First Nation land and well-being:

Exploring the relationship of First Nation land management systems with community well-being, informality within land management, and the development of an agent-based First Nation land-use voting model for experiments on policy adoption at Curve Lake First Nation

by

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Examining Committee Membership

The following served on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

This thesis has been structured according to the manuscript option. Chapters 2 and 3 have been published in a peer-reviewed journal, and Chapter 4 has been submitted for publication. Since each chapter has been written for publication there is the potential for minor overlap among the chapters (e.g., study area).

For all chapters in this thesis, Robert A. Fligg was the lead author. Dr. Derek T. Robinson was the academic advisor and Robert A. Fligg and Dr. Derek T. Robinson worked together on the conceptualization of each chapter and research. Robert A. Fligg conducted all the data analysis, data curation, and main substance of each chapter. Dr. Derek T. Robinson provided edits and proofed each chapter before publication. Dr. Brian Ballantyne, also contributed with substance and edits for Chapters 2 and 3. Specific author contributions are outlined in each peer-reviewed journal publication where applicable.

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Abstract

Land management is a pressing issue for reconciling and reconnecting First Nations with their land. Many First Nations have taken more control and responsibility over the management of their land that is key to their well-being. Currently, two legislative pathways (e.g., the First Nation Land Management (FNLM) regime and frameworks of self-government) provide more control by First Nations over their land outside of the Indian Act, however, there are gaps in societies' understanding about the relationship of First Nation land management (in the broader sense) and their well-being.

The overarching goal of the thesis, seeks to improve societies' understanding about the relationship between First Nation land management (broadly defined, including land management systems, property rights systems, land-use policies and planning) and First Nation well-being. Chapter 2 contributes by asking the question: "does the land-management regime of a First Nation correlate with differing levels of community well-being among First Nations as measured using the community well-being (CWB) index?". It also investigates if there have been temporal effects by asking the question: "do First Nation communities experience different CWB trajectories when under a particular land management regime when they transition from one land management regime to another?" First Nation communities that have more control over managing their land have on average higher CWB scores, however, a community under any land management regime (e.g., under the Indian Act, or sub-set of the Indian Act 'Reserve Land and Environment Management Program' (RLEMP), Framework Agreement on First Nation Land Management Act (formerly First Nations Land Management Act (FNLM)) or a framework of self-government) could achieve a high CWB score (e.g., above the non-Indigenous average) depending on key economic factors (e.g., location of a community to an economic area). Regardless of CWB scores a land management regime is crucial to First Nation cultural well-being that may include pathways or mechanisms to develop formal community objectives and policies on land-use practices (e.g., on land relationships and stewardship).

Building on Chapter 2, Chapter 3 looks deeper into First Nation land management, land-use practices, policy and planning, and property rights through collaboration with Curve Lake First Nation. Chapter 3 investigates by First Nation member-type (i.e., land holder vs non-land holder, and 'on' vs 'off-reserve' members) land management knowledge, and the impact member type has on land management and land-use practices. To achieve the objective of Chapter 3, a social survey was created in collaboration with Curve Lake First Nation to investigate formal and informal land-use practices and policy in land management, and whether there was a gap between members "wants and needs" regarding what should happen according to (formal) policy or process

and what actually happens on the ground (informal). Although results from Chapter 3 found a correlation of land holder/non-land holder disconnect with uncertainty regarding policy on land use-practices that suggested a need for formal land-use policy and planning, the results also suggested CP holders and non-CP holders agreed that all parcels should be managed and used according to community values.

Chapter 4 takes a step toward filling the gap in societies' understanding by utilizing the knowledge and data from Chapters 2 and 3 in the development of a First Nation land-use voting model to investigate how formal land use policy on individual support for land policy and community land objectives could be conceptualized as a collective well-being. Chapter 4 investigated the objective by asking research questions on "how different member-levels of propensity for land information knowledge, ambition, stewardship, and how they collaborate affect formal land-use plan and potential land-policy adoption", and secondly "how relationships and changes in members' knowledge and attitudes affect support of formal land-use policy and its potential adoption?" Responses to the Curve Lake First Nation social survey was further coded for member responses on land related questions about their community, and outside community, on systems of land management, property rights, land-use policy and planning, and opinions on well-being that could be used to empirically inform an agent-based model called the 'First Nation Land-Use Voting Model'. Model results suggest with greater support for community specific objectives for a balance in socio-economic and cultural well-being, there is greater support for the adoption of formal land-use policy and planning.

Acknowledgements

I would like to acknowledge first - my loving wife Sue as without her support, I would not have been able to complete this long part-time PhD journey without her.

I acknowledge Curve Lake First Nation, Chief and Council, Alison Irons-Cummings (previous Lands Manager), the Lands and Environment Committee (previously Lands Committee) who acted as my First Nation advisory committee, and the people of Curve Lake First Nation.

I acknowledge my academic advisor Dr. Derek T. Robinson, who kept me going with 'you got this' confidence, patience, and his interest in my self-funded research. I would also like to acknowledge Dr. Brian Ballantyne, committee member, who spent considerable time conversing with me about First Nation land management, editing papers, and co-authoring one of the thesis papers.

I would also like to acknowledge my other committee members, Dr Johanna Wandel for providing feedback on my thesis and feedback at my comprehensive exam that proved to be quite helpful with my First Nation research and paper that I delivered to the World Bank, Washington, D.C. in 2019; and, Dr. Michael Drescher for participating on my committee and providing feedback to improve my thesis.

I entered this PhD journey as a full-time employee at Natural Resources Canada (NRCan) and although now retired from the federal government, I continue to work part-time in the geomatics industry and teach modules for the First Nations Applied Lands Management course through the Tulo Centre of Economics and Thompson Rivers University. I was fortunate to have the support of NRCan, while in their employ, and support from my friends, family and colleagues.

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List of Abbreviations

Abbreviations	Definitions
AANDC	Aboriginal Affairs and Northern Development Canada
ABM	Agent-based model or modelling
AFN	Assembly of First Nations
AMO	Association of Municipalities Ontario
CCP	The Curve Lake First Nation Comprehensive Community Plan, 2009
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
CLFN	Curve Lake First Nation
CLSR	Canada Lands Survey Records
CP	Certificate of Possession
CWB	Community Well-Being Index
eRIP	Electronic Registry Index Plan
FAO	Food and Agriculture Organization of the United Nations
FNLMA/FNLM	Framework Agreement on First Nation Land Management Act
FN-LUVM	First Nations Land Management Act/First Nations Land Management regime First Nation – Land-use voting model
HDI	Human Development Index
IALM	Indian Act land management regime
ILG	Institute for Local Government
ILRS	Indian Lands Registry System
ILSC	Indigenous Land Stewardship Circle
INAC	Indian and Northern Affairs Canada
ISC	Indigenous Services Canada
LABRC	Land Advisory Board – Resource Centre
LEED	Leadership in Energy and Environmental Design – green building rating system
LS/LTS	Location sketch/Location title sketch
LUS/LUS19	Curve Lake First Nation land-use survey/land-use survey 2019 dataset
MLR	Multinomial logistic regression
NADF	Nishnawbe Aski Development Fund
NALMA	National Aboriginal Lands Managers Association
NCCIH	National Collaborating Centre for Indigenous Health
NGO	Non-governmental organizations
ODD	Overview, Design concepts, and Details for agent-based models
OECD	Organization for Economic Cooperation and Development
OPPI	Ontario Professional Planners Institute
ORE	Office of Research Ethics, University of Waterloo
PIN	Parcel Identifier Number
RCAP	Royal Commission on Aboriginal People, 1996
RLAP	Regional Lands Administrative Program (now RLEMP)
RLEMP	Reserve Land and Environment Management Program
SGLM/FSG	Self-government land management regime/Framework of self-government

STATSCAN	Statistics Canada
TRC	Truth and Reconciliation Commission of Canada (2015)
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples

Positionality Statement

The author, Robert A. Fligg, is not an Indigenous person and not a member of any First Nation. I have worked with reserve communities and with First Nation people most of my career of over 40 years as an Ontario Land Surveyor, and a Canada Lands Surveyor. During this time, I worked in the land surveying profession for approximately 25 years with Natural Resources Canada, Surveyor General Branch (1976 – 1987, 2004 - 2021) and in private practice (1987 - 2004, 2021 - 2024). Over the course of this time, I connected with Indigenous people across the country by working on approximately 80 First Nation reserves across Ontario and in the north in Nunavut and the Northwest Territories. While employed with Natural Resources Canada, Surveyor General Branch, and a member of the Association of Canada Lands Surveyors, I was involved in discussions and consultation with Indigenous peoples across Canada, mainly about lands matters.

Since 2018 I have been a sessional instructor at the Thompson Rivers University in collaboration with the Tulo Centre of Indigenous Economics, where I was engaged with First Nation land professionals and aspiring ones from across the country by teaching two modules in the First Nations Applied Land Management certificate program.

A need for this research was inspired by my personal involvement and observations over the years of:

- cultural differences, not only between non-Indigenous people and First Nations, but between various First Nations.
- differences between on and off reserves, and between reserves:
    - in standard of living,
    - on how their land was managed and land-use practices, and
    - in property rights and practices,
- a lack of formal land-use policies and planning on most First Nation communities.

It is hoped that my research might fill gaps (or improve) in societies' understanding about how First Nation reserve lands are managed, and the importance of their land and how their land is managed to their well-being. Further, it is hoped this research might assist First Nations with the management of their land (in the broader sense, including land management systems, property rights, land-use planning and policy), and with setting community objectives in:

- Socio-economic well-being, and
- Cultural well-being

During the research for my thesis, I was primarily employed with Natural Resources Canada, Surveyor General Branch, (research period of 2014 to 2021), and then part-time for Raikes Geomatics Inc from 2021 to present (2024). I was considered a self-funded PhD student with no research grants, but I did have assistance with tuition from Natural Resources Canada. However,

as a self-funded student, I primarily worked on this research on my own time and therefore was not under any bias towards the position of the Federal Government of Canada.

Before I started this PhD journey, I selected Curve Lake First Nation (CLFN) for various reasons. Besides CLFN location, being close to where I reside for more personal contact, as a Canada Lands Surveyor I engaged in work for CLFN and signed survey plans, and I knew that CLFN managed their land under the Indian Act (before being under RLEMP), and were not under the First Nation Lands Management (FNLM) regime or a framework of self-government. My pre-investigation indicated various land issues at CLFN (e.g., disorderly development, land management capacity issues, individual (CP) landowners land-use issues, and no land-use plan) according to a Comprehensive Community Plan (CCP) study done in 2009. Before I started 'official' research at Curve Lake First Nation, the Chief (on behalf of council and the community) provided me with a letter of permission to conduct research on Integrated Land Management, where the term 'Integrated' (in land management), included land management systems, property rights, land-use planning and policy (Letter PS1). Before conducting the 2019 CLFN land-use survey (in collaboration with CLFN) I completed the mandatory training on the Tri-Council -TCPS2, where Chapter 9 of the TCPS 2 … "is offered in a spirit of respect. It is not intended to override or replace ethical guidance offered by Indigenous Peoples themselves. Its purpose is to ensure, to the extent possible, that research involving Indigenous Peoples is premised on respectful relationships". Completion of this training is required before conducting research with Indigenous people. This training formed part of a rigorous process to satisfy conditions for the Office of Research Ethics (ORE), University of Waterloo, where ORE permission was required before the land-use survey could be conducted at Curve Lake First Nation. The process to obtain ORE 40248 and conduct research in collaboration with CLFN took approximately 3 months of discussions between the University (ORE), myself, and CLFN that included not only how the information would be collected, but how it would be disseminated. Further and as part of the ethical protocol process about conducting research at CLFN, I abided by the CLFN research ethics guidelines document.

During the early years of my research and visits to Curve Lake, (research period 2014 to 2020), I worked closely with Alison Irons-Cummings, Lands Manager who invited me into the community and to the CLFN Lands Committee meetings to learn the ways of the community and people of Curve Lake First Nation, for this I am grateful. The Lands Committee renamed the Lands and Environment Committee (in 2020) agreed by motion (in their meeting minutes) to be my 'First Nation advisory committee' (Committee), and I discussed my progress with both Alison and the Committee on my progress. The progress included providing them with draft and published papers

that would form part of this thesis. Although Covid19 changed how people interacted in the world (for a while), communication during this time was conducted virtually (e.g., by Zoom).

Chief Keith Knott, Curve Lake First Nation, and Alison Irons-Cummings (to the extent of their knowledge about my research) have kindly provided letters of approval about my academic collaboration at Curve Lake First Nation (Letters PS2 and PS3).

Letter PS1 – from Chief Phyllis Williams, Curve Lake First Nation

Government Services Building
22 Winookeeda Street
Curve Lake, Ontario K0L1R0

Phone: 705.657.8045
Fax: 705.657.8708
www.curvelakefn.ca

Friday, October 24, 2014

Mr Robert Fligg, MSc, OLS, CLS, OLIP

RE: Letter of Support for Research Project

Aaniin Mr. Fligg:

We are writing to express our support for your proposed ***"Study on an Integrated Model on Land Use and Parcel Fabric to Promote Integrated Land Management"*** whereas Curve lake First Nation, as a community, will be the basis of the study and research.

As previously negotiated, we expect that you will report to the Council on a bi-annual basis to report your progress and findings. Your point person for the First Nation will be Alison Irons-Cummings, Land Manager. You may also wish to work along with our Rights & Resources Committee. We would like to ensure and reiterate Curve Lake's ability to remove ourselves from the project at any time and ensure the following statement of disclosure is maintained:

> *"All the information that is collected, analyzed and mapped will be disclosed to the First Nation for review of any concerns that might arise. The intention of the research is to assist the First Nation in making informed decisions about land use and not put the First Nation in a position that would cause disrepute or jeopardize other programs and funding. The research will be used for academic purposes and will be published and discussed to promote innovative methods in the area of land use planning."*

On behalf of our First Nation, we are pleased to enter into this mutually beneficial partnership and look forward to this creative and forward thinking endeavour.

Miigwech,

Phyllis Williams
Chief

The "project" referred to as integrated land management was a term used for integrating land management systems, land-use policy and planning, and property rights in 'land management'.

Letter PS2 – from Chief Keith Knott, Curve Lake First Nation

Curve Lake First Nation
22 Winookeedaa Street
Curve Lake, ON K0L 1R0
PHONE (705) 657-8045 FAX (705) 657-8708
www.curvelake.ca

February 27, 2024

Robert A. Fligg

Re: Robert Fligg's PhD academic research in collaboration with Curve Lake First Nation

Robert's PhD academic research at Curve Lake First Nation began with an approval letter from Chief Phyllis Williams dated October 24, 2014 on the "The Study on an Integrated Model on Land Use and Parcel Fabric to Promote Integrated land Management". *(attached for reference)*

It is our understanding the term Integrated Land Management is about the integration of Curve Lake's land management system, property rights system, land-use policies and planning. It is also our understanding that the research could be published and used in Robert's dissertation.

While Robert's academic endeavor has been a long journey it has encompassed several changes in Chief and Council, staff, and committees, and also endured the Covid19 pandemic, which stalled many of our community initiatives.

It is our understanding that Robert had regular, in person, meetings with the Lands Manager, Alison Irons-Cummings from 2014 to 2020 (until Covid19). After Alison stepped down from being Lands Manager, Robert continued to keep in touch with Alison who provided feedback on his dissertation. During Covid19, Robert continued to be active in the land-use planning initiative with Delaney Jacobs, Lands Manager (2020-2021 & 2023 to present), and with the acting Lands Manager, Breanna Knott (2021-2022).

Curve Lake First Nation
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Robert attended Curve Lake First Nation Lands Committee meetings on a regular basis. The committee acted as his First Nation advisory committee. Between Alison, Delaney and Breanna, and the Lands Committee (now the Lands and Environment Committee) we were kept informed of Robert's progress. Most significantly, Robert worked in collaboration with Curve Lake on the 2019 Land-Use Survey and Study, which helped our land use planning initiative with valuable information from our members about the use and future of our land.

On behalf of Curve Lake First Nation, we are pleased to have been apart of this research and that it will not only benefit our community but others as well.

Miigwech,

Chief Keith Knott

Letter PS3 – Letter from Alison Irons-Cummings, member and former Lands Manager, Curve Lake First Nation.

Alison Irons-Cummings
68 Quinquish Rd
Curve Lake First Nation
K0L 1R0

February 23, 2024

c/o Robert Fligg

Re: Robert Fligg's PhD academic research in collaboration with Curve Lake First Nation

Aaniin:

I am happy to write this letter regarding Robert's PhD academic research in collaboration with myself and Curve Lake First Nation. Our partnership formally began with an approval letter from Curve Lake First Nation Chief Willimas dated, October 24, 2014 on the "The Study on an Integrated Model on Land Use and Parcel Fabric to Promote Integrated land Management". My understanding about the research and the term Integrated Land Management was about the integration of Curve Lake's land management system, property rights system, land-use policies and planning.

Over the next 6 years (2014 to 2020), we had regular formal and informal meetings to discuss our community and lands related matters. Robert regularly attended our Lands Committee meetings, where many lands issues were tabled that helped Robert gain perspective at Curve Lake. The Lands Committee served as Robert's First Nation advisory committee (passed by motion, in the committee minutes) and the committee was available for Robert to discuss First Nation land matters and questions that he had.

During that time, and up until COVID-19 hit, Robert attended various community events, that furthered his perspective about our community and members that live on both on and off reserve. Our Pow Wows, First Nation School community events, and also accompanied me on our reserve lands and waters when my work took me in the field.

Most significantly, in 2019, Robert worked in collaboration with our Lands Committee on our community Land Use Survey and Study to assist with the development of our land use plan and policies. The information collected was approved by the Chief (according to terms and conditions in the original letter) to be used in Robert's academic papers that formed part of his dissertation.

While progress was being made on land use planning, in 2020 Covid19 hit and many of our initiatives were stalled. At this time, I stepped down from being the Lands Manager, but Robert continued to work with the new Land Manager(s) that followed and attended meetings by Zoom as necessary.

I am again involved formally with Curve Lake Lands, as I now sit as a community member (vs a staff resource) on the Lands and Environment Committee. We have recently discussed Robert's work and past involvement, and we hope to discuss the possibility of continuing our partnership to build upon the work that has been done to date on the development of our land-use plan and policies.

