenous knowledge-holders with high levels of involvement should be included as co-authors (Kendrick et al., 2005).
• Indigenous language speakers should be accommodated when hosting workshops and conducting interviews by hiring translators. Translation services may be able to be organized by the Indigenous collaborator. Compensation for interpretation and/or translation services should be budgeted by the Western researcher (Ferguson et al., 1998).
• As part of retention of data, results of the project must be made accessible to the Indigenous community. Present the results to the community in the format of their choosing (i.e. live presentation, FB groups, etc). Be mindful of presentation style and avoid jargon (Ferguson et al., 1998).

in question should be consulted for confirmation about their boundaries.

3 | DISCUSSION

In this study, we produced a protocol for a systematic map that examines the research framework, practices and process of past research which has aimed to bridge knowledge systems between Indigenous knowledge and Western science in tǫdzı conservation and management. The systematic map methodologies from this study will provide resources for Western researchers and Indigenous Peoples so that best practices can be used when working to bridge knowledge systems. Ultimately, this paper will identify research practices which benefit both parties and address their management needs. As the number of contemporary environmental issues across the world expands, our need for holistic and collaborative management practices has never been greater. Our consideration of multiple types of studies ranging from the peer-reviewed and grey literature to case studies examining spatial mapping of caribou based on Indigenous knowledge can be used to inspire evidence-based and collaborative partnerships in addressing our most pressing conservation problems.

AUTHOR CONTRIBUTIONS

The study was conceived by Alana Westwood. Preliminary searching and database testing was conducted by Jacquelyn Saturno. The manuscript was drafted by Jacquelyn Saturno and Alana R. Westwood. Matthew Boeckner, Samuel Haché, James Hodson, Emily McAuley, Eliot McIntire, Tatiane Micheletti, Jean Polfus, Sophie Sliwa, Trevor Teed provided comments and revisions on the manuscript. All authors have read and approved the final manuscript.

ACKNOWLEDGEMENTS

We thank our colleagues that have provided us with valuable feedback to strengthen this current protocol. This includes Sam Bullock and Joe Dragon for providing constructive criticism and feedback on various aspects of this work during its development. Gianina Giacosa assisted in the collection and screening of literature. This work was funded by Environment and Climate Change Canada through a contract to Dalhousie University, as well as supported by Dalhousie University's BELONG Grant award to Alana Westwood.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interests.

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1002/2688-8319.12211.

DATA AVAILABILITY STATEMENT

This article does not contain data. Any data used for the full Stage 2 report will be made publicly available with that article.

ORCID

Jacquelyn Saturno https://orcid.org/0000-0003-1935-7889
Samuel Haché https://orcid.org/0000-0003-3952-009X
Emily McAuley https://orcid.org/0000-0002-9720-3730
Eliot McIntire https://orcid.org/0000-0002-6914-8316
Tatiane Micheletti https://orcid.org/0000-0003-4838-8342
Jean Polfus https://orcid.org/0000-0002-1886-4232
Alana R. Westwood https://orcid.org/0000-0002-5388-356X

REFERENCES

Adams, M. S., Carpenter, J., Housty, J. A., Neasloss, D., Paquet, P. C., Service, C., Walkus, J., & Darimont, C. T. (2014). Toward increased engagement between academic and indigenous community partners in ecological research. *Ecology and Society*, *19*(3), 1–10. https://doi.org/10.5751/ES-06569-190305

Alexander, S. M., Provencher, J. F., Henri, D. A., Nanayakkara, L., Taylor, J. J., Berberi, A., Lloren, J. I., Johnson, J. T., Ballard, M., & Cooke, S. J. (2021). Bridging indigenous and Western sciences in freshwater research, monitoring, and management in Canada. *Ecological Solutions and Evidence*, *2*(3), e12085. https://doi.org/10.1002/2688-8319.12085

Ball, J., & Janyst, P. (2008). Enacting research ethics in partnerships with indigenous communities in Canada: "Do it in a good way". *Journal of Empirical Research on Human Research Ethics*, *3*(2), 33–51.

Ban, N. C., Frid, A., Reid, M., Edgar, B., Shaw, D., & Siwallace, P. (2018). Incorporate indigenous perspectives for impactful research and effective management. *Nature Ecology and Evolution*, *2*(11), 1680–1683. https://doi.org/10.1038/s41559-018-0706-0

Boyd, C., & Swinscoe, J. (2018). Acho Dene Koe first Nation boreal Caribou traditional knowledge and cumulative impacts qualitative assessment: Non-confidential final report. Unpublished report by Landmark Resource Management Ltd. for the Acho Dene Koe First Nation, NT. 36 pp.