I am still in contact with Robert (as a colleague and friend) and have continued to provide feedback on his academic work and dissertation where I can. I feel our community has benefitted from this work on his academic endeavour and it was a pleasure to get to know him.

Miigwech,

Alison Irons-Cummings
Cc: Chief Knott
Delaney Jacobs, Director of Lands
Mindy Knott, Acting General Manager

Chapter 1: Introduction

1.1 Background on First Nation land and well-being

To improve societies' understanding of First Nations, their land, and the relationship between their land management and their well-being first requires understanding the context within which they reside and contemporary reconciliation efforts within Canada. In Canada there are 50 distinct Nations among approximately 634 First Nation communities (CIRNAC, 2021; AFN 2023). Many First Nations honour the principles of the Seven Sacred Teachings, and Teaching of the Seven Grandfathers[1]. These principles form the basis of the Anishinaabeg[2] term Mino Bimaadiziwin - living the good life[3] that is said to not belong to the Anishinaabe exclusively (e.g., the seven Cree principles[4] and the Haudenosaunee seventh generation principle[5])[6] and that achieving Mino Bimaadiziwin has an epistemological relationship in reconnecting and reconciling First Nations with their land (Nightingale & Richmond, 2022)[7].

Land is the essence of a community (OECD, 2021, Chapter 3) and supports socio-economic well-being, which has been measured by the Federal government's "Community Well-Being Index" (CWB) (ISC, 2022). The CWB index is based on four metrics associated with housing, education, income, and labour[8] that may be used to assist in identifying communities in need (StatsCan 2017, Hardy & O'Sullivan, 2004). However, the metrics fail to represent the holistic relationship First Nations have with their land that is critical to their cultural well-being (Guthro, 2021; Cameron et al, 2019; Bouchard, 2020) and part of greater symbiotic relationship[9] where everything is connected[10].

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[1] ojibwe.net/projects/prayers-teachings/the-gifts-of-the-seven-grandfathers/ - respect, love, truth, bravery, wisdom, generosity/honesty and humility - some lists include generosity and others honesty.

[2] Anishinaabe is most commonly used to describe Ojibwe, Ojibwa, Ojibway people and can include other First Nation people, e.g., Odawa, Mississauga, Chippewa, Algonquin.
Canadian Encyclopedia https://www.thecanadianencyclopedia.ca/en

[3] ojibwe.lib.umn.edu/main-entry/mino-bimaadiziwin-ni

[4] aseniwuche.ca/7-cree-principles/

[5] ictinc.ca/blog/seventh-generation-principle - ensuing that decisions or relationships made today about energy, water and natural resources are sustainable for seven generations

[6] moccasintrailnews.com/index.php/2021/01/08/the-seven-principles-of-anishinaabe-mino-bimaadiziwin/

[7] mspace.lib.umanitoba.ca/handle/1993/33359

[8] For further reading about the Community of Well-being (CWB) index see Fligg & Robinson (2019) or Government of Canada, Indigenous Services Canada, https://www.sac-isc.gc.ca/eng/1100100016579/1557319653695

[9] cepf.net/stories/indigenous-peoples-and-biodiversity-symbiotic-relationship

[10] firstnationspedagogy.ca/interconnect.html
empoweringthespirit.ca/cultures-of-belonging/

While land supports First Nation socio-economic well-being (e.g., as a commodity, Majumder & Gururani, 2021), land also supports First Nation cultural well-being (e.g., cultural attitude, AFN, (2022); cultural perception, le Polain de Waroux et al, (2021)). A system of land management may be designed to meet the well-being needs of a community[11], but there are gaps in societies' understanding about how First Nation land management can be used to balance socio-economic well-being (e.g., land used as a commodity) with cultural well-being (e.g., land-use practices that are guided by First Nation land stewardship[12]). Our ability to understand the relationship between First Nation land management and their well-being is complicated by cultural loss due to colonization and years of wrongdoing leading up to and after the Indian Act (R.S.C., 1985, c. I-5, enacted in 1876). How cultural loss has impacted well-being is uncertain as some land-uses and developments that may support socio-economic well-being and a community's CWB index[13] score (e.g., housing development along shorelines) may not support First Nation cultural well-being (e.g., impacting wildlife habitats). Exploring the relationship between First Nation land management (in the broader sense)[14] with socio-economic well-being (Fligg & Robinson, 2019) and cultural well-being (Fligg et al, 2021) may assist in societies' understanding of pathways on reconciling First Nations with their land.

The importance of reconciling First Nations with their land and the need to improve societies' understanding of the pathways on reconciling First Nations with their land is evident in three of 94 "Calls to Action" by the Truth and Reconciliation Commission of Canada, (TRC, 2015)[15] to redress wrongdoings against First Nation communities from colonization[16] (CIRNAC, 2022; TRC, 2015) (see Appendix 1, summary of the TRC). These actions are: 1) Action 45, which calls upon the Government of Canada to develop with Indigenous peoples of Canada a Royal Proclamation:

[11] fao.org/3/Z5700E/z5700e07.htm
stuflash.com/smart-growth-vs-wisely-planned-communities/

[12] First Nation land stewardship and Indigenous land stewardship is used synonymously.

[13] Supra 9

[14] The broader sense may include systems of land management, land tenure, and planning.
ontario.ca/document/ontario-municipal-councillors-guide/10-land-use-planning

[15] Truth and Reconciliation Commission of Canada, trc.ca/ (now archived - web.archive.org/web/20200513112354/ & trc.ca/index-main.html)
Reconciliation Education, reconciliationeducation.ca/en-ca/
Calls to Action, ehprnh2mwo3.exactdn.com/wp-content/uploads/2021/01/Calls_to_Action_English2.pdf

[16] The TRC was driven by the legacy and wrongdoings of church run residential schools.
History of Canada's Indian Residential Schools, reconciliationeducation.ca/what-are-truth-and-reconciliation-commission-94-calls-to-action

"to repudiate concepts used by European sovereignty over Indigenous lands, such as terra nullius" (e.g., "nobody's land or land belonging to nobody" and "land over which no previous sovereignty has been exercised" (Rule of Law Education Centre, 2022, pg 1)*)* (Action 45 (i)); and for *"…the recognition and integration of Indigenous laws and legal traditions in negotiation and implementation processes involving Treaties, land claims …";* (Action 45 (iv);

2) Action 43, which calls upon governments across Canada (e.g., federal, provincial, territorial, and municipal) to adopt the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP[17]), and;

3) Action 92, which calls upon the corporate sector of Canada to adopt the UNDRIP:

"… to apply its principles, norms, and standards to corporate policy and core operational activities involving Indigenous peoples and their lands and resources.";

and for *"… meaningful consultation, building respectful relationships, and obtaining the free, prior, and informed consent of Indigenous peoples before proceeding with economic development projects"* (Action 92 (i))

Although these "calls to action" redress wrongdoings related to land, they fall short on providing a clear pathway to restore cultural loss First Nations have with their land (AFN, 2022; RCAP, 1996).

Recognizing the First Nation relationship with their land was identified before the TRC[18] in the 1996 Royal Commission on Aboriginal People (RCAP). The RCAP set out 440 recommendations for change in relationships between Indigenous and non-Indigenous people, and Indigenous relationships with governments across Canada. The RCAP, Volume 1, "Looking Back, Looking Forward", p.9, states:

"*We learned from our hearings and from the research we commissioned that Aboriginal peoples share strongly held views of the relationship between their nations, their lands, and their obligations to the Creator"*[19]

and in Volume 2, Chapter 4, Lands and Resources, Section 3.2 "Significance of Lands and Resources to Aboriginal Peoples" recognizes the socio-economic and cultural significance of land and First Nation loss in traditional land base, p. 438 states:.

[17] The UNDRIP is a document (or instrument) that "sets out the rights of Indigenous peoples around the world…intended to define and uphold human rights in international law" (Canadian Museum for Human Rights), "that addresses the economic, social, cultural, political, civil, spiritual, and environmental rights of Indigenous peoples" (Canadian Friends Service Committee). See Footnote 28 for further information about the UNDRIP in Canada.

[18] nctr.ca/records/reports/#trc-reports

[19] RCAP, Royal Commission on Aboriginal People, 1996, data2.archives.ca/e/e448/e011188230-01.pdf

"Aboriginal people have told us of their special relationship to the land and its resources. This relationship, they say, is both spiritual and material, not only one of livelihood, but of community and indeed of the continuity of their cultures and societies"

Although the RCAP recognized the First Nation relationship with their land, only "a few" recommendations "were implemented"[20], and what was recognized in the RCAP about land was not explicitly identified in the TRC (e.g., as to an action or pathway on First Nation reconciliation with their land).

Both the TRC and RCAP demonstrated significant progress from the 1969, 'White Paper'[21], a publication by the Government of Canada, that "ignored more than a century of discrimination and handicaps that the state itself had imposed on Aboriginal people"[22] (Russell, 2003). The White Paper was Ottawa's approach to mitigate wrongdoings and discrimination of First Nation people[23], but was "profoundly assimilationist" and would lead to "cultural annihilation" (Cardinal, 1969)[24], by proposing to eliminate the Indian Act, Indian Status, department of Indian Affairs, convert reserve land to private land and more. The White Paper failed to address First Nations concerns of historical injustices and failed to recognize the cultural well-being of First Nation. Approximately 26 years after the White Paper, the 1996 RCAP, V1, p. 9, recognized a cultural relationship First Nations have with their land and then approximately 19 years after the RCAP, the 2015 TRC addressed wrongdoings and actions for potential pathways for reconciliation[25].

The purpose of this thesis is to improve societies' understanding of the potential pathways on reconciling First Nations with their land**.** Specifically, the focus is on understanding how land management activities relate to First Nation well-being and gaining insight into how community perspectives relate to land-use practices that could influence their support for future land management and land-use policies.

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[20] Pg., 2, Report on a National Forum on Reconciliation, Marking the 20th Anniversary of the Royal Commission on Aboriginal Peoples, November 2016, Winnipeg, Manitoba
queensu.ca/sps/sites/spswww/files/uploaded_files/Events/17-068_Land_of_our_Fathers_final_English.pdf

[21] The White Paper, nctr.ca/wp-content/uploads/2021/01/1969-The-White-Paper.pdf
For further reading see: https://indigenousfoundations.arts.ubc.ca/the_white_paper_1969/
and responses 1) called the Red Paper (1970) – see: https://www.thecanadianencyclopedia.ca/en/article/citizens-plus-the-red-paper and 2) the Brown Paper, by the Union of British Columbia Indian Chiefs, A Declaration of Indian Rights (Lagace et al, 2020).

[22] Canada's Human Rights History, 1969 White Paper on Indian Policy,
https://historyofrights.ca/encyclopaedia/main-events/1969-white-paper-indian-policy/

[23] The White Paper, 1969 (Lagace et al, 2020)

[24] For further reading about Harold Cardinal see: https://www.thecanadianencyclopedia.ca/en/article/harold-cardinal

[25] Limits to the TRC; Spheres of Influence, The Limits of Canada's Truth and Reconciliation Commission, spheresofinfluence.ca/the-limits-of-canadas-truth-and-reconciliation-commission/

1.2 Land management as a pathway forward

Although the RCAP and TRC recognize the significance of First Nation culture, there is a gap in societies' understanding on how current actions or pathways support reconciliation of First Nations with their land[26]. One provision in the TRC (AFN, 2022)[27] calls upon all levels of government to adopt the UNDRIP[28]. Under Article 11, the UNDRIP states that First Nation's should have "… the right to practice and revitalize their [Indigenous] cultural traditions and customs", which, when combined with another 14 UNDRIP Articles (e.g., Article 32 states, "Indigenous peoples have the right to determine and develop priorities and strategies for the development or use of their lands or territories, and other resources" see Appendix 2) suggests that a land management system could contribute to a pathway for reconciliation with their land and embrace a relationship of First Nation land and well-being.

Federal legislation was passed June 21st, 2021, to adopt the UNDRIP[29] (S.C. 2021, c. 14) but at the provincial and territorial level, only the province of British Columbia (to date) has passed legislation[30]. While each province has their own Indigenous policies and some are working on legislation for the adoption of the UNDRIP (e.g., Ontario, Alberta), as key stakeholders on First Nation land claims, treaty land entitlement process[31] and specific land claims[32], the adoption of

[26] ibid

[27] Ontario Human Rights Commission, Indigenous spiritual practices, ohrc.on.ca/en/policy-preventing-discrimination-based-creed/11-indigenous-spiritual-practices

[28] Although the UNDRIP received royal assent to federal legislation in Canada on June 21st, 2021 (S.C. 2021, c. 14), assent came 18 years after adoption by the U.N. General Assembly. The federal government of Canada was one of four countries in the U.N. (together with New Zealand, Australia, and United States) to vote it down in 2007 (For further reading of United Nations reports see: Discrimination of Aboriginals on Native Lands in Canada Gorelick, 2007, United Nations Chronicle, UN and the UN Human Rights Committee on violations, Human Rights) and in 2010 only supported the UNDRIP as an "aspirational document" (Canadian Museum for Human Rights, UNDRIP, humanrights.ca/story/the-united-nations-declaration-on-the-rights-of-indigenous-peoples). In 2016, the federal government of Canada endorsed the UNDRIP by dropping its objector status at the U.N., but as non-binding law (Canadian Museum for Human Rights, 2022). Five years later in 2021, Bill C-15 received royal assent after being identified as one of the TRC calls to action (No. 43) in 2015.

[29] ibid

[30] British Columbia 'Declaration on the Rights of Indigenous Peoples Act www2.gov.bc.ca/gov/content/governments/indigenous-people/new-relationship/united-nations-declaration-on-the-rights-of-indigenous-peoples

Ontario is in the process as Bill 76, but Quebec won't endorse it, due to fear of veto of economic projects (Canadian Press, 2020) montreal.ctvnews.ca/legault-won-t-endorse-un-declaration-on-indigenous-peoples-fears-veto-on-economic-projects-1.5064919. Alberta has an action plan alberta.ca/united-nations-declaration-on-the-rights-of-indigenous-peoples.aspx

[31] Treaty land entitlement (TLE) process – "First Nations who did not receive all the land they were entitled to under treaties signed by the Crown and First Nations.."sac-isc.gc.ca/eng/1100100034822/1612127247664

[32] Specific land claims - "claims made by a First Nation against the federal government which relate to the administration of land and other First Nation assets and to the fulfilment of Indian treaties.."

the UNDRIP by provinces and territories would show support in understanding the First Nation position (i.e., as First Nations rely on the UNDRIP in land negotiations, AFN, 2017).

At the municipal level, some municipalities within Canada have endorsed or adopted the UNDRIP (e.g., the City of Yellowknife, Town of Fort Smith, Town of Inuvik, City of Saskatoon[33] have adopted the UNDRIP, and the Association of Municipalities Ontario - endorsing numerous calls to action in the UNDRIP, AMO, 2021), and for many other municipalities the UNDRIP is "under review"[34] (Andersen & Flynn, 2021). Although the UNDRIP is legally binding and/or endorsed at various levels of governments across Canada[35], research is needed on how current pathways in First Nation land management support reconciling First Nations with all levels of governments across Canada and reconciling First Nations with their land.

First Nations manage their reserve land under three legislative pathways that were constructed by or in collaboration with the federal government. The Indian Act, constructed by the federal government in 1876 lacks in recognition in First Nation sovereignty and autonomy over their lands: therefore, two legislative pathways were constructed in collaboration with First Nations for more control over their land outside of the Indian Act. About 4% of First Nation communities manage their land under a framework and First Nation collaboration with the federal/provincial or territorial governments on legislation for self-government, and about 16% of First Nation communities manage their land under a First Nation collaboration with the federal government on legislation called the 'Framework Agreement on First Nation Land Management Act', SC 2022, c 19, s 121 (Act) (formerly First Nations Land Management Act (SC 1999, c 24)) [36]. The Act however refers to a 'Framework Agreement on Land Management' presented by 13 First Nation Chiefs in1994 to the federal government regarding more authority over the management of their land outside the Indian Act (LABRC, 2022). A third pathway of land management which affords First Nations some control over their land is called the Reserve Land and Environment Management Program (RLEMP) being a subset of the Indian Act whereby communities work with Indigenous Services Canada (ISC) on

[33] Protocol agreement, sharing propensity through reconciliation
pub-saskatoon.escribemeetings.com/filestream.ashx?DocumentId=100495

[34] Association of Municipalities Ontario endorses UNDRIP - amo.on.ca/advocacy/indigenous-relations/municipal-indigenous-relations
tspace.library.utoronto.ca/bitstream/1807/107492/1/imfgpaper_no55_indigenousmunicipal_douganderson_alexandraflynn_september_23_2021.pdf

[35] "Centuries of rights violations have taught many Indigenous people to fear laws that promise much but deliver little" Dr. Wilton Littlechild, after the passage of the federal UNDRIP Act, Canadian Museum for Human Rights, 2022, and nctr.ca/exhibits/residential-school-timeline/

[36] The 'Framework Agreement on First Nation Land Management Act', SC 2022, c 19, s 121 (prior to December 15, 2022, First Nations Land Management Act, S.C. 1999, c. 24) is a sectoral self-governance for lands only, whereas 'framework of self-government' is all matters that includes land.

managing their land (ISC, 2021). With approximately 80% of First Nation communities that continue to manage their land under the Indian Act (LABRC, 2022[37], Fligg et al, 2021; Fligg & Robinson, 2019) further research is needed to understand how land management embraces or could embrace the UNDRIP for sovereignty and control over their lands that supports both socio-economic and cultural well-being.

1.3 Thesis Summary

This introductory chapter has laid out the context that motivated three manuscripts that form the core chapters of the thesis (Chapters 2, 3 and 4). Chapters 2 and 3 are published and Chapter 4 is submitted for publication (see Statement of Contributions). Each of the core chapters are related and build on each other to support the **overarching goal of the thesis, which is to improve societies' understanding about the relationship between First Nation land management (broadly defined, including land management systems, property rights systems, land-use policies and planning) and First Nation well-being.**

To achieve this goal, the objective of Chapter 2 was to synthesize and review existing literature and to investigate the relationship between First Nation land management systems (regimes) and their community well-being. To date, research about the relationship of First Nations land and well-being predominantly focused on socio-economic well-being (as measured by the Government of Canada's Community Well-Being Index (CWB)). For example, research that: 1) uses CWB scores based on the four Statistics Canada metrics about housing, income, education, and labour for communities across Canada (ISC, 2022); 2) postulates or explains reasons for First Nation CWB scores (Flanagan, 2019, 2019a, 2016); research on, 3) CWB scores and land tenure (Ballantyne & Ballantyne, 2016); 4) CWB scores and geographic location (Blankinship & Lamb, 2022, Ballantyne et al. 2012); and, 5) strategies for improving Indigenous CWB scores (National Indigenous Economic Strategy for Canada, 2022).

Chapter 2 contributes to these efforts by asking the question: "does the land-management regime of a First Nation correlate with differing levels of community well-being among First Nations as measured using the community well-being (CWB) index?". It also investigates if there have been temporal effects by asking the question: "do First Nation communities experience different CWB trajectories when under a particular land management regime when they transition from one land management regime to another?" To answer these questions, literature is reviewed and

[37] According to the LABRC website, 100 (approximately 16%), First Nation communities manage their lands under the FNLM regime, labrc.com/wp-content/uploads/2021/07/FAQs-July-2021.pdf (pg 4, How is the Framework Agreement ratified) and approximately 4% manage their lands under a framework of self-government (Fligg & Robinson, 2019).

synthesized on the history of First Nation land management, which identified the following three dominant regimes: the Indian Act land management (IALM); First Nations Land Management (FNLM), and frameworks of self-government land management (SGLM). The three regimes are quantitatively compared using CWB scores to determine if there are differences between regime-CWB scores and are there different rates of change in CWB scores for different regimes. Results from these efforts identified five key findings; 1) while higher levels of CWB score are found in all three land-management regimes, there is an increasing trajectory in CWB average scores from IALM, to FNLM, to SGLM communities; 2) there is a significant statistical difference between CWB average scores of the IALM with FNLM and SGLM land management regimes, 3) higher levels of CWB scores were found among communities having a formal versus an informal land tenure system; 4) increasing rates of CWB scores were found in higher scoring communities, however, the rates were higher at the lower quartile; 5) increase in CWB scores was observed in FNLM communities both prior and after transition to FNLM, however, the rate of increase slowed down after transition.

Building on Chapter 2, Chapter 3 looks deeper into First Nation land management, land-use practices, policy and planning, and property rights through collaboration with a First Nation community. In recent years there has been mounting research on cultural well-being about: 1) the lack of inclusion of cultural well-being in the CWB index (Guthro, 2021, Bouchard et al, 2021); 2) the relationship of land and self-determination, and a need for a “more holistic model” (Cameron et al, 2019, P.14); 3) land relationship and cultural well-being (Nightingale & Richmond, 2022); and 4) land and elder contribution in well-being (Viscogliosi et al 2020). To contribute to this area of scientific inquiry, the objective of Chapter 3 was to investigate First Nation member-type (i.e., land holder vs non-land holder, and ‘on’ vs ‘off-reserve’ members) land management knowledge, and the impact member type has on land management and land-use practices.

To achieve the objective of Chapter 3, a social survey was created in collaboration with Curve Lake First Nation (CLFN). I selected CLFN for various reasons: the location of CLFN, being close to where I reside for more personal contact; as a Canada Lands Surveyor I performed work at CLFN and I knew that CLFN managed their land under the Indian Act (before being under RLEMP); and my pre-investigation indicated various land issues at CLFN (e.g., disorderly and haphazard development, land management capacity, and no land-use plan) according to a Comprehensive Community Plan (CCP) study done in 2009.

The social survey comprised a number of land related questions about member knowledge and opinions related to their community land management system, land-use policy and planning, existing land-use practices, property rights system, and on general well-being, and was completed

by 156 members of CLFN. These responses were coded and used to determine whether any disconnect among First Nation members about community accepted land-use practices and formal policy was correlated to formal or informal policy in land management, and 2) whether there was a gap between members "wants and needs" regarding what should happen according to policy or process (formal) and what actually happens on the ground (informal). By exploring formal and informal (sanctioned/unsanctioned) policies and practices in land management that relate to both land-use and land tenure the research was able to answer the question if the aforementioned disconnect among community members was due to uncertainty in policy and community accepted land-use practices.

Results from Chapter 3 suggest that CP[38] holders and non-CP holders agreed that all parcels should be managed/used according to community values. There was similar agreement between on-Reserve members and off-Reserve members. However, there was little understanding of existing land tenure and land management regimes, and much uncertainty about the distinction between formal and informal land-use. Further analysis revealed, on the one hand, there was a significant difference in knowledge about how Reserve land may be used between CP holders and non-CP holders, and between on-Reserve and off-Reserve members. We refer to this difference as a disconnect and found a correlation between informality and disconnect. On the other hand, there was no disconnect about the need for formal land-use policies and bylaws, which finding supports the CLFN community while they are in the process of developing a land-use plan.

The research for Chapter 2 provides us with a better understanding about First Nation land management and well-being and Chapter 3 elucidated member perspectives about land management policies, plans, land tenure, and other aspects of the land system. However, there still remains a gap in societies' understanding about the relationship between First Nation land and their community well-being. This gap is due to the more than 150 years of western laws, influence and policies in First Nation land management with predominantly a focus on socio-economic well-being, even though in more recent years there has also been a focus on cultural well-being (e.g., by 'calls to action' under the TRC, and 'articles' under the UNDRIP). How to embrace both socio-economic and cultural well-being within First Nation land management is not well-understood and therefore there is a gap in societies' understanding.

Chapter 4 takes a step toward filling this gap in societies' understanding by utilizing the knowledge and data from Chapters 2 and 3 in the development of a First Nation land-use voting

[38] a certificate of possession (CP), is evidence of possessory title by a member of the First Nation to a parcel of land on reserve land as defined under the Indian Act.

model (FN-LUVM). The objective of Chapter 4 was to investigate how formal individual support for land policy and community land objectives could be conceptualized as indicating collective well-being. Chapter 4 investigated the objective by asking research questions on "how different member-levels of propensity for land information knowledge, ambition, stewardship, and how they collaborate affect formal land-use plan and potential land-policy adoption", and secondly "how relationships and changes in members' knowledge and attitudes affect support of formal land-use policy and its potential adoption?"

To achieve this objective, a conceptual model was designed around community engagement, an activity where members interact to discuss and possibly collaborate on their knowledge and opinions about land-use matters. Community engagement is also an activity for members to learn, transfer knowledge, and be influenced by key members in the community (e.g., Elders; Chief & Council, First Nation governance, and committees; and youth) about systems of land management and property rights, land-use policy and planning, and about community objectives on socio-economic and cultural well-being. Responses to the CLFN social survey (as previously mentioned, for Chapter 3) was further coded for member responses on land related questions about their community, and outside community, on systems of land management and property rights, land-use policy and planning, and opinions on well-being that could be used to empirically inform the First Nation land-use voting model (FN-LUVM). FN-LUVM contributes to scientific inquiry by assisting with answering the research questions. This is achieved by providing feedback - on individual members and the collective on land knowledge and attitude on land matters - in relation to community objectives about socio-economic and cultural well-being. The feedback is interrogated on how members might vote in one of four categories being; yes, no, abstaining, or not voting, in support of community objectives to adopt a potential land-use plan and policies, and interrogated on attitude in land stewardship, ambition (on land development) and collaboration.

Key findings at CLFN suggest a correlation of high land stewardship[39] with adopting a potential land-use plan. Although land stewardship increases as land knowledge increases, the process of learning (e.g., by community engagement) about land matters may only be an option for some members (e.g., limitations, such as personal, or possibly funding). Analysis of results from various scenarios derived from FN-LUVM identified an alternate pathway when the process of learning in community engagement has limitations and suggests that the key influencers (e.g., Elders; Chief & Council, First Nation governance and committees; and youth) play an increased role in member

[39] High land stewardship at CLFN considered three criteria: 1) CLFN vision statement on land stewardship , 2) a value greater than the initial average value of the respondents to the 2019 CLFN land-use survey, and 3) a value generally thought to be above 80 out of 100. For further information see Chapter 4.

attitude about land related matters in the support to adopt a potential land-use plan. Finally, further to our findings in Chapter 3 about member disconnect (among member types on land matters), Chapter 4 explored this disconnect and found a decrease in CP and non-CP holder disconnect with an increase in member land knowledge and less uncertainty that resulted in greater support to adopt formal land-use policy and planning.

The research for Chapters 2, 3 and 4 provides us with a better understanding about the overarching goal of the thesis and culminates in Chapter 4 by modelling and investigating the member/community perspective on land matters in relation to the collective well-being of a First Nation community.

1.4 Concluding remarks

The laws that were in place before colonization in Canada (known by some Indigenous people as part of Turtle Island[40]), and before the Indian Act, and other legislation that governs the use of First Nation land (e.g., Environmental Protection Act, S.C. 1999, c. 33) are now referred to as inherent rights[41]. Although the Government of Canada recognizes inherent rights under Section 35 of the Constitution Act, 1982[42] (being the rights that existed before colonization), cultural loss in land as a result of colonization (e.g., loss of traditional land-use areas and land-use practices) presents a challenge to prove the rights ever existed[43]. Cultural loss due to colonization not only resulted in the loss of traditional land base (Fligg & Robinson, 2019), but it has resulted in loss of First Nations cultural relationship with their land[44] e.g., by land-use practices that are not condoned by the community or unsanctioned (Fligg et al., 2021). Although government recognition of inherent rights supports First Nation control over their land under the various land management regimes (e.g., frameworks of self-government, FNLM, and RLEMP), more research is needed to understand the relationships of these land management regimes with socio-economic well-being (as measured by the CWB index) and cultural well-being (e.g., guided by First Nation land stewardship), and to understand the difference between reconciling First Nation relationships with non-Indigenous people and governments, and reconciling First Nation relationship with their land[45]. The difference

[40] Canada is part of Turtle Island, being North America.
[41] Further reading on inherent rights: fngovernance.org/our-inherent-rights/
[42] Enacted as Schedule B to the Canada Act 1982, 1982, c. 11 (U.K.), which came into force on April 17, 1982.
[43] constitutionalstudies.ca/2019/07/aboriginal-self-government-2/
[44] briarpatchmagazine.com/articles/view/land-as-a-social-relationship
un.org/development/desa/indigenouspeoples/mandated-areas1/culture.html
[45] spheresofinfluence.ca/the-limits-of-canadas-truth-and-reconciliation-commission/

being, the First Nation inherent right to a profound spiritual connection and symbiotic relationship with their land[46], whereby everything is connected[47] and to protect Mother Earth[48] (AFN, 2022).

The presented research contributes to these efforts to not only monitor the relationship of First Nation land and their well-being, but provide feedback on the various actions that support: 1) First Nation well-being (e.g., by land management regimes, such as frameworks of self-government, FNLM, and RLEMP); 2) actions that support decolonization in land (reverse the injustice in Indigenous land, Stadnyk, 2023) through reconciliation of First Nations with their land (Report on a National Forum on Reconciliation, 2016). With the various aforementioned research and actions that have taken place and are taking place that support First Nation well-being, and on the decolonization and reconciliation with their land, there is a need to interrogate the research about what has been done (on the relationship between First Nation lands and well-being) and what continues or remains that would assist in societies' understanding.

It is hoped that the presented research within this thesis advances societies' understanding about First Nation land and well-being. However, more importantly, it is hoped that the presented research and outreach via publications provides a catalyst for others to engage and build upon these efforts to advance our scientific understanding, provide additional decision-making capacity for First Nations, and in some small way aid in the efforts of reconciliation.

[46] Assembly of First Nations, Honouring Earth, afn.ca/honoring-earth/
cepf.net/stories/indigenous-peoples-and-biodiversity-symbiotic-relationship
ictinc.ca/blog/first-nation-relationship-to-the-land
cca.qc.ca/en/articles/80853/mikwayndaasowin-remembering-that-which-was-there-before
unep.org/news-and-stories/story/indigenous-peoples-and-nature-they-protect

[47] supra note 10

[48] afn.ca/honoring-earth/

Chapter 2. Reviewing Canadian First Nation Land Management Regimes and Exploring their Relationship to Community Well-Being

2.1. Introduction

Land and systems of land management provide a foundation for governance (FAO, 1999, 2002) and socio-economic development (Appiah-Adu & Bawumiah, 2015). A key factor in socio-economic development is a formal land-tenure system, where title to defined parcels is well documented (Ballantyne et al, 2014) and security of tenure attracts investment in land (Aragon, 2015; Dale, 1997, De Soto 2000). Despite the existence of formal and informal land-tenure systems, few are aware that multiple versions of these systems operate within Canada due to the presence of Indigenous lands.

Indigenous lands often differ in land management and tenure from non-Indigenous lands, and they often vary among each other (Alcantara, 2003). Our understanding and awareness of Indigenous lands is limited, in part, due to heterogeneity in governance and land tenure among these land systems and how it subsequently affects socio-economic development. While literature abounds on the significance of governance, land tenure, and socio-economic development in a land management system (e.g., by De Soto, 2000, Appiah-Adu & Bawumiah, 2015, FAO 1999, 2002, Ballantyne et al, 2014, Ballantyne & Ballantyne, 2016, Alcantara, 2003, Flanagan 2015, 2016, and Flanagan & Harding, 2016), empirical evidence is lacking that describes the relationship among these attributes that have led to heterogeneous land management systems and differences in well-being among communities on Indigenous lands.

The origins of many of the Indigenous land management systems around the world can be traced back to Europeans following colonization by treaty (Strelein & Tran, 2013; RCAP, 1996) or by conquest (Reynolds, 1981, 2006). However, in recent years inherent rights of Indigenous people (that is, pre-existing rights that First Nations had prior to European settlement) in a global context have been addressed under the United Nations Declaration on the Rights of Indigenous People (UNDRIP) (Coates & Mitchell, 2013; Strelein & Tran, 2013, Pentassuglia, 2011). The UNDRIP has brought attention to the importance of recognizing indigenous inherent rights (INAC, 2016) in governance, land tenure, and socio-economic development on Indigenous lands.

Canada officially adopted the UNDRIP In 2016 with 3 Aboriginal[49] peoples defined under Section 35 of the 1982 Constitution Act as: Indians (known as First Nations), Métis, and Inuit. The largest Indigenous peoples in Canada are First Nations (StatsCan, 2016). Nearly all First Nations

[49] Aboriginal, Indigenous and Indian are used in this paper synonymously.

were initially governed under federal legislation called the Indian Act[50], which limited and still limits First Nation governance over their land (Warkentin & Canada, 2014; Millette, 2011). Recently, First Nations have had alternatives to 1) opt out of sections of the Indian Act on land management and manage their land under the First Nations Land Management Act, Statute of Canada (S.C.) 1999 (Warkentin & Canada, 2014) or 2) govern their own land by way of comprehensive land claims, modern treaty and self-governing agreements with provincial or territorial and federal governments (Warkentin & Canada, 2014; Wherrett & Canada, 1999).

As of July 15, 2019, approximately 84% of First Nations managed their lands under the Indian Act, 12% under the First Nations Land Management (FNLM) Act, and 4% under a form of self-governance[51].

Given a lack of discussion in academic literature about the heterogeneity in land-management regimes on First Nation lands and linking these regimes to First Nation community well-being; we synthesize and review the history of land management regime creation in Canada and their unique characteristics. We then investigate the relationship between land-management regimes and community well-being by answering the following question: does the land-management regime of a First Nation correlate with differing levels of community well-being among First Nations as measured using the community well-being (CWB) index? We also investigate if there have been temporal effects by answering the question: do First Nation communities experience different CWB trajectories when under a particular land management regime or when they transition from one land management regime to another? We conclude with a broader discussion about the relationship among land management regimes and varying rates of change and higher levels of CWB.

2.1.1 Background

The 1763 Royal Proclamation is the first known official document to recognize First Nations rights and title to land In Canada (RCAP, 1996; Slattery 2014, 2015), which ensured First Nations' land could not be taken without surrender and government consent. For 51 years following the Royal Proclamation, the British military relied on First Nations support until the end of the war of 1812 (INAC, 2010). After the war this relationship changed from First Nations being a military ally to being under the auspices of civil control and a ward of the state (Makarenko, 2008a; Hanson,

[50] Indian Act (R.S.C., 1985, c. I-5)

[51] As of July 15, 2019; percentages are based on 630 First Nation Communities (CIRNA, 2017). The number of First Nations operational under the FNLM regime is 78 (54 are in the developmental stage). The IALM regime includes communities operating under sections 53 and 60 of the Indian Act, now under the Reserve Land and Environment Management Program (RLEMP) described in Section 2.2.1 of this paper - The Indian Act Land Management regime.

2009a). While land was required for settlement, the British realized a responsibility under the Royal Proclamation to protect First Nations from land grabs and trespass by European settlers (Woroniak & Camfield, 2013; McNab, 1999). What followed was paternalistic legislation governing First Nations affairs and their land starting in 1839 with the Crown Lands Protection Act authorizing the government as guardian of Crown lands including land set aside for First Nations. For example, Eurocentric reserves were created for First Nation housing and agriculture without consultation and knowing their customs and traditions (Dorsett & Godden, 1998). In an effort to assimilate First Nations into a British way of life, the Gradual Civilization Act in 1857[52] encouraged literate Indians to give up their traditional ways, Indian status, and live a civilized lifestyle as a British citizen. Local governments then took control and managed their land under the Management of Indian Land and Property Act[53] enacted in 1860 (known as the Indian Land Act) (INAC, 1978) and with the passing of the Constitution Act in 1867 First Nations fell under the auspices of the Federal Government of Canada[54].

Following the passing of the Constitution, First Nations were encouraged to give up their Indian Status to become citizens of Canada and patent[55] their parcels of land outside of the reserve system under the Gradual Enfranchisement of Indians Act in 1869[56] (AANDC, 2010, 2013d; Brinkhurst, 2013). Legislation concerning First Nations was then consolidated into the first federal Indian Act, enacted in 1876[57] (Scholtz, 2004; Brinkhurst, 2013). This was the start of a land management approach referred to as the Indian Act Land Management (IALM) Regime, implementing a land-tenure system (Brinkhurst, 2013) to convert First Nations lands from a communal system of ownership to a more individual system based on possessory rights.

Despite First Nation objections to legislation that controlled their affairs and governed their land (Coates, 2008), 75 years passed before significant amendments were made to the Indian Act. In 1951 sections of the Act were repealed, in particular one that prohibited raising money in support of land claims, and the elimination of an Indian Agent, a Government appointee under the Indian Act to oversee First Nation governance (AANDC, 2013d). In 1982, recognition of First Nations rights was re-affirmed in section 35 of the Constitution Act (Schedule B to the *Canada Act 1982* (UK), 1982, c 11.) stating:

[52] An Act for the Gradual Civilization of the Indian Tribes in the Canadas. Statutes of Canada 1857, c. 6 (20 Vict.)