Brunet, N. D., Hickey, G. M., & Humphries, M. M. (2016). Local participation and partnership development in Canada's Arctic research: Challenges and opportunities in an age of empowerment and self-determination. *Polar Record*, *52*(3), 345–359. https://doi.org/10.1017/S003224741500090X

Burgar, J. M., Burton, A. C., & Fisher, J. T. (2018). The importance of considering multiple interacting species for conservation of species at risk. *Conservation Biology*, *33*, 709–715. https://doi.org/10.1111/cobi.13233

Carlson, M., Wells, J., & Jacobson, M. (2015). Balancing the relationship between protection and sustainable Management in Canada's boreal forest. *Conservation and Society*, *13*(1), 13–22. https://doi.org/10.4103/0972-4923.161209

Castleden, H., Morgan, V. S., & Lamb, C. (2012). "I spent the first year drinking tea": Exploring Canadian university researchers' perspectives on community-based participatory research involving indigenous peoples. *Canadian Geographer*, *56*(2), 160–179. https://doi.org/10.1111/j.1541-0064.2012.00432.x

Collaboration for Environmental Evidence. (2018). Guidelines and standards for evidence synthesis in environmental management. In A. Pullin, G. Frampton, B. Livoreil, & G. Petrokofsky (Eds.), *Version 5.0*. Collaboration for Environmental Evidence. www.environmentalevidence.org/information-for-authors

Council of Canadian Academies. (2019). *Greater than the sum of its parts: Towards integrated natural resource management in Canada*.

Covidence Systematic Review Software. (n.d.). *Veritas health innovation*. Melbourne, Australia. https://covidence.org/

d'Entremont, M. V. (2017). Traditional use study: Boreal Caribou habitat and habitat use–final report. Unpublished report by LGL Limited environmental research associates, Sidney BC, for the Deninu Kue First Nation, Fort Resolution, NT. 19 pp.

Environment and Climate Change Canada. (2018). *Action plan for the woodland Caribou* (*Rangifer tarandus caribou*), *boreal population, in Canada: Federal actions 2018*. https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/action-plans/woodland-caribou-boreal-federal-actions-2018.html

Environment and Climate Change Canada. (2019). *Amended recovery strategy for the Woodland Caribou* (*Rangifer tarandus caribou*), *Boreal population, in Canada* [*Proposed*].

Environment and Climate Change Canada. (2021). *The Government of Canada supports Dene Nation initiative to help conserve boreal caribou*. Government of Canada https://www.canada.ca/en/environment-climate-change/news/2021/07/the-government-of-canada-supports-dene-nation-initiative-to-help-conserve-boreal-caribou.html

Esri Inc. (2015). *ArcMap for Desktop 10.3*.

Ferguson, M. A. D., Williamson, R. G., & Messier, F. (1998). Inuit knowledge of long-term changes in a population of arctic tundra caribou. *Arctic*, *51*(3), 201–219. https://doi.org/10.14430/arctic1062

Government of the Northwest Territories. (2019). *A framework for boreal Caribou range planning* (p. 87). Environment and Natural Resources, Government of the Northwest Territories.

Haddaway, N. R., Macura, B., Whaley, P., & Pullin, A. S. (2018). ROSES reporting standards for systematic evidence syntheses: Pro forma, flow-diagram and descriptive summary of the plan and conduct of environmental systematic reviews and systematic maps. *Environmental Evidence*, *7*(1), 4–11. https://doi.org/10.1186/s13750-018-0121-7

Henri, D., Provencher, J., Bowles, E., Taylor, J., Chelick, C., Steel, J., Popp, J., Cooke, S. J., Rytwinski, T., McGregor, D., Ford, A. T., & Alexander, S. (2021). Weaving Indigenous knowledge systems and Western sciences in terrestrial research, monitoring, and management in Canada: a protocol for a systematic ma. *Ecological Solutions and Evidence*, (#ESO-20-1(November 2020)), *2*, 1–9. https://doi.org/10.1002/2688-8319.12057

IPCC. (2018). *Global Warming of 1.5°C above pre-industrial and related global greenhouse gas emission pathways, in the context of a strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Intergovernmental Panel on Climate Change.

Kendrick, A., Lyver, B., & Łutsël K'é Dene First Nation. (2005). Denésǫliné (Chipewyan) knowledge of barren-ground caribou (*Rangifer tarandus groenlandicus*) movements. *ARCTIC*, *58*(2), 175–191.

Kothari, A., Camill, P., & Brown, J. (2013). Conservation as if people also mattered: Policy and practice of community-based conservation. *Conservation and Society*, *11*(1), 1–15. https://doi.org/10.4103/0972-4923.110937

Kutz, S., & Tomaselli, M. (2019). "Two-eyed seeing" supports wildlife health. *Science*, *364*(6446), 1135–1137. https://doi.org/10.1126/science.aau6170

Legat, A., & McCreadie, M. (n.d.). *Tǫdzı (Boreal Caribou) and the State of their Habitat*.