[53] An Act respecting the Management of the Indian Lands and Property. Statutes of Canada 1860, c. 151 (23 Vict.).

[54] under Section 91(24) of the Constitution Act, 1867 (formerly the British North America Act)

[55] A transfer of Crown land to a private owner (www.ontario.ca/page/crown-patents).

[56] An Act for the gradual enfranchisement of Indians, the better management of Indian affairs, and to extend the provisions of the Act 31st Victoria, Chapter 42. Statutes of Canada 1869 c. 6 (32-33 Vict.).

[57] An Act to amend and consolidate the laws respecting Indians, S.C. 1876, c. 18 (known as the Indian Act)

"35. (1) The existing aboriginal and treaty rights of the aboriginal peoples of Canada are hereby recognized and affirmed.

(2) In this Act, "aboriginal peoples of Canada" includes the Indian, Inuit and Métis peoples of Canada.

(3) For greater certainty, in subsection (1) "treaty rights" includes rights that now exist by way of land claims agreements or may be so acquired.

(4) Notwithstanding any other provision of this Act, the aboriginal and treaty rights referred to in subsection (1) are guaranteed equally to male and female persons."

In 1985, the Indian Act repealed sections on enfranchisement and included provisions for delegation of responsibility and control over land management to First Nations (AANDC, 2013d; Coates, 2008). Despite these changes the Indian Act still contains statements regarding authority and approvals required by the Minister of Indian Affairs and Northern Development Canada[58] (the Department) on land transactions, regulations, and by-laws (e.g., Indian Act R.S.C., 1985, c. I-5. s. 20, 24, 54 and 83; for explanation see Coates, 2008; AANDC, 2013c, 2013d). Although gradual transfer of control may be viewed as a positive step, some First Nations have moved to alternative regimes that offer more control and authority over their land outside of the Indian Act.

In 2014, the land base of First Nations in Canada was approximately 3.5 million hectares (AANDC, 2014b), an increase of 12% from 2006 (AANDC, 2014b) and continues to increase (CIRNAC/ISC, 2017). Approximately 630[59] of 3,247 reserves[60] (CIRNA, 2017; StatsCan 2016) are used for communities by approximately 50 distinct First Nation and language groups (AANDC, 2014b; AFN, 2016; CIRNAC, 2017). Approximately half of all First Nation communities across Canada are found in the Western Provinces of British Columbia, Alberta, Saskatchewan and Manitoba; approximately one-quarter within Ontario and one-quarter in Quebec, Atlantic Provinces and Territories.

[58] The Department of Indian Affairs and Northern Development Canada (DIAND) is referred to under the Indian Act, however, has been known by other names. In August 2017, the Prime Minister announced the dissolution of Indigenous and Northern Affairs Canada (INAC) and the creation of two new departments: Indigenous Services Canada (ISC) and Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC). The term "the Department" is used throughout this paper and refers to the legal name, and known names.

[59] Approximately 630 First Nation bands.

[60] According to 2016 Statistics Canada, reserves across Canada number more than 3,247, an increase from the 2011 Statistics Canada number of 3,100. Brinkhurst & Kessler (2013) found reserves with the same Administrative Land Identifier and with these removed the number of reserves in 2011 was 3,003.

2.2. Regimes of Land Management and Property Rights

First Nation lands in Canada reside in one of three land-management regimes: Indian Act Land Management (IALM) regime[61], First Nations Land Management (FNLM) regime, and various frameworks of self-governing land management (SGLM). These regimes differ in terms of their governance, land tenure, and socio-economic development (see "1. Table A.1" in the Supplementary data, on-line Appendix for a summary of land management regimes). This section reviews the legislation that sanctions each land management regime and the property rights systems under which First Nations operate.

2.2.1 The Indian Act Land Management Regime

The Indian Act (R.S.C. 1985, c. I-5, last amended April 2, 2015) is (federal) legislation that sanctions the most widely used land management regime by First Nations. The Minister of Indigenous Services Canada, and Minister of Crown-Indigenous Relations and Northern Affairs[62] (see "2. Table A.2" in the on-line Appendix, Supplementary data for terminology) is responsible for administering the Indian Act as well as "any other Act of Parliament relating to Indian affairs" (RSC 198 c. I-6, s. 3).

Approximately one third of the Indian Act (43 sections of 122) relates to land management, resources, and the environment (for further information see "3. Table A.3" in the on-line Appendix, Supplementary data). The remaining two thirds of the Indian Act (sections 1-17, 32, 33, 43 to 48, 50 (excluding 50 (4)), 51, 52, 61 to 65, 67, 68, 72, 74 to 80, 82 to 86, 88, 91, 92 and 94 to 122) are not specific to land, resources or environmental management, and are not discussed within this paper.

The land tenure system under IALM has been proven to have a negative impact on socio-economic development (Flanagan & Alcantara, 2002, 2004; Flanagan, Alcantara & Le Dressay, 2010); however, the extent of that impact remains a subject of ongoing discussion (by First Nations and First Nation scholars; e.g., Flanagan, Alcantara & Le Dressay, 2010). The main focus of their discussion is that title on non-reserve land maybe held in fee simple[63], whereas title on reserve land is held in trust by the Crown. Under the Indian Act, the Crown may grant First Nations a possessory title to land with evidence of title called a certificate of possession (CP; for additional information see "3.Table A.3" in the on-line Appendix, Supplementary data, Sections 19 and 20;

[61] Includes the Reserve Land and Environmental Management Program (RLEMP, 2015).

[62] Supra note 58

[63] Fee Simple is the "The maximum possible interest (estate) one can possess in real property" The fee simple estate has unlimited duration and can be passed on to heirs. The Complete Real Estate Encyclopedia by Denise L. Evans, JD & O. William Evans, JD. Copyright © 2007 by The McGraw-Hill Companies, Inc.

and 1.Table A.1.b). Certificates of Possession (CPs) are part of a formal property rights system where evidence of title is registered in a legally recognized land registry that is sanctioned under the Indian Act. While CP lands are inheritable and can be leveraged to a First Nation band council or another First Nation member (Alcantara, 2007; additional information see "3.Table A.3" in the on-line Appendix, Supplementary data, Section 89), CP lands cannot be leveraged like fee simple lands for business loans, which restricts economic land-development opportunities.

Development of a formal land-tenure system on First Nation land was a recommendation in the Bagot Commission of 1842 to 1844 (Dickason, 1997; Alcantara, 2003). This recommendation was adopted in the first Indian Act of 1876 to encourage individual land ownership on reserves and facilitate a change from a communal to an individual land holding system. The introduction of a Western society system of land management (Slattery, 2014) was not familiar to the traditional ways of many First Nations and was viewed by them as a step towards integration and assimilation with the rest of the country (INAC, 2010; AANDC, 2013d).

Since the introduction of the Indian Act in 1876 until 1951, two forms of evidence of title were used called a location ticket[64] and the cardex system[65] (Ballantyne, 2010; Chen, 2015; Alcantara, 2003). These forms of evidence were not well documented and the location of property rights within a reserve was based on a 'location sketch' (LS or LTS) of unknown accuracy (Ballantyne, 2010). In 1951, the CP replaced prior title documents providing greater security of title with an improved description of land title (Alcantara, 2003), location of a parcel of land based on surveyed information (Ballantyne, 2010), and the recording of CP's in the Indian Lands Registry System (ILRS).

The lack of security of land tenure on reserves has been raised as a potential drawback for economic development (Flanagan, Alcantara & Le Dressay, 2010) although the Department has an obligation under the Indian Act to maintain a land registration system and approve land transactions ("3.Table A.3", section 21 in the on-line Appendix, Supplementary data). The system maintained by the Department for recording possessory rights in land in the ILRS has some similarities to the system of recording fee simple property ownership in a land titles or Torrens land registration system found in Provinces and Territories. For example: 1) both systems have a Parcel

[64] Location Ticket is "a document issued under the Indian Act, 1880 or any statute relating to the same subject matter, which is evidence of a person's lawful possession of reserve lands" (Land Management Manual, 3-1 pg 4, INAC, 2002)

[65] Cardex System is a "a historical individual interest in reserve land created by Band Council Resolution and approved by the Minister under Section 20(1) of the Indian Act. The legal land descriptions associated with Cardex Holdings were vague and often inaccurate. The interest of the holder of a Cardex holding is considered lawful possession under the Indian Act, however, no evidence of title is issued (NETI) until the land is surveyed" (Land Management Manual 3-2, pg 7, INAC, 2002)

Identification Number (PIN) assigned to an individual land holding (i.e., parcel of land) that provides an efficient method for searching title, and 2) title to parcels of land are shown on plans of survey. For off-reserve lands, plans of survey are recorded in the land registry office (LRO), managed by provincial or territorial government, whereas, surveys of reserve land are recorded in a repository known as the Canada Lands Survey Records (CLSR) managed by Natural Resources Canada, Surveyor General Branch (Ballantyne, 2010). While a formal land tenure system under the Indian Act offers a higher level of security of land tenure, it does not offer a guarantee of title (Warkentin & Canada, 2014). A guarantee of title is found in Provincial or Territorial land titles or Torrens systems and is based on the "mirror principle" (Dixon, 2016, 2012) where one can rely on the title description and does not have to search behind it.

In addition to the CP, another type of land holding sanctioned under the Indian Act and used by First Nations to attract outside off-reserve investment is leasehold. A First Nation band or CP land holder is able to lease their land to non-First Nations without the land losing reserve status. A leasehold title may be viewed as being more secure than a CP (Alcantara, 2007) as the land is managed by the Department and the lessor is the Crown (INAC, 2002). A lease can be mortgaged and is subject to seizure ("3.Table A.3", section 89 in the on-line Appendix, Supplementary data; Warkentin & Canada, 2014).

Despite the formality of land tenure offered through CPs, 50% of First Nations[66] (AANDC, 2011) do not use CPs and instead use an informal system of property rights referred to as customary allotments that may be recognized by a First Nation band (and may be recorded locally by the First Nation), but such property rights are not sanctioned under the Indian Act (Johnstone v Mistawasis First Nation, 2003[67]; Warkentin & Canada, 2014). Within this system, individual land holdings are managed internally (Brinkhurst & Kessler 2013; Alcantara, 2007) and are subject to the risk of being used by band council or the government for community purposes (Alcantara, 2007). An informal system lacks security of title (Flanagan, Alcantara & Le Dressay, 2010) due to poor documentation and often unsurveyed land holdings (Alcantara, 2007). The lack of security of tenure makes these lands less desirable to outside off-reserve investors resulting in less local economic-development.

While sections of the Indian Act state that land transactions require approval by the Minister (see "3. Table A.3", section 24, in the on-line Appendix, Supplementary data) there are sections of the Act that provide delegation of responsibility to First Nations over management of their lands

[66] Based on ILRS information dated January 2016 (ILRS, 2016), approximately 381 First Nation reserves use CP's as evidence of title. AANDC (2011) reports 50% of First Nations use CP and 50% customary allotment.

[67] Johnstone v. Mistawasis First Nation, 2003 SKQB 240

(referred to as 53/60 delegation[68] - see “3. Table A.3”, sections 53 and 60 of the Indian Act, in the on-line Appendix, Supplementary data). Further, under section 81 of the Indian Act, a First Nation council has the power to enact by-laws over many areas that are similar to those seen in Municipalities (e.g., under the Municipal Act, in Ontario, S.O. 2001, Chapter 25). While First Nations have the ability to pass by-laws, most First Nations have not done so (or passed very few) due to the lack of capacity to enforce them (Edgar & Graham, 2008).

In 2009, Aboriginal Affairs and Northern Development Canada (AANDC) implemented a program under the Indian Act called the Reserve Land and Environment Management Program (RLEMP). The objective of RLEMP is “to enable First Nation communities to develop and sustain land, natural resources and environmental management expertise”(RLEMP, 2015, pg 6) and to enable the transfer of decision-making responsibilities of land management from the Department to First Nations. The RLEMP program offers two distinct levels of land management, “operational” and “delegated” replacing the Department’s previous programs called the Regional Lands Administrative Program (RLAP) and the 53/60 delegated program[69].

Under the “operational” level of RLEMP, First Nations have more control over their land and work with the Department on transactions, land use planning and environmental control, but land transactions still require Ministerial approval; whereas First Nations under the “delegated“ level have the ability to approve land transactions (AANDC, 2013c, 2014a).

2.2.2 First Nations Land Management Regime

In 1994, 13 First Nation chiefs presented a Framework Agreement to Indian and Northern Affairs Canada to manage their lands outside of the Indian Act. The Framework Agreement was signed in 1996 and specified that a First Nation’s land code sets out the “rights and powers” over their land, but does not constitute a treaty within the meaning of section 35 of the 1982 Constitution Act (LABRC, 2019, Framework-Agreement). The Framework Agreement was ratified in 1999 with 14 First Nations signatory to the First Nations Land Management (FNLM) Act (S.C. 1999, c.24) (summarized in “4. Table A.4” in the on-line Appendix, Supplementary data). While First Nations have more authority and control over their land than under the Indian Act (Louie, 2013, 2014), the land remains in reserve status as under the Indian Act whereby the Federal Crown holds title to reserve land in trust. Existing land holdings under the Indian Act (e.g., CP’s that were registered

[68] Refers to Sections 53 and 60 of the Indian Act that allows delegation of certain transactions normally done by the Department (CIRNAC/ISC). First Nations with delegated authority act on behalf of the Minister, subject to all legislation, regulations and departmental policies (INAC, 2002). The 53/60 program has been replaced by RLEMP.

[69] ibid

in the ILRS or customary allotments, see “4. Table A.4”, section 6, in the on-line Appendix, Supplementary data) may be brought forward with formal rights (CP’s) moved from the ILRS to the First Nations Land Registry System (FNLRS) maintained by the Department (“3. Table A.3”, section 25, in the on-line Appendix, Supplementary data).

Initially 24 sections[70] or approximately one third of the Indian Act regarding the management of land were replaced (“3.Table A.3” in the on-line Appendix, Supplementary data) by a First Nation’s land code tailored to their system of land management, economic-development, resources and environmental management (Warkentin & Canada, 2014; AANDC, 2013f; Louie, 2013). While the Crown’s fiduciary obligation diminishes as First Nations implement responsibilities under their land code, the Crown has a fiduciary obligation for sections of the Indian Act that still apply, e.g., social security, and health and welfare benefits (AANDC, 2013f). The FNLM Act is not only about opting out of sections of the Indian Act on land management, but First Nations must include in their land code an environmental plan and laws (see “4. Table A.4”, sections 21 and 40, in the on-line Appendix, Supplementary data) that are not dealt with under the Indian Act. As of July 15, 2019, 78 First Nations were operational under the FNLM Act (LABRC, 2019) and approximately 54 in the developmental stage (e.g., those First Nations preparing for a community vote to determine if they should move under the FNLM regime, AANDC, 2013e, 2013f).

Although First Nations under the FNLM regime are still governed by approximately two thirds of the Indian Act, there are many potential benefits of opting out of sections of the Indian Act and moving under this regime for land management. Some benefits, as set out in a First Nations land code, include increased environmental protection; no provincial or municipal expropriation of land (First Nations may negotiate an exchange of lands); restricted federal expropriation of land; ability to increase security of land tenure; ability to leverage properties; and land-transaction approval is not required by Indigenous Services Canada (the Department). The approval of land transfers and dispositions under the IALM regime was a time-consuming process, whereas under the FNLM regime the Department is not involved (Alcantara, 2007). Furthermore, under the FNLM regime, First Nations have greater authority over their land relative to the IALM regime, e.g., the ability to create and enforce laws about their land that align with their traditions and inherent rights. While these benefits increase the potential for socio-economic development that is not possible under the Indian Act (Alcantara, 2007; Louie, 2013, 2014; Warkentin & Canada, 2014), they are dependent on each community’s ability to exercise them under the land code.

[70] The 1999 FNLM Act indicates 24 sections are replaced; however, AANDC (2013f) reports 32 sections of the Indian Act are replaced by a First Nations land code under the current Framework Agreement.

2.2.3 Self-Government Land Management Regime

The first Self-Governing First Nations involved nine Cree First Nation communities and one Naskapi First Nation (Province of Quebec) as a result over the First Nations asserting their rights over traditional lands during the James Bay Hydro project initiated in 1973[71]. An agreement was arrived at in 1975 between the Cree First Nation, Governments of Canada and Quebec, the James Bay Development Corporation, the James Bay Energy Corporation and Hydro Quebec (James Bay Northern Quebec Agreement, JBNQA) followed by a subsequent agreement included the Naskapi First Nation[72] in 1978.

Further to the Cree-Naskapi agreement, self-Government became a viable option for First Nations in 1985 when the Federal Government passed the "Inherent Right Policy". The policy was the outcome of the Penner report in 1983 that expressed Indigenous request for greater authority over their land and precursor to the first Self-Governing legislation in 1984 (Wherret & Canada, 1999). Since then numerous Federal Acts have been passed to implement each Self-Government framework with approximately 22 (Indigenous) agreements signed with the Federal Government. The list includes eight First Nation Self-Government frameworks: the Westbank First Nation Self-Government Act (S.C. 2004); the Yukon First Nations Self-Government Act (S.C. 1994) implementing 11 First Nation agreements; Sechelt Indian Band Self-Government Act (S.C. 1986); 9 Cree communities and 1 Naskapi community under the Cree-Naskapi (of Quebec) Act (S.C. 1984); Nisga'a Final Agreement Act (S.C. 2000); Tsawwassen First Nation Final Agreement Act (S.C. 2008) and Tsawwassen First Nation Land Act (S.C. 2009); the Maa-nulth First Nations Final Agreement Act (S.C. 2009) and Miawpukek First Nation Self-Government agreement, implemented in 1999. There are approximately 90 negotiations tabled for self-government across the country at various stages (AANDC, 2015b)

A framework of self-governing land management can be achieved through one of two approaches. The first approach is a comprehensive land claim process, referred to as modern treaties (Coates, 2008; INAC 2010). This approach involves First Nations entering into agreements with both the governments of Canada and the Province or Territory in which they are situated (Wherrett & Canada, 1999). The second approach, which applies only to reserves, involves transitioning from under the IALM or FNLM regimes to a self-governing framework (Wherrett & Canada, 1999; Warkentin & Canada, 2014). Unlike the land codes used under the FNLM, most

[71] The Cree-Naskapi (of Quebec) Act (S.C. 1984) implements The James Bay and Northern Quebec Agreement (JBNQA) signed on November 11, 1975 by; the Cree and Inuit peoples of Quebec, the governments of Canada and Quebec, the James Bay Development Corporation, the James Bay Energy Corporation and Hydro Quebec. https://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-HQ/STAGING/texte-text/cin00_1100100030849_eng.pdf (1998-1999, Annual Report, pg 7).

[72] The Naskapi First Nation was included in the JBNQA after signing the Northeastern Quebec Agreement in 1978.

self-governing First Nations prepare a constitution that sets out additional rules to their legislation and agreement. Since each framework for self-government is distinct for each First Nation a variety of pathways within these two general approaches have been taken (for additional information see Supplementary Data, on-line Appendix, 5. Self Governing Examples; 7. Examples under the 3 Land Management Regimes; 8. Milestone Cases).

2.3 Community Well Being

Measuring and representing socio-economic development is challenging (Milenkovic et al, 2014) and unique challenges are found in computing a meaningful measure of social-economic well-being for First Nation communities in Canada. A numeric indicator of the socio-economic well-being of a community used within Canada is called the index of community well-being (CWB). This indicator is based on the United Nations Development Programme's "Human Development Index" (HDI)[73], which is used to measure well-being in approximately 170 countries (AANDC, 2015a, CWB index). The CWB index compliments the HDI by using community information on housing conditions, labour force activity, income and education (AANDC, 2015a) and is represented on a scale from 0 (lowest) to 100 (highest). While the CWB suffers from an arbitrary equal weighting among the four components of which it is comprised and has aggregated interpretation (Flanagan 2016) to observable measurements, as well as misses other types of variables related to preferences and satisfaction, it provides a tractable and consistent index over time that represents a good base line.

Attributes of the CWB index (those related to housing, income, labour and education) and how they are combined for a CWB score of a community is explained in literature, e.g, Flanagan, 2016; AANDC, 2015a. We explore if a relationship exists between the CWB index with land governance (Appiah-Adu & Bawumiah, 2015) in terms of the 3 land management regimes.

Not all First Nations have reported CWB scores, including several large Iroquois First Nations, for example, Six Nations of the Grand River, Province of Ontario (approximate reserve population of 12,271); the Mohawks of Akwesasne, Provinces of Ontario and Quebec (approximate reserve population of 8,857), and Kahnawake Mohawk Territory, Province of Quebec (approximate reserve [population of 8,000); also, CWB scores excludes communities with a population of less than 100.

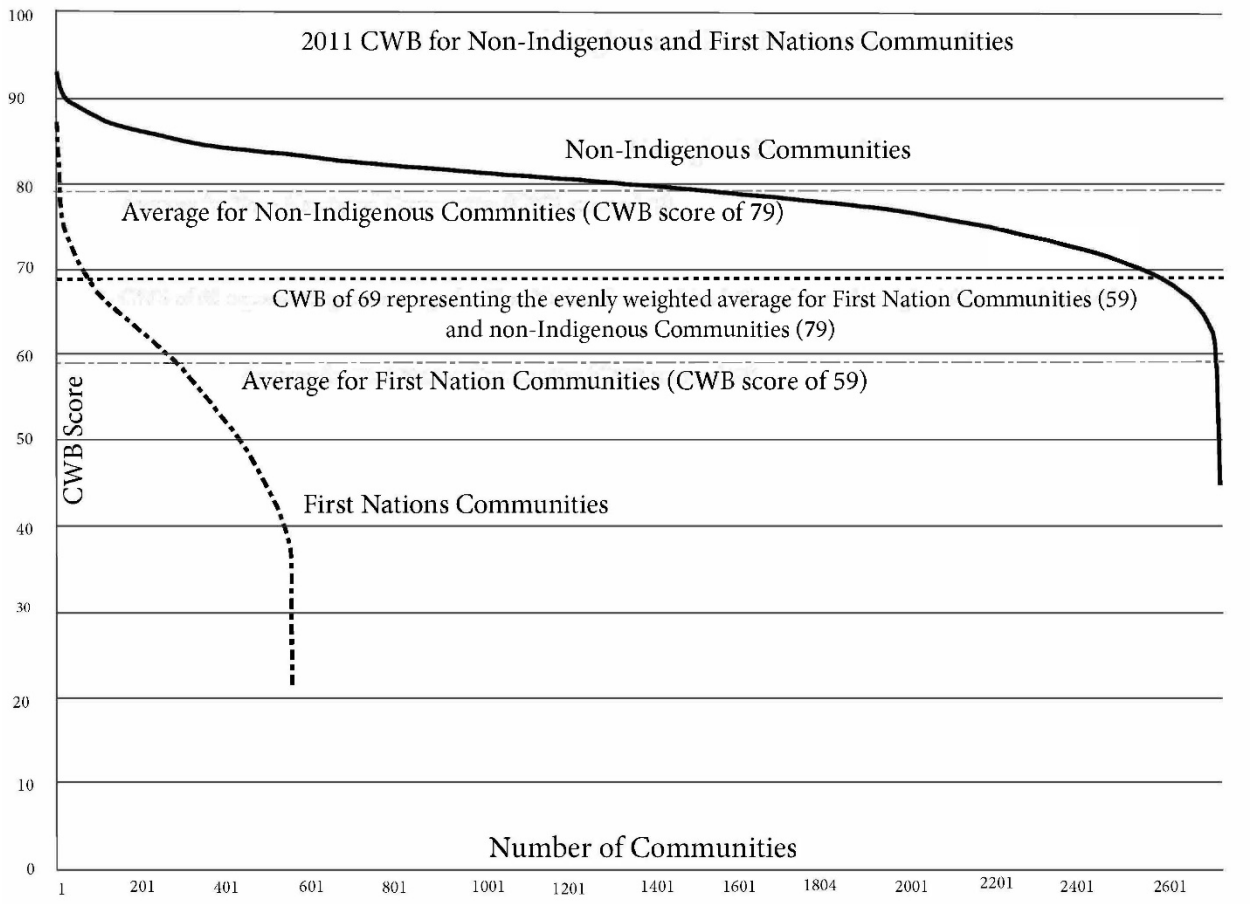
[73] United Nations Development Programme's Human Development Index (HDI) is a statistic that is used to rank countries based on life expectancy, education, and per capita income indicators; "criteria for assessing the development of a country, not economic growth alone" http://hdr.undp.org/en/content/human-development-index-hdi

Based on these exclusions, the sample size is approximately 90%[74] of First Nation reserve population.

For the broader Canadian population, CWB index scores have been calculated for the years 1981, 1991, 1996, 2001, 2006, 2011, and 2016 based on Canada's Census and National Household Survey. Since the 2016 CWB information was recently published (May 2019), and CWB values have been calculated using a slightly different formula, 2016 CWB information is not compatible with 2011 CWB published values. For the purpose of this paper, 2011 CWB published information is used for statistical analysis and for comparison with other papers that also used 2011 CWB. (see Supplementary Data, Excel workbooks 1 to 4).

The 2011 CWB Index (score) across all communities in Canada has scores for 2726 non-Indigenous communities and 556 First Nation communities. The scores indicate that the non-Indigenous communities have an average of 79 (standard deviation or sd. of 5.6), whereas, First Nations have a much lower average score at 59 (sd. 10.4) (AANDC, 2015a) (Chapter 2, Figure 1). Only 9 (0.3%) non-Indigenous communities, have a CWB score less than the First Nation's average score of 59. This disparity is further shown with 56 (10%) First Nations scoring below the minimum non-Indigenous score of 45 with the minimum First Nation score residing at 21. Ten of 556 First Nation communities have a CWB score above the non-Indigenous average score of 79, representing only 1.8% of First Nation communities. The other 98.2% fall below the non-Indigenous average.

[74] Based on 2011 Census the First Nation population was 851,560 (StatsCan 2011, https://www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-011-x/99-011-x2011001-eng.cfm). Approximately 47.4% live on reserve (AANDC 2013), being approximately 403,639 First Nations people. Exclusions suggest that more than 40,000 (10%) First Nation people were not included in the census. The 2016 Census indicates the First Nation population has grown to approximately 977,230.



CHAPTER 2, FIGURE 1: COMMUNITIES VS CWB SCORE
The heavy solid line represents non-Indigenous communities, and the dashed line is First Nation communities across Canada. Three CWB averages are provided: Non-Indigenous communities with an average of 79, First Nations communities with an average of 59, and 69 represents the evenly weighted average of both communities. Source: Statistics Canada 2011 on the Community Well Being Index (AANDC, 2015a).

2.3.1 Land-Management Regimes and Community Well-Being

Two analyses are presented that examine the relationship between CWB scores of First Nations and the three land-management regimes, namely the IALM, FNLM and SGLM regimes. The first analysis reviews scores of First Nation communities according to the land-management regime they were operating under at each year when CWB was calculated (1981 to 2011). This analysis offers a static year-by-year comparison of CWB by land-management regimes. The second analysis provides insight into the rate of change of community CWB over time and groups these changes by the land-management regime in which they resided in 2011 (CWB11).

2.3.2 Static CWB Comparison

The 556 First Nation communities with CWB reported scores in 2011 were grouped into the 3 land management regimes they resided in as of December 31, 2010. The breakdown is as follows: 515 communities under IALM; 25 communities under FNLM (LABRC, 2019) and 16 communities

under SGLM. While this section assesses CWB scores by the 3 land management regimes, there are significant differences about each regime. As noted in Section 2, all IALM and FNLM communities are on reserves while under SGLM, a community may be reserve, such as Westbank First Nation, British Columbia, however, the majority are not. SGLM communities are unique by operating under their own framework agreement with the governments of Canada, and Province or Territory they are situated in. CWB scores are further convoluted by the 25 FNLM communities transitioning from IALM at different years between 1999 – 2011; 2 communities between 1999 and 2001, 7 during 2001 to 2006, and 16 during 2006 to 2011 (Chapter 2, Table 1). Similarly, 16 SGLM communities also transitioned at different times between 1981 and 2011 (Chapter2, Tables 1 & 2).

To determine if significant statistical differences (in First Nation's 2011 CWB scores) occur among communities, an analysis of variance (ANOVA) was performed. The 515 IALM communities average score was 57.8 (sd. 10.2), the 25 FNLM communities average score was 66.1 (sd. 9.5), and 16 SGLM communities average score was 70.6 (sd. 7.4)[75] (Chapter 2, Table 1). Results from the ANOVA showed a significant difference among the three land management regimes at an $\alpha = 0.01$.

To further investigate if CWB values were statistically different between each land-management regime, a pairwise comparison between land-management regimes was conducted using the Student's t-test for the 2011 data. The t-test results showed CWB scores were significantly different between IALM and both FNLM and SGLM ($\alpha = 0.01$) but not significantly different between FNLM and SGLM regimes ($\alpha = 0.01$). Similar results were found among all land management regimes for 2006 CWB ($\alpha = 0.01$)(Chapter 2, Table 1).

CHAPTER 2, TABLE 1: AVERAGE CWB OF COMMUNITIES BETWEEN 1981 TO 2011.
Standard deviation (SD) is in brackets and number of communities 'n' is below.

Community Type	1981 (SD) n	1991 (SD) n	1996 (SD) n	2001 (SD) n	2006 (SD) n	2011 (SD) n	change
All First Nations	46.6 (10.9)	51.3 (10.0)	54.9 (9.9)	56.8 (9.8)	57.4 (10.3)	58.6 (10.3)	+12
	469	485	539	536	538	556	
IALM	46.6 (10.9)	51.2 (10.1)	54.8 (10.0)	56.7 (9.9)	57.0 (10.2)	57.8 (10.2)	+11.2
	466	479	529	524	516	515	
FNLM	Pre-FNLM	Pre-FNLM	Pre-FNLM	66.5 (4.9)	66.0 (5.1)	66.1 (9.5)	-0.4
				2	8	25	
SGLM	43.0 (10.4)	53.3 (5.6)	60.7 (2.9)	62.4 (3.8)	67.4 (7.2)	70.6 (7.4)	+27.6
	3	6	10	11	14	16	
Non-Indigenous	67 (6.5)	71 (6.5)	72 (6.3)	73 (6.2)	77 (5.9)	79 (5.7)	+12
	4635	4627	4521	4087	3860	2726	

[75] 25 (operational) FNLM and 16 SGLM communities as of December 31, 2010 that have 2011 Census CWB scores.

The overall change in 30 years of CWB scores for the 16 SGLM communities while under self-government resulted in an average increase per community (over 30 CWB years) of 8.68[76] (Chapter 2, Table 2). Fourteen SGLM communities had an increase, while 2 had small decreases (-1, and -3). In comparison, the average CWB increase per community for the 25 communities operating under FNLM (over 3 CWB years) is 1.8 (Chapter 2, Table 3). The breakdown in CWB change is: 17 increased, 5 communities decreased, and 3 had no change[77]. The comparison of CWB scores for FNLM communities with SGLM communities is based on a small sample size ranging from 2 to 25 communities, over 3 CWB time periods, versus 6 CWB time periods for SGLM communities.

CHAPTER 2, TABLE 2: CWB AVERAGE SCORES AND CHANGE FOR COMMUNITIES UNDER THE SGLM REGIME

The values to the right of the shaded boxes contain CWB average scores for communities while under SGLM. The shaded boxes contain pre-SGLM CWB average scores. The average change is calculated by the difference in change between the shaded box and CWB 2011. The total average change is the average multiplied by the number of communities. The change per community is the sum of the averages divided by the number of all the communities (16).

CWB Time period and (n) number of Communities went under SGLM	CWB 1981	CWB 1991	CWB 1996	CWB 2001	CWB 2006	CWB 2011	Average change in CWB	Total Average x n
2006-2011 (n=**1**)					**89**	86	-3	-3
2001-2006 (n=3)				**76**	78.7	79	+3	+9
1996-2001 (n=1)			**66**	68	56	65	-1	-1
1991-1996 (n=2)		**62**	63	67	66.5	74	+12	+24
1981-1991 (n=1)	nv	64	63	63	70	73	+9	+9
Pre 1981 (n=8)	48 (3)	51.2 (5)	59.7 (7)	61.0 (7)	64.1 (7)	65.1 (8)	12.5	100*
Total n = 16 (communities)								Total = 138 Average change by community is + 8.68

[76] The CWB average community increase of 8.68 was obtained using 16 SGLM communities that had more than one reported CWB year (including the previous score to SG shown in the shaded box in Ch.2 Table 2). The total average is calculated by multiplying the average by the number of communities that transitioned within the CWB period. The total change over all years is then divided by the number of communities (16).

[77] Change in CWB score includes the score prior to transition as shown in the shaded box in Ch. 2 Table 3.

CHAPTER 2, TABLE 3: CWB AVERAGE SCORES AND CHANGE FOR COMMUNITIES UNDER THE FNLM REGIME
The values to the right of the shaded boxes represent average CWB scores for communities while under FNLM. The shaded boxes contain pre-FNLM CWB average scores. The average change is calculated by the difference in change. The total average change is the average multiplied by the number of communities. The change per community is the sum of the averages divided by the number of all the communities (25).

FNLM Community Time-line	1996	2001	2006	2011	Average change in CWB	Total Average x n
2006-2011 (n=16)			**65.9**	67.1	+1.2	+19.2
2001-2006 (n=7)		**60.2**	63.8	62.6	+2.4	+16.8
1999-2001 (n=2)	**65.5**	66.5	66.0	70.0	+4.5	+9
Total n = 25 (communities)						Total = 45 Average change by community = +1.8

2.3.3 Change in Community Well-Being

Similar to Section 2.3.2, we grouped the 556 First Nation's communities with CWB reported scores in 2011 according to the land management regime they resided in for CWB 2011 (CWB11). In this section, a historical CWB assessment of the 2011, 515 IALM (IALM11), 25 FNLM (FNLM11) and 16 SGLM (SGLM11) community scores over 30 years (6 CWB years, 1981 to 2011) was undertaken (Chapter 2, Table 4).

Chapter 2, Table 4: History of CWB 2011 Communities – The chart shows average CWB Scores 1981 to 2011 (with standard deviation in brackets and n below) for communities as they resided in CWB 2011.