Leroux, S. J., Schmiegelow, F. K. A., & Nagy, J. A. (2007). Potential spatial overlap of heritage sites and protected areas in a boreal region of northern Canada. *Conservation Biology*, *21*(2), 376–386. https://doi.org/10.1111/j.1523-1739.2006.00626.x

Native Land Digital. (2021). *Native Land*. https://native-land.ca/

Park, A., Puettmann, K., Wilson, E., Messier, C., Kames, S., & Dhar, A. (2014). Can boreal and temperate Forest management be adapted to the uncertainties of 21st century climate change? *Critical Reviews in Plant Sciences*, *33*(4), 251–285. https://doi.org/10.1080/07352689.2014.858956

Polfus, J. L., Heinemeyer, K., Hebblewhite, M., & Taku River Tlingit First Nation. (2014). Comparing traditional ecological knowledge and Western science woodland Caribou habitat models. *Management and Conservation*, *78*(1), 112–121. https://doi.org/10.1002/jwmg.643

Species at Risk Committee. (2012). *Species status report for boreal Caribou (Rangifer tarandus caribou) in the Northwest Territories*. Species at Risk Committee.

Stern, E. R., & Humphries, M. M. (2022). Interweaving local, expert, and indigenous knowledge into quantitative wildlife analyses: A systematic review. *Biological Conservation*, *266*, 109444. https://doi.org/10.1016/j.biocon.2021.109444

Stewart, F. E. C., Nowak, J. J., Micheletti, T., McIntire, E. J. B., Schmiegelow, F. K. A., & Cumming, S. G. (2020). Boreal Caribou can coexist with natural but not industrial disturbances. *Journal of Wildlife Management*, *84*(8), 1435–1444. https://doi.org/10.1002/jwmg.21937

The First Nations Information Governance Centre. (2014). *Ownership, Control, Access and Possession (OCAP): The Path to First Nations Information Governance*.

Westaway, C., & Reiss, L. (2019). *We have always been here: The significance of Dene knowledge*. Dene National and Assembly of First Nations.

Western Boreal Initiative. (2022). *Western boreal initiative*. https://wbi.predictiveecology.org/

Westwood, A., Barker, N. K. S., Grant, S., Amos, A. F., Camfield, A., Cooper, K., Dénes, F. V., Jean-Gagnon, F., McBlane, L., Schmiegelow, F. K. A., Simpson, J. I., Slattery, S. M., Sleep, D. J. H., Sliwa, S., Wells, J., & Whitaker, D. (2020). Towards actionable, coproduced research on boreal birds focused on building respectful partnerships. *Avian Conservation & Ecology*, *15*(1), 1–26. https://doi.org/10.5751/ACE-01589-150126

Westwood, A. R., Hutchen, J., Kapoor, T., Klenk, K., Saturno, J., Wang, J., Falconer, M., & Nguyen, V. M. (2021). A systematic mapping protocol for understanding knowledge exchange in forest science. *Ecological Solutions and Evidence*, *2*(3), e12096. https://doi.org/10.1002/2688-8319.12096

Wiebe, G. (2021, July 16). *Feds to help fund Western Boreal Initiative with Dene Nation*. [Radio Broadcast] The Bull https://www.thebull.ca/2021/07/16/feds-to-help-fund-western-boreal-initiative-with-dene-nation/

Winder, R., Stewart, F. E. C., Nebel, S., McIntire, E. J. B., Dyk, A., & Omendja, K. (2020). Cumulative effects and boreal woodland Caribou: How Bow-Tie risk analysis addresses a critical issue in Canada's forested landscapes. *Frontiers in Ecology and Evolution*, *8*(February), 1–9. https://doi.org/10.3389/fevo.2020.00001

Young, N., Cooke, S. J., Hinch, S. G., Digiovanni, C., Corriveau, M., Fortin, S., Nguyen, V. M., & Solås, A.-M. (2020). "Consulted to death": Personal stress as a major barrier to environmental co-management. *Journal of Environmental Management*, *254*, 109820. https://doi.org/10.1016/j.jenvman.2019.109820

Zalatan, R., Gunn, A., & Henry, G. H. R. (2006). Long-term abundance patterns of barren-ground caribou using trampling scars on roots of picea mariana in the Northwest Territories, Canada. *Arctic, Antarctic, and Alpine Research*, *38*(4), 624–630. https://doi.org/10.1657/1523-0430(2006)38[624:LAPOBC]2.0.CO;2

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1. ROSES for Systematic Map Protocols. Version 1.0.

Appendix S2. Data Extraction Questions.

How to cite this article: Saturno, J., Boeckner, M., Haché, S., Hodson, J., McAuley, E., McIntire, E., Micheletti, T., Polfus, J., Sliwa, S., Teed, T., & Westwood, A. R. (2023). Setting a foundation for Indigenous knowledge systems-guided boreal caribou (tǫdzı) conservation planning in the Western Boreal Region of Canada: A systematic map protocol. *Ecological Solutions and Evidence*, *4*, e12211. https://doi.org/10.1002/2688-8319.12211