Community Type	1981 (SD) n	1991 (SD) n	1996 (SD) n	2001 (SD) n	2006 (SD) n	2011 (SD) n	Total increase
All First Nations	47.6 (10.9)	51.3 (10.0)	54.9 (9.9)	56.8 (9.8)	57.4 (10.3)	58.6 (10.3)	+12
	469	485	539	536	538	556	
IALM11	46.3 (10.8)	50.8 (9.9)	54.3 (9.7)	56.4 (9.6)	56.8 (10.2)	57.8 (10.1)	+11.5
	455	461	509	501	505	515	
FNLM11	56.2 (7.1)	57.9 (6.6)	62.5 (8.6)	62.8 (9.8)	66.0 (6.4)	66.1 (9.5)	+9.9
	17	14	23	24	21	25	
SGLM11	54.8 (14.6)	60.8 (10.7)	64.5 (7.2)	88.3 (7.4)	68.9 (8.9)	70.6 (7.4)	+15.8
	6	13	15	15	15	16	
Non-Indigenous	67 (6.5)	71 (6.5)	72 (6.3)	73 (6.2)	77 (5.9)	79 (5.7)	+12
	4635	4627	4521	4087	3860	2726	

Given the statistical assessment of CWB scores for land management regimes in Section 2.3.2, we assessed average CWB scores for prior CWB years (1981 to 2006). Similar to the previous outcomes, we found (using ANOVA) statistically significant differences in CWB scores between all the land management regime communities ($\alpha = 0.01$). The combination of pairwise comparison

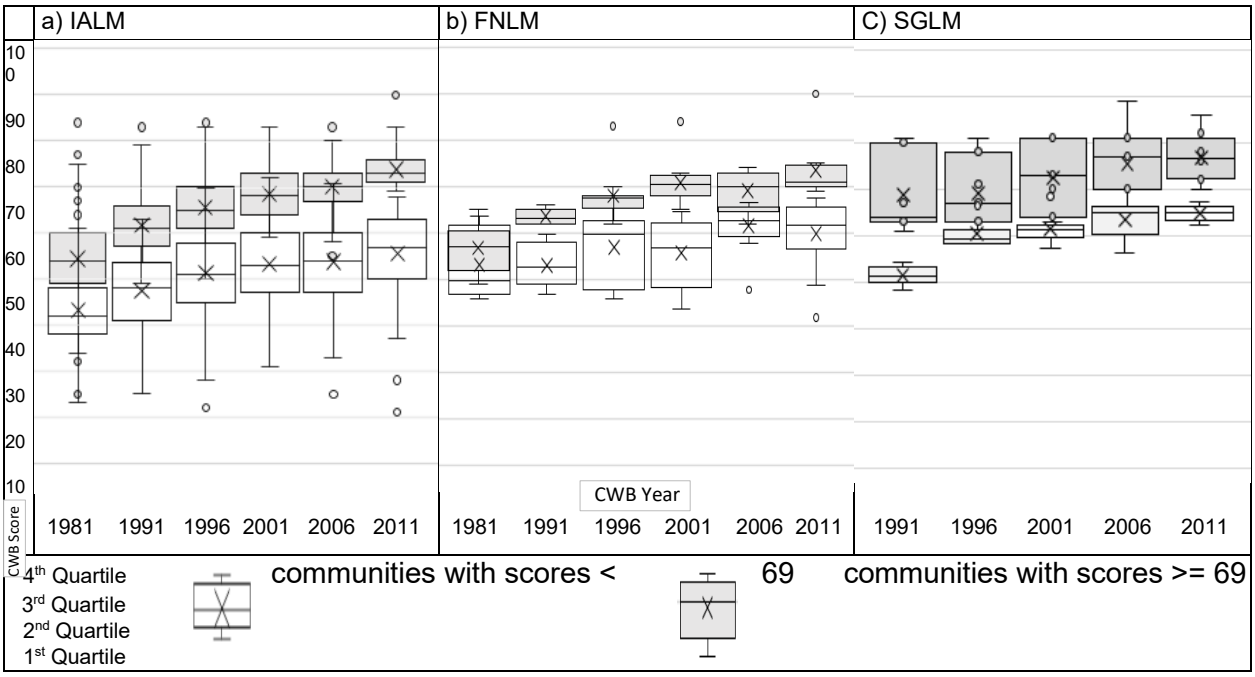
results (using Students t-test) showed significant differences between IALM11 with both FNLM11 and SGLM11, but not a significant difference between FNLM11 and SGLM11 for all years (α = 0.01). The results suggest that (on average) CWB scores differ by communities according to their land management regime with SGLM11 First Nation communities having the highest scores followed by and FNLM11 and IALM11 communities (respectively).

Overall increase in CWB scores for all First Nations matched the increase of non-Indigenous communities maintaining a disparity between First Nation and non-Indigenous community CWB scores of 20 points from 1981-2011. Similar to non-Indigenous communities, over the 30-year timespan reviewed (1981-2011), the average CWB increase of all First Nations was 12 (Chapter 2, Table 4) (AANDC 2015a). IALM11 communities representing 92.5% of First Nations (with reported CWB scores) experienced a similar average increase of 11.5, while FNLM11 communities representing 4.5% of First Nations (with reported CWB scores) had an increase of 9.9 (1981-2011) and SGLM11 communities representing 3% of First Nations (with reported CWB scores) had the highest overall increase of 15.8 on average over the same time frame.

In view of a differential increase in CWB score by land management regime, we evaluated if a community's increase in CWB score was dependent on initial CWB relative to others within their 2011 identified land management regime. Communities within a land management regime were classified as lower scoring if their CWB was below the combined First Nation and non-First Nation equal average of 69, whereas, a community equal to and above this average was classified as a higher scoring community. A comparison of the averages of higher and lower scoring communities across all regimes from 1981-2011 found improvement in CWB scores within land management regimes varied greatly (for a listing of 85 communities that have a 2011 CWB score >= 69, see Supplementary Data, on-line Appendix 6). The widest spread in CWB lower and higher average scores with a difference of 21.0 points occurred among IALM11 communities (high average of 19.2 and low average of -1.8), followed by FNLM11 of 9.9. SGLM11 communities had a difference of 9.1, with an increase in lower scoring communities of 24 points, and an increase of 14.8 in higher average communities. (Chapter 2, Table 5). This approach indicates that higher CWB scoring communities (among all land management regimes), and lower scoring SGLM11 communities had greater increases (greater than the average of 12) in CWB scores. These results led to further assessment of both higher and lower scoring communities by grouping CWB index data into quartiles. The quartile data is displayed using box and whisker plots by higher and lower scoring communities and by land management regime (Chapter 2, Figure 2).

Chapter 2, Table 5: Average CWB scores by land management regime communities >= 69 and < 69 (being the evenly weighted CWB average of First Nation and non-Indigenous communities)

land management regime	n (number of communities	CWB 1981	CWB 1991	1996	2001	2006	2011	change
IALM >= 69	66 (13%)	54.6	62.1	65.6	68.6	70.1	73.8	19.2
IALM < 69	449 (87%)	43.2	47.4	51.2	53.2	43.6	41.4	-1.8
FNLM >= 69	11 (44%)	56.8	63.6	68	70.9	69	73.5	16.7
FNLM < 69	14 (56 %)	53.4	53.4	57.2	56	61.9	60.2	6.8
SGLM >= 69	8 (50%)	62.0	68.6	69	72.3	75.4	76.8	14.8
SGLM < 69	8 (50%)	40.5	51.2	60.1	61.1	63.1	64.5	24

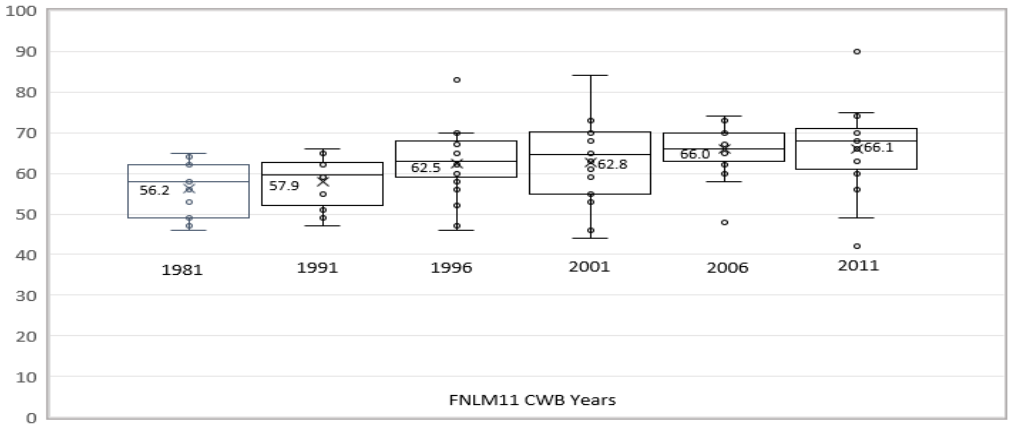


CHAPTER 2, FIGURE 2: BOX AND WHISKER DIAGRAMS OF QUARTILE GROUPINGS OF COMMUNITIES
(a) IALM, b) FNLM, c) SGLM) with CWB scores >=69, and < 69 from 1981 to 2011. Figure 2 c) SGLM lacks CWB data in 1981 and depicts box and whisker diagrams from 1991 to 2011

Rates of change in the higher scoring IALM, FNLM and SGLM communities (>= 69) were greatest in the 1st quartile, followed by 2nd, 3rd and 4th quartiles (Chapter 2, Figure 2). Lower scoring ILAM and FNLM communities (< 69) increased less than higher scoring communities (>= 69) with greater increases in the 1st and 2nd quartiles, followed by 3rd and 4th quartiles. Rates of

change in lower scoring SGLM communities were more uniform in all quartiles having scores within 6 points of 69 (e.g., 63, 64.5, 66, and 67, quartiles 1 to 4 respectively). Higher scoring IALM11, FNLM11, and SGLM11 communities in quartiles closer to the average of 69 (e.g, quartiles 1 and 2) had the highest increase in CWB scores over all years.

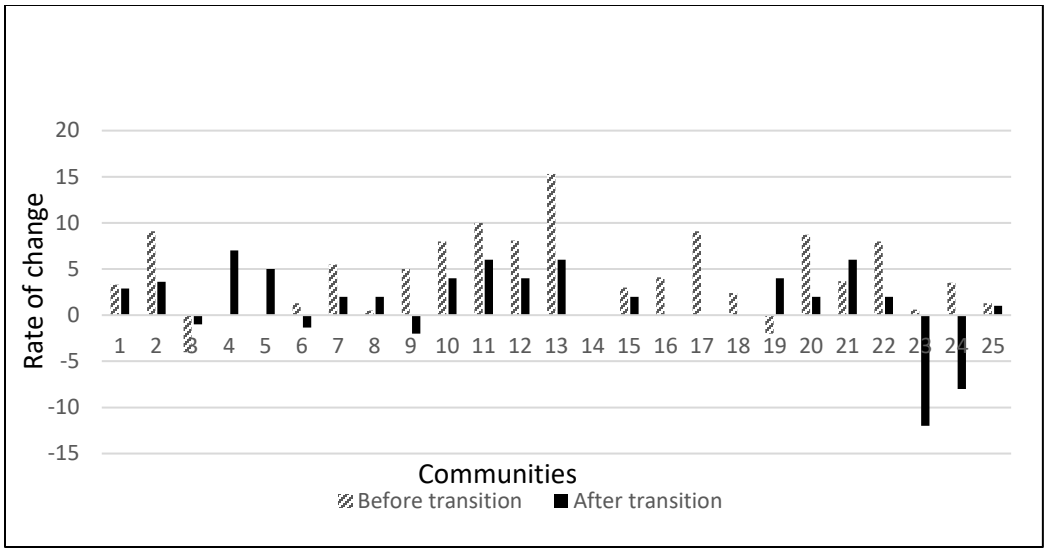
As previously mentioned, the FNLM regime came into effect in 1999, however in this approach we tracked 30 years of CWB data (1981-2011) scores for 25 FNLM11 communities. Twenty-one of 25 FNLM11 communities (84%) showed improvement, while 2 (8%) communities had a decrease and 2 remained the same. When we review the trajectory of CWB scores over the 30 year period, we see the rate of increase between FNLM11 communities differs before and after 1999 (Chapter 2, Figure 3).



CHAPTER 2, FIGURE 3: BOX AND WHISKER DIAGRAMS OF CWB VALUES
1981 to 2011 of the 25 FNLM11 communities. The value depicted within the box shown by an 'X' is the mean CWB value as provided in Ch. 2, Table 4. Note the change in trajectory from 1981 to 1999 (slope is approximately 3.2), and 2001 to 2011 (slope is approximately 1.7).

The difference in trajectories were assessed for pre-FNLM communities versus those communities operating under FNLM; 68% (17 of 25) had an increase in CWB scores while under FNLM; whereas, 91% (20 of 22)[78] communities had an increase pre-FNLM (Chapter 2, Figure 4 and Chapter 2, Table 6). Further, investigation of the rate of change by comparing the linear slope of change for each of the 25 FNLM11 communities (Chapter 2, Figure 4) found an average rate of change of 4.8 before transition versus 1.5 after. An ANOVA and Student's t-test compared the 25 communities rates of change in CWB slopes (before and after transition) and found the 2 groups to be significantly different (alpha 0.05). These results suggest the rate of growth in CWB score slowed down after transition to FNLM.

[78] 3 of 25 Communities had insufficient CWB scores to determine the rate of change.



CHAPTER 2, FIGURE 4: RATE OF CHANGE IN CWB FOR 25 FNLM COMMUNITIES
before and after transition to FNLM. The bar chart compares the linear slopes of change of 25 FNLM11 communities before and after transition.

Chapter 2, Table 6: Percent (%) of FNLM communities having an increase in CWB scores, both pre-FNLM and while operational.

	Transition Period - the time period that communities transitioned to the FNLM regime.	Number of communities that transitioned to the FNLM regime.	% of the number of communities that increased in CWB while pre- FNLM (1981 to operational under FNLM).	% of the number of communities that increased in CWB while operational under FNLM.
1	1999 to 2000	2	100% (2 of 2)	100% (2 of 2)
2	2001 to 2005	7	100% (7 of 7)	57% (4 of 7)
3	2006 to 2010	16	94% (15 of 16)	69% (11 of 16)
	total	25	96% (24 of 25)	68% (17 of 25)

2.3.4 Summary of Results

CWB average scores by land management regime, from lowest to highest, are IALM, FNLM and SGLM, suggesting that statistically SGLM and FNLM provide a mechanism for higher levels of CWB (as supported by Sections 2.2.2 and 2.2.3). Yet, the rate of increase in CWB scores among land management regimes was highest for IALM followed by FNLM and SGLM when communities had a CWB score >= 69. In contrast, in communities with a CWB score < 69, the rate of increase

was highest in SGLM, followed by FNLM and IALM. Our findings suggest the rate of improvement may be more difficult or require more effort for communities in the highest scoring communities and in IALM and FNLM communities with CWB scores < 69. Further, statistical analysis on FNLM communities suggest rate of increase slowed down after transition.

Results from the ANOVA showed a significant statistical difference between all land management communities ($\alpha = 0.01$) and the Student t-test showed a significant statistical difference between IALM with FNLM and SGLM communities. Interrogation of these results found rates of change differed significantly as communities with higher CWB scores experienced a greater increase over time relative to communities with a lower CWB score. When combined with the historical CWB data (CWB11), the results suggest there is a higher likelihood for improvement under FNLM and SGLM[79]. Statistically, no significance in difference exists between SGLM11 and FNLM11 communities and within both land management regime communities over all CWB years. Our analysis suggests that FNLM and SGLM communities are statistically similar in terms of CWB scores and rates of change in scores. Relative to IALM, the formal property rights, access to market, and authority of governance, many FNLM and SGLM communities are better positioned to achieve higher CWB scores (Flanagan, 2016; Ballantyne, 2017[80]).

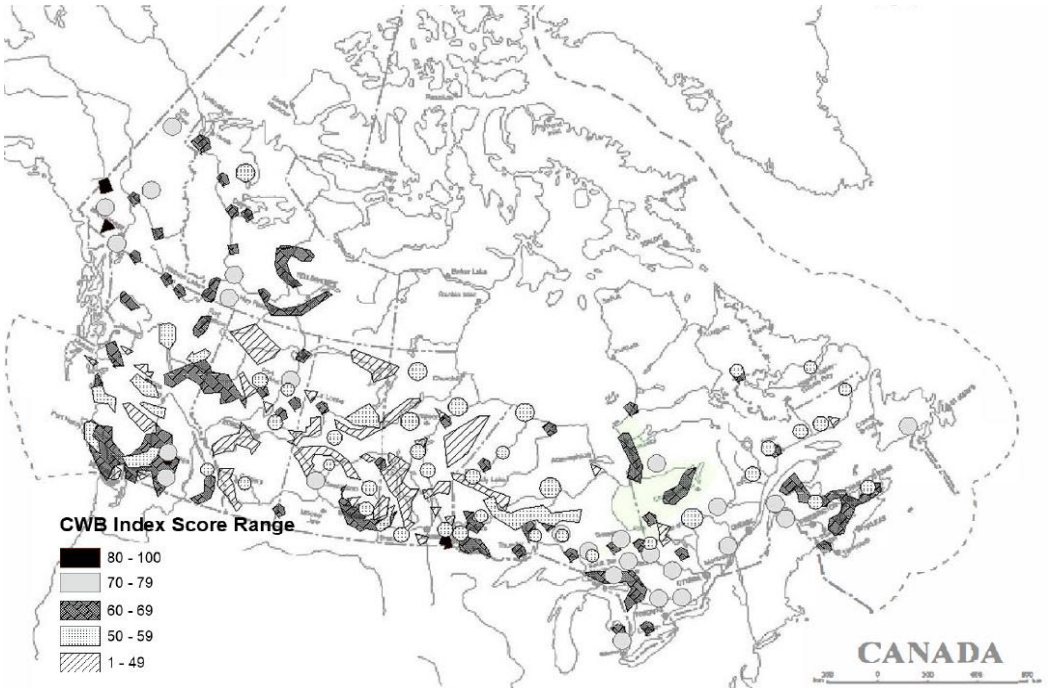
Although our results suggest there is a relationship of land management regime type and higher average CWB[81], greater increases in CWB scores were found among higher CWB scoring IALM11, FNLM11 and SGLM11 communities (e.g., >= 69) and SGLM11 communities < 69, but greater increases were found among these communities with a CWB score closer to 69. While Flanagan (2016) investigated drivers for 21 higher CWB scoring communities by governance, property rights and economics, Flanagan did not "distinguish among different types of non-Indian-Act government" (Flanagan, 2016, pg 12). Armstrong (2001, 1999); Ballantyne et al, (2012, 2016, 2017); AANDC, (2013b) also found that drivers of higher scoring CWB communities are associated with property rights[82], geographic location (Chapter 2, Figure 5), revenue sources, and health.

[79] See Flanagan (2016) for further information on the 21 higher CWB scoring communities and on their governance, property rights and economics.

[80] Ballantyne (2017) is an assessment of 143 reserves. Inferences suggest formality in property rights and location to markets with positive economic growth and possibly higher CWB.

[81] Knauer (2010) examined 40 First Nation communities; 8 communities under the FNLM regime and 32 under the IALM regime, using 2006 CWB information. While the conclusions indicate there was insufficient information to support a correlation of First Nation communities under the FNLM regime with a better CWB score, the results showed a positive effect on housing for FNLM communities vs non-FNLM communities.

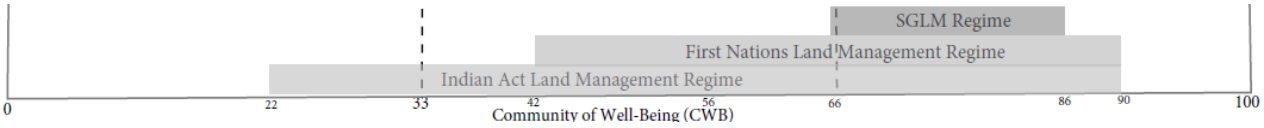
[82] See Ballantyne (2016, 2017) for further information on formal and informal property rights and the CWB index.



CHAPTER 2, FIGURE 5: MAP OF DISTRIBUTION OF CWB INDEX SCORES ACROSS CANADA
This map depicts the distribution of CWB index scores across Canada by 4 categories: CWB scores 1 - 49, 50 – 59, 60 - 69, 70 -79, and 80 - 100. The map indicates the majority of lower scoring communities are in the Prairie Provinces, while higher scoring communities are found in the Yukon Territory, and Provinces of British Columbia., Ontario and Quebec. Source: 2011 Community of Well-Being Map Index Map, (AANDC, 2015a) and Atlas of Canada, reproduced under the Open Government Licence – Canada.

2.4. A Relationship among Land Management Regimes, Community-Well Being and Property Rights.

Warkentin & Canada (2014) outlined a hierarchy of authority for First-Nations' land-management regimes as a linear trajectory of increasing authority as First Nations move from the IALM to FNLM and SGLM regimes. The hierarchy conceptually aligns with the average CWB scores for each land management regime, however, when CWB scores for communities within each land management regime are plotted to demonstrate the variation in CWB scores the ordinal increase in CWB by land management regime is less clear (Chapter 2, Figure 6). For example, the same level of CWB may be achieved through any of the three land-management regimes where the scores overlap. These results suggest that while the land management system used by a First Nation community plays a critical role in its CWB, multiple pathways to increase CWB exist. One such pathway is land tenure (for additional information see Supplementary Data, on-line Appendix 7, Examples).



CHAPTER 2, FIGURE 6: 2011 CWB SCORES BY LAND MANAGEMENT REGIME
2011 CWB scores for the three land management regimes in relation to the hierarchy of authority. IALM CWB scores range from 21 to 90, FNLM scores range from 42 to 90 and SGLM scores range from 62 to 86.

IALM regime communities with lower CWB scores (using the evenly weighted CWB average score for non-Indigenous and First Nation communities of 69) were found to be associated with the use of an informal land tenure system (ILRS, 2016[83]; Ballantyne, 2017[84]). Whereas, higher CWB scores (over 69) were associated with communities having greater control over managing their land (e.g., communities under RLEMP "Operational" and the use of a formal land tenure system). In comparison with the FNLM regime, over 90% of IALM communities overlap in the range of CWB scores. Similar to the IALM regime, FNLM communities at the low end (under a CWB score of 69) also tend to manage their land under an informal land tenure system (ILRS, 2016)[85]. Approximately 40% of First Nations' communities under the FNLM regime do not use the CP (or equivalent) as evidence of title (ILRS, 2016) and these communities have an average 2011 CWB score of 58.3 (sd.9), whereas, FNLM communities that use the CP (or equivalent) have an average 2011 CWB score of 70 (sd. 7.5) [86].

The SGLM regime, having the highest CWB average scores (Chapter 2, Table 1), overlaps with both the IALM and FNLM regimes (Chapter 2, Figure 6). Many self-governing communities have negotiated within their agreement that title be held in fee simple and not held in trust by the Crown as found under the IALM and FNLM regimes (e.g., Sechelt and Nisga'a First Nations hold land in fee simple and assurance of title is addressed in their constitutions). SGLM regime communities with lower self-governing CWB scores were found associated with implementing an independent property rights system, e.g, Nisga'a and Cree-Neskapi having their own land registry and not linked with either the provincial or federal land registry systems.

2.5. Conclusions

In Canada, a relationship exists among multi-levels of government (e.g., Federal, Provincial, and local governments) referred to as federalism (Makarenko, 2008b) or fiscal federalism (Tulo, 2014).

[83] ILRS and FNLRS Records provided by INAC in 2016, indicate the majority of non-CP (or FNLM equivalent) Reserves are in the Prairie Provinces (Manitoba, Saskatchewan and Alberta).
[84] supra note 79.
[85] supra note 82.
[86] 55% of FNLM regime communities that have a CWB score >= 69 use a formal system (e.g., CP or equivalent) whereas 100% of FNLM regime communities with a CWB score < 69 do not use CP (ILRS, 2016). All non-CP communities are found in Manitoba and Saskatchewan.

This relationship provides the people of Canada (not living on reserves) an understanding on how services will be delivered such as health and education. However, First Nations were not included in this relationship being an "afterthought in the design of the Canadian fiscal framework" (Tulo, 2014, pg 149) and placed under the responsibility of the Federal government (Constitution Act, 1867 and Indian Act, 1876). Despite 140 years of controversy (Coates, 2008), the Indian Act remains in place[87]. However, in the last three-to-four decades some First Nations have taken steps to acquire greater authority and control over their land within or outside of the Indian Act. Although the Indian Act Land Management (IALM) Regime offers the lowest level of authority (Warkentin & Canada 2014), changes to the Indian Act has provided an increase in potential to manage their lands, e.g., under RLEMP. Two alternatives to the IALM regime that have emerged in the last 35 to 40 years are the First Nations Land Management (FNLM) and self-governing frameworks of land management (SGLM) regimes. While both offer higher levels of authority than the IALM (as described in Sections 2.2.2, 2.2.3 and 2.4), self-government offers the greatest potential for authority. In addition, self-governing framework agreements also support First Nation vision, inherent rights, self-determination and government to government relationships (Carrier Sekani Agreements, 2015; Satsan (Herb George[88])) that support socio-economic development and a higher level of CWB score.

Our statistical analysis suggest higher average levels of CWB scores are associated with governance (in terms of land management regime type) and land tenure (Appiah-Adu & Bawumiah, 2015; Flanagan, 2016; FAO, 1999, 2002, Ballantyne; 2016; Knauer 2010; AANDC, 2013b, pg 3). This assessment is supported by: 1) higher CWB average scores were observed in the order (from lowest to highest) in IALM, FNLM and SGLM communities respectively, 2) SGLM communities observed a history of the highest average CWB scores, 3) First Nation communities under FNLM on the average showed improvement in CWB scores (1981 to 2011) both prior to transition and after, and 4) higher levels of CWB were found associated with communities that have a formal property rights system. A key conclusion of our findings suggest a relationship with CWB and the economic law of diminishing returns when "conditions for maximal product are fulfilled" (Zheng et al, 2014, pg 1). Statistical assessment suggest (although there is no empirical evidence) many communities that transitioned to FNLM or SGLM were well positioned to do so but our analysis also suggest increases in CWB score may peak (but at what score) for a

[87] Warkentin & Canada, 2014, p. 15 indicates some First Nations prefer not to terminate "Canada's role in respect of those lands, considering that Canada owes specific fiduciary obligations related to reserve lands." House of Commons, AANO, Evidence, 1st Session, 41st Parliament, 24 November 2011, (Andrew Beynon, Director General, Community Opportunities Branch, AANDC).

[88] Lecture by Satsan (Herb George) May 2, 2016, University of Waterloo, Aboriginal Educational Centre, stating "government-to-government relationships are not possible under the Indian Act".

community as it approaches its CWB score potential. This suggestion is supported by 1) higher CWB scoring communities (greater than 69) were observed in all 3 land management regimes, however, across all regimes greater rates of improvement were observed closer to a CWB score of 69, and 2) for FNLM11 communities, while on average these communities increased in CWB score both prior and after transition the rate of increase slowed down after transition.

Based on existing literature (e.g., Flanagan, 2016; Ballantyne, 2016) and our analysis, we identified three considerations in understanding First Nations CWB scores.

First, is understanding the relationship between CWB and the integration of First Nation customs and traditions with various land-management systems.

Second; understanding the relationship between CWB and property rights (Appiah-Adu & Bawumiah, 2015; Ballantyne et al, 2014; Ballantyne, 2016) and the proposition that increased security of land title leads to a better economic position and community well-being (CWB) index (Flanagan, Alcantara & Le Dressay 2010; Ballantyne, 2016; AANDC, 2015a, CWB Index).

Third; understanding the relationship of CWB and economic development. Communities with higher CWB scores are associated with geographic location (Chapter 2, Figure 5), economic area, and communities with land available for development (e.g., GIFN, 2016 and WFN, 2015; McCue, 2011; Wien, 1997; Ballantyne et al, 2012).

Further research that would help to fill gaps in societies' knowledge and better understand the relationship of First Nation land management and community well-being (CWB) scores include:

1. modelling how land governance drives socio-economic development, as measured by the CWB index .
2. empirical research on what First Nations consider important in relation to how the land is used, land-use decision-making, and how land-use and decision-making impacts the CWB index.
3. empirical research on how informality versus formality in property rights impacts CWB scores in First Nation communities.
4. empirical research on what is considered "well positioned" to attain a high CWB score by exploring the law of diminishing returns, and exploring the impact of variables such as, land systems, geographic location and markets on return (e.g., CWB ceiling scores).
5. further analysis on the relationship of land management regimes and CWB scores by comparing the computational difference in 2011 with 2016 CWB scores, and statistical analysis using 2016 CWB published values.

While many communities remain under the Indian Act and rely on Federal Government resources for assistance in land management, other First Nations are restoring inherent-rights and authority over their land. Whether or not transition takes place (e.g, to RLEMP, FNLM or self-government) land is important to their society (Duke & Wu, 2014, Nisga'a's, 2015) and the cultural relationship First Nations have with land, e.g., "a physical representation of their spirituality" (Hanson, 2009b). For thousands of years First Nations lived a self-governing, sustainable lifestyle,

according to customs and traditions (Schmalz, 1991; AANDC, 2013d). As a result of significant Supreme Court of Canada cases such as the Sparrow, Calder, Van der Peet, Delgamuukw and Tsilhqot'in (for further reading on significant and milestone cases, see Supplementary Data, online Appendix 7) , steps have been taken (e.g., through RLEMP, FNLM and self-governing frameworks) to restore First Nation inherent-rights and take greater control over their land. Although, improvement in CWB may be achieved by many pathways, all 3 land management regimes offer First Nations pathways (e.g., as described in Sections 2.2 and 2.4) for increased authority over their land.

Supplementary data

Supplementary data to this article can be found online at:

https://doi.org/10.17632/N639NN6KTK.2

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Chapter 3: Informality within Indigenous land management: A Land-Use Study at Curve Lake First Nation, Canada

3.1 Introduction

Within the country of Canada there are 3,247 First Nation Reserves (ISC, 2018) across about 640 First Nation communities. Approximately 82% of First Nations manage their land under the Indian Act (Act)[89] or a subset of the Act called the Reserve Land and Environmental Management Program (RLEMP) (Fligg & Robinson, 2019)[90]. Within this context, land management includes defining how land is possessed, occupied, transferred and used. However, since the Act does not fully accommodate the cultural land management needs of First Nation people (Fligg & Robinson, 2019), many First Nations take a more informal approach to land-use that involves using undocumented practices that follow traditions and community values (AFN, 2021; Millete, 2011; Ecotrust Canada, 2009).

Formal rules and policies can support efficient and effective land management (OECD, 2017; OPPI, 2019). Furthermore, because formality requires articulation and communication, a formal approach can also facilitate a more unified knowledge base and a better understanding within a community about the use of land (CMHC, 2021). Therefore, a correlation might exist between a formal land-management system and the awareness of community members about what land-use practices are sanctioned and subsequently the members be "on the same page" about land-management issues. The corollary may provide an alternative that derives a similar outcome, whereby informal land-management may have a correlation to member disconnect, i.e., members are less aware or certain about sanctioned land-uses and are subsequently less "on the same page" as other community members.

Although literature exists about First Nation land management (e.g., Fligg & Robinson, 2019; Flanagan, Alcantara, & Le Dressay, 2010) and community cohesion (e.g., Flanagan & Harding, 2016; Flanagan, 2016), there is a lack of empirically-based studies on First Nation members' perception of formal or informal land-use[91] and how managing land under the Act, or a subset

[89] Indian Act (R.S.C., 1985, c. I-5)

[90] Approximately 18% of First Nations manage their land outside of the Indian Act; 14% under the First Nations Land Management Act (LABRC, 2021), and 4% under a framework of self-government. See, ISC, 2020, or Fligg & Robinson, 2019.

[91] The number of non-peered/peered reviewed papers, book chapters, and articles using the University of Waterloo's OMNI search tool (https://ocul.on.ca/introducing-omni) that referred to both land use study and First Nations were 81. Of the 5 peer-reviewed papers, none made reference to land management systems or land-use policy.

thereunder, impacts members connectivity. In collaboration with Curve Lake First Nation, we define member connectivity as being more or less "on the same page" about land management, policy and vision about the use of their Reserve land.

Many First Nation communities lack land-use plans and policy[92] owing to "insufficient capacity" within the community (OPPI, 2019, p. 11), which often results in disorderly development, sprawl and unsustainable land-use, e.g., mix of land-use types, and poor environmental practices (CCP, 2009; Baijius & Patrick, 2019). Therefore, First Nation communities might benefit from community participation in land-use studies to improve access to information and to enhance member's knowledge, understanding, and perception on 1) land management and policy, 2) informal land-use practices (e.g., those sanctioned or condoned, or those unsanctioned by the community, and Chief and Council), and 3) the potential benefits of land-use policy to support a collective land-use vision and land stewardship plan for all members.

The benefits of land-use planning and policy are partly dependent on the presence of a coherent land tenure system (ILG, 2010; FAO, 2002), because zoning and land-use mapping relies on a parcel system that are linked to property rights. Yet, across Canada, approximately 50% of First Nation communities do not have parcel fabric and do not allot individual property rights (Fligg & Robinson, 2019). Furthermore, for 82% of Reserve communities[93], the Act defines how land is managed and governed, including how land is held in title and transferred. This differs with off-Reserve lands, where anyone may live within and be a member of a community (e.g., a municipality). Although, some First Nation members may or may not live on a Reserve, all members have the right to an opinion or a vote about the use of their affiliated Reserve land (ISC, 2021). This right and the "wants and needs" of all members are characteristics of the heterogeneous nature of Reserve communities (Fligg, 2019). The "wants and needs" of members may be better understood by empirical research on member knowledge base and their perception and opinions about land-use and management.

In collaboration with the Lands Manager and Council of Curve Lake First Nation, Ontario, Canada, we elicited information on members' knowledge and opinions about land management, including land use policies/practices and land tenure. The information was acquired for two purposes. The first purpose was to gain insight about the "wants and needs" of community members. The second purpose was to determine whether a disconnect (i.e., a difference in understanding or disagreement) existed between members or conversely, whether members were

[92] Approximately 5% of First Nations have a community land-use plan in place, based on the number of First Nation communities that make this information known on their website.
[93] Supra note 90

"on the same page" (i.e., aligned) about land management issues. Respondents were categorized as a member land holder or non-land holder (CP or non-CP holder[94]) and as a member living on- or off-Reserve. Using 156 survey responses, we sought to determine 1) whether any disconnect among First Nation members was correlated to formal or informal land-use policy and land management, and 2) whether there was a gap between members "wants and needs" regarding what should happen according to policy or process (formal) and what actually happens on the ground (informal).

To answer these questions, we provide a brief overview on the cultural exclusivity of First Nation membership and property rights under the Indian Act as well as an overview on the land management matrix, impacted by informality. Then we describe the demographics, land systems, land-use and policies, and challenges in land management at Curve Lake. The need for research in this area is given followed by the land-use study approach and how it was implemented prior to our results, by land policies and systems, CP holders and non-CP holders, and on- and off-Reserve members. Finally, we discuss our findings and what they mean for First Nations communities in general and for Curve Lake First Nation in particular.

3.2 Background

3.2.1 Indian Act

The Indian Act (Act) defines how approximately 82% of First Nations manage their Reserve land, and how land can be possessed/held in title and used[95]. Although, individual land holdings can only be held by a First Nation Band member (e.g., by a certificate of possession (CP))[96], non-members can lease land from the Band or from a CP holder. In contrast to off-Reserve land tenure, which is composed of fee simple land holdings, on-Reserve land tenure means that a CP provides formal evidence of title sanctioned under the Act. The CP is recorded in the Indian Lands Registry System (ILRS), administered by the federal government. The system underpins security of tenure and clarifies who has the right to possess, occupy, transfer, subdivide, use and develop a parcel of land (Fligg & Robinson, 2019; Ballantyne & Ballantyne, 2016).

Approximately 10 sections of the Act (Sections 5 to 14) define "Indian"[97] and set out rules and process for First Nation membership. For example, Curve Lake First Nation membership is defined

[94] An allotment such as a parcel of Reserve land held by a certificate of possession (CP), is evidence of possessory title by a member of the First Nation to a parcel of land on Reserve land as defined under the Indian Act.
[95] Reserve land is held in trust by the Crown for the use and benefit of a band (First Nation).
[96] According to Statistics Canada, 2016, approximately 50% of the First Nation population live off-Reserve.
[97] Although the word Indian has been replaced by First Nation, however, it remains defined under the Indian Act.

under Section 11 of the Act which sets out that the First Nation membership list is maintained by the Department of Indigenous Services Canada (ISC), and under Section 6 which defines how a member is entitled to be registered as an Indian. Understanding who is a First Nation member (e.g., by definition under Sections 10 or 11 of the Indian Act) and how Reserve land is possessed/held in title (e.g., communal and/or sanctioned individual land holdings) is significant to conducting a land use study within any First Nation community.

3.2.2 Informality in Land Management

Informality in land management refers to land-use practices or property rights that are not sanctioned by the government – neither by the First Nation government (i.e., Chief and Council) nor by the state (i.e., the Crown or Indigenous Services Canada). Thus, there is a theoretical matrix of land management. Along one side of the matrix, are the two types of governance (informal and formal land management) and along the other, land-use and property rights (Chapter 3, Table 1).

CHAPTER 3, TABLE 1: MATRIX OF LAND MANAGEMENT
The matrix has four quadrants. The left column has Formal Land Management and the right column is Informal Land Management. The top row is land-Use and the bottom row is Property Rights (land tenure)

	Formal Land Management Sanctioned by the Government of Canada, legislation, or Chief and Council	Informal Land Management Not sanctioned but condoned by Chief and Council at will or not condoned by Chief and Council or the community
Land Use	• land use according to a Reserve land management system • land use by-laws, policy, and plans as passed by Chief and Council	• land use based on custom or tradition • The community {e.g., CP holders or lessees) do as they please
Property Rights	• title is sanctioned by legislation – title is registered • parcel fabric is officially recorded	• customary system of communal or individual land holdings • Buckshee leases[98] or agreements

In the developing world, such a nuanced matrix is often described as legal pluralism (Ballantyne, 2007), which refers to the multiplicity of statutes, principles, and legal institutions that inform and

[98] "A buckshee lease refers to a lease that has not been granted by Her Majesty pursuant to the Indian Act", First Nations Land Management Resource Centre, https://labrc.com/

direct land management (land-use and property rights). Yet there is also a sense of entitlement in land management debates – "by which different parties base their claims on whichever legal framework … best fits their situation" (Meinzen-Dick & Pradham, 2002, p. 15). In this context, informality is sometimes used interchangeably with customary. However, informality can be unfair across a community, and the extent to which informality is accepted can vary across a region or country (Knight, 2010). Finally, informal land management can sometimes be difficult to define – some communities have retained custom as-is, some have reinvented and modernized custom, some have done both, and some have had customary rights recognized in formal statutes (Cousins & Claassens, 2006).

Informality within First Nation communities includes at least five actors – Chief and Council, the Lands Manager (to whom responsibility for land management issues has been delegated), Indigenous Services Canada, community members, and non-member lessees (Alcantara, 2010). Analysis of informality in land management is fledgling, tends to focus on how land is possessed/held and not on how land is used, and does not easily lend itself to statistical analysis owing to its ethnographic heterogeneity (Flanagan & Beauregard, 2013). Thus, the courts have held that Chief and Council have the authority as to which families have the right to possess certain parcels, and that informal (i.e., customary) rights can revert from the family to the community.[99]

The presented research expands on this analytical net to investigate informality in land management. If informality is characterized as CP holders being able to "just about do what they want on their land"[100] then formality is characterized by discrete policies from Chief and Council that manifest themselves in by-laws, policies, and land-use plans administered by the Lands Manager.

3.3 Study area

Curve Lake First Nation (CLFN) is located on a peninsula adjacent to two lakes, approximately 150 km's north-east of Toronto, Ontario, and abutting the Municipal Township of Selwyn, within the County of Peterborough[101] (Chapter 3, Figure 1). CLFN membership is approximately 2,177 people, of whom 768 (35%) members reside on the Reserve (in approximately 331

[99] Johnstone v. Mistawasis First Nation, 2003 SKQB 240. (CanLII), https://canlii.ca/t/57tb, retrieved on 2021-06-21

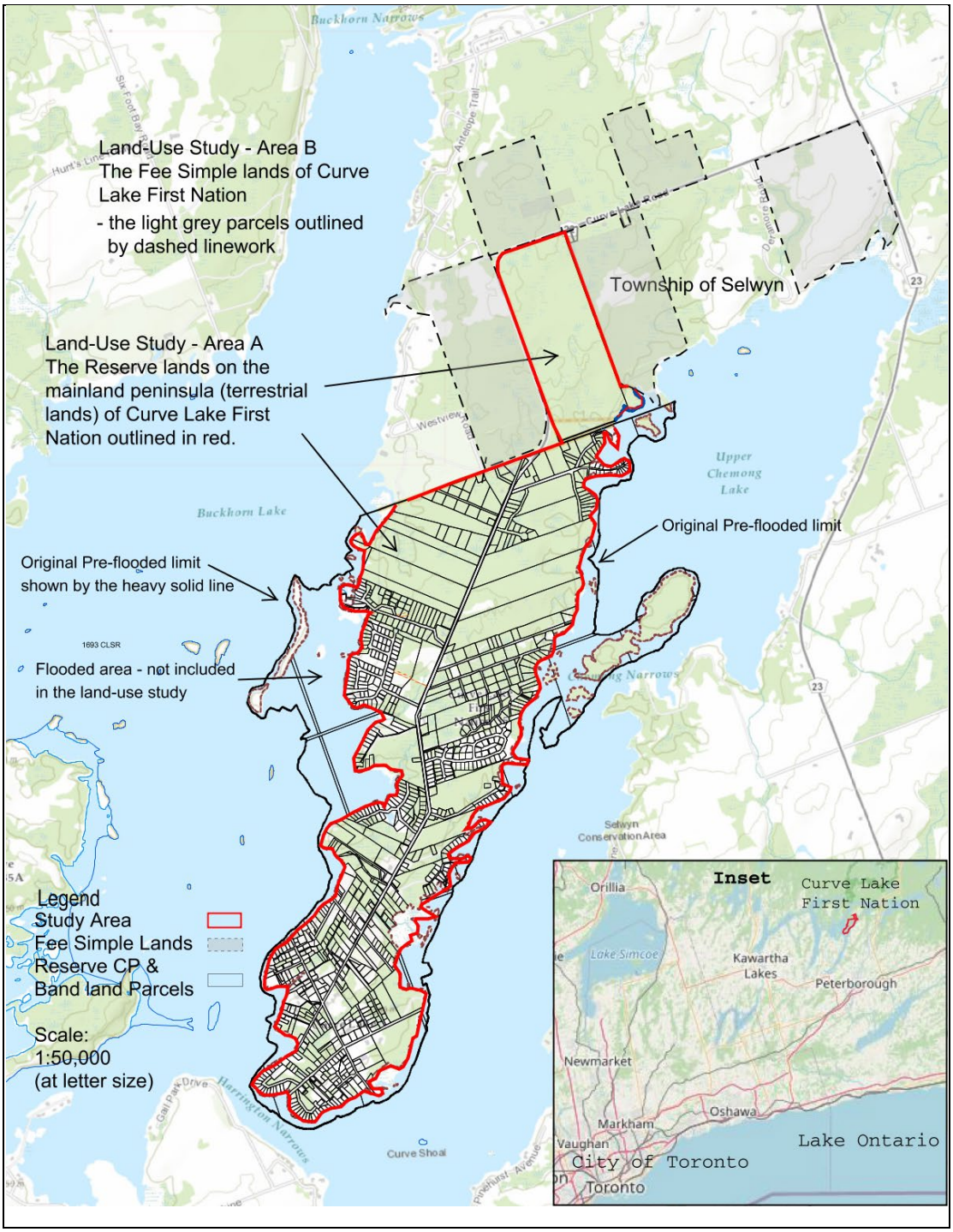
[100] As described by a respondent to the Curve Lake First Nation land-use study questionnaire, 2019.

[101] The County of Peterborough is an upper-tier municipality that contains lower-tier municipalities located within it, such as the City of Peterborough (population 84,032, as of the 2016 Census) and the Township of Selwyn (population 17,060, as of the 2016 census).

households). The remaining 1409 CLFN members live off-Reserve (CLFN, 2019)[102]. According to the 2016 Census (ISC, 2018: StatsCan, 2016) 45% of the members are male and 55% are female; 17% of the membership are aged 0 to 14 years, 66% are aged 15 to 64 years and 17% are aged 65 years and over. Approximately 600 non-CLFN members (in 211 households[103]) reside on the Reserve on leased land, 50% of which are seasonal (cottages) and 50% of which are year-round (homes). Thus, the total on-Reserve population is approximately 1,368; 56% of whom are CLFN members (CLFN, 2019).

[102] Census Canada 2016 reports a 2016 Reserve population of 1059, 613 households (457 by usual residents) and an average household size of 2.3. The census includes non-member leasehold residents, and therefore has a higher population and number of households.

[103] There are approximately 220 leases; 211 are occupied by non-members, and nine are occupied by CLFN members.



CHAPTER 3, FIGURE 1: CURVE LAKE FIRST NATION. THE LAND-USE STUDY AREA

The "Land-Use Study – Area A" lands represents all the CP-held parcels and community held (band) land on Reserve, as of March 31, 2021. Area A lands are only the terrestrial lands - bounded by the red line (to the water's edge or flooded limit) and the inland parcel to the north. The "Land-Use Study – Area B" lands are the areas shaded in grey and outlined by dashed lines (to the north of the Reserve), which depict the approximate location of the fee simple lands owned by Curve Lake First Nation. The inset shows Curve Lake First Nation in relation to Peterborough and Toronto. Source – the Base Map © OpenStreetMap contributors. The parcel data is from the Government of Canada, Indian Lands Registry System (ILRS) and electronic Registry Index Plan (eRIP) maintained by Indigenous Services Canada (ISC).

3.3.1 Reserve and non-Reserve lands

The CLFN study area includes approximately 649 hectares of the mainland Reserve (Chapter 3, Figure 1, Land-Use Study – Area A, Reserve lands[104]) and approximately 315 hectares of fee simple land within the Municipality of Selwyn (Chapter 3, Figure 1, Land-Use Study – Area B, fee simple land). A portion of the Reserve was flooded during the construction of the Trent-Severn Waterway, which is excluded from our study (Chapter 3, Figure 1 – flooded area). CLFN Reserve land is managed under a subset of the Indian Act (Act) called the Reserve Land and Environmental Management Program (RLEMP) at an "operational" level, which offers CLFN more control over the management of their land than under the Act itself. RLEMP has two program categories, operational and delegated. Delegated may be found on Reserves that were operating under the former "53/60" program (referring to Sections 53 and 60 of the Act for delegated authority) whereas under operational authority means a First Nation works with Indigenous Services Canada on managing their land[105]. CLFN fee-simple land is managed according to municipal zoning and by-laws enacted pursuant to provincial legislation, although, 50% of it will be added to the Reserve pursuant to the Addition to Reserve (ATR[106]) process.

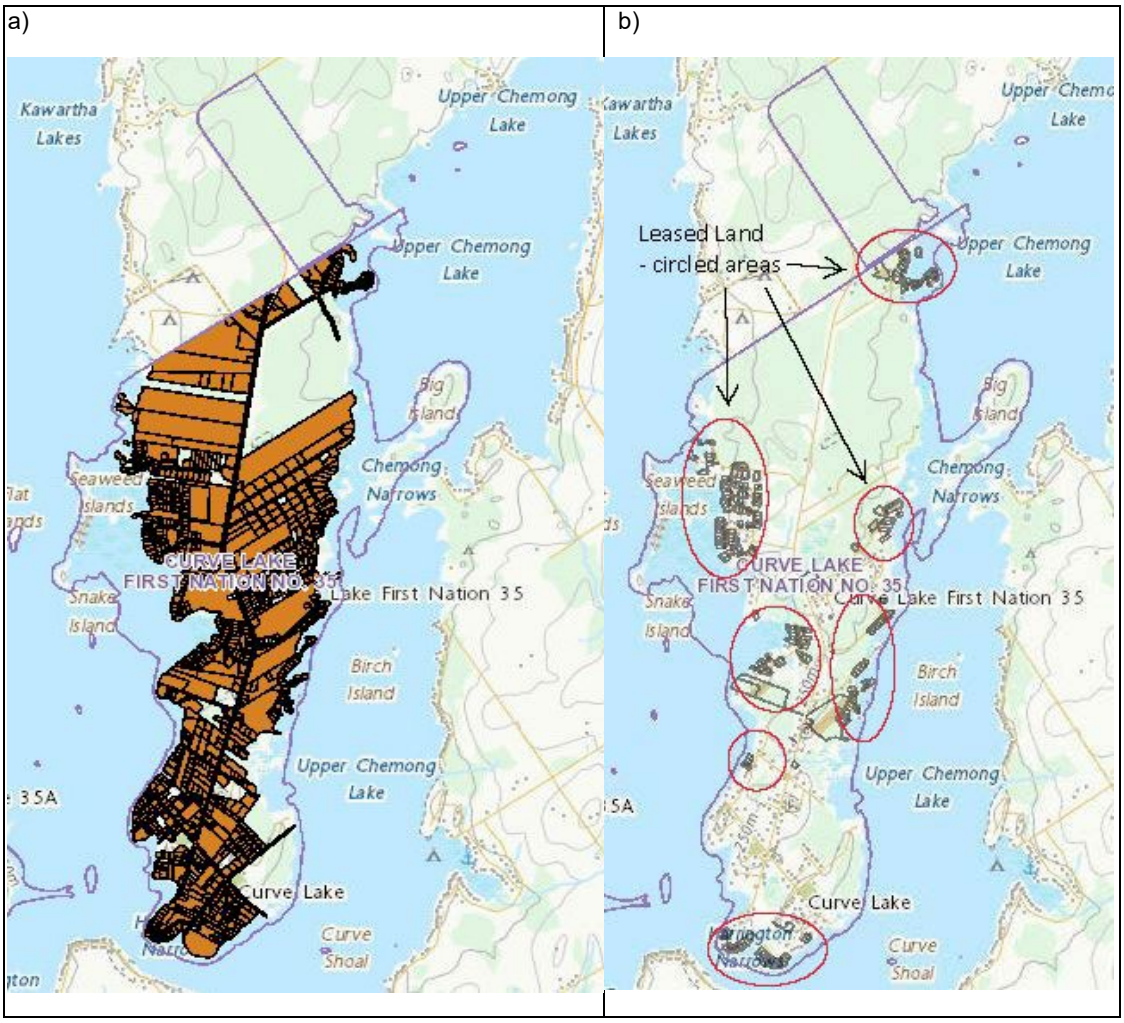
The CLFN community has a mixture of rural and urban areas. Rural areas are used for small farms, hunting, and wildlife habitats (CLFN, 2019; Whetung-Derrick, 1976). Urban areas are used for residential housing, year-round and seasonal leases, tourism, and small businesses. There are two main types of land holdings: 1) individual land holdings, held by certificate of possession (CP lands[107]) and 2) Band land[108] (community lands or non-CP land). A third type of land holding is leasehold, a subset of individual land holdings or band land[109]. According to the ILRS there are 1006 current CP's[110] that covers approximately 70% of the Reserve[111] (Chapter 3, Figure 2a). Approximately 57% (571 of 1006) of CP parcels have been developed (e.g., they contain a structure such as a house), leaving 43% CP parcels undeveloped. The developed parcels are occupied by: CP owners (63% of Reserve land - 331 households), lessees (6% of Reserve land -

[104] Indigenous Services Canada - First Nation profiles; https://fnp-ppn.aadnc-aandc.gc.ca/fnp/Main/index.aspx?lang=eng Curve Lake Indian Reserve Number 35. This area includes many islands, swampy and wildlife habitats, and flooded riparian lands. The useable land base is approximately 650 hectares.
[105] Reserve Land and Environmental Program Readiness, first edition, National Aboriginal Lands Managers Association (NALMA, 2020). Also see Fligg & Robinson, 2019 and ISC, 2020.
[106] "An Addition to Reserve [ATR] is a parcel of land added to the existing Reserve land of a First Nation" https://www.aadnc-aandc.gc.ca/eng/1332267668918/1332267748447
[107] Certificate of Possession (CP) is the evidence of title issued by Indigenous Service Canada (ISC) for individually held land. It is a possessory title; Reserve land is held in trust by the Crown.
[108] Band is a term used for the First Nation, defined under the Indian Act.
[109] There are approximately 220 leases, all on CP land (as per September 2020).
[110] 1006 CP's based on ILRS records, November 2019. A First Nation member may hold more than one CP.
[111] Based on the November 3, 2019 dataset for Curve Lake First Nation, by Natural Resources Canada.

220 leases[112] - CLFN, 2019), and private commercial activities (2% of Reserve land - CCP, 2009). About 35% of members have a CP within their immediate family, which could be used for development (CCP, 2009). All 220 leases are on CP held land (September, 2020), which occupies approximately 6% of Reserve mainland, near or along the lake shores (Chapter 3, Figure 2b). The non-CP Reserve land comprises 30% of the Reserve and is CLFN band or community held land (Chapter 3, Figure 2a). Approximately 11 hectares (or 5%) of band land is used for community purposes such as for the First Nation governance building, school, medical centre, parks, and cultural grounds. The remainder of community land resides in forest and protected areas, such as wildlife habitats.

How land is used (whether the use is formal or informal according to Chapter 3, Table 1) and the process of land-use decision-making over community (band) land are guided by the CLFN land management system, infrastructure and housing policies (CLFN, 2019), and in collaboration with Indigenous Services Canada (ISC). There are no by-laws pursuant to Section 81 (1) (g), (h) and (i) of the Indian Act which sets out the "Powers of the Council" on land management, planning, housing and surveys (First Nations Gazette, 2020). Except for CLFN policies on infrastructure, and on housing when CLFN money is used (CLFN, 2019), there are no formal land-use and development policies. The reason for the lack of formal land-use policy is uncertain, although, the lack of capacity (e.g., resources, trained staff, and funding) to enforce formal policy is affecting the implementation of formal land-use policies[113]. However, despite the perception that CP land holders may do as they please[114], members are guided by community land-use values, based on custom, tradition, and a vision for effective and sustainable land-use[115].

[112] 96% of leases are occupied by non-members; 4% of leases are occupied by CLFN members, three of which are seasonal (cottages), and six of which are year-round (homes).
[113] According to the CLFN Lands Manager, land-use by-laws will be difficult to enforce.
[114] According to the CLFN land-use study 2019, and the CLFN comprehensive community plan 2009 (CCP, 2009)
[115] CLFN Lands Manager, discussion on the use of land.



CHAPTER 3, FIGURE 2: CURVE LAKE FIRST NATION CP AND LEASED LANDS

Figure 2 (a): CP held lands comprise about 70% of the Reserve on the peninsula (shown in brown). The open areas within the Reserve boundary (shown in a heavy purple line) are band lands. Figure **2 (b): T**he leased lands are shown as the shaded parcels and outlined by 7 ovals (about 10% of the Reserve on the peninsula). Source – the Base Map © OpenStreetMap contributors. Parcel data is from the Government of Canada, Indian Lands Registry System (ILRS) and electronic Registry Index Plan (eRIP) maintained by Indigenous Services Canada.

3.4 Land-Use Survey

In 2009, a comprehensive community plan (CCP, 2009) outlined a number of land-use issues at Curve Lake First Nation (CLFN), which included unstructured development, haphazard use of land, lack of housing, and unprotected wildlife habitats. The comprehensive community plan included a land-use forecast that CLFN would soon run out of useable land for housing, community facilities and commercial development; suffer irreversible environmental degradation, and given the practice of haphazard land use it would alienate people from their land, their shorelines and their traditional use area. The primary recommendation of the comprehensive community plan was to

undertake a land-use planning exercise. It was recognized that the planning exercise would be a difficult task since the CLFN "does not have a process for the acquisition, regulation, or development of land….as First Nation members, we can do what we like when it comes to the land we own" (CCP, 2009, p. 15). After 12 years, land-use and policy has not changed significantly[116].

To elicit information and opinions from members about land management (including actual land-use) and community well-being (CWB), we undertook a Community-Based Participatory Research approach (Castleden et al 2012; Hartwig et al, 2006, Chapter 3, Table 2) to develop and implement a land-use survey in 2019[117]. The Community-Based Participatory Research approach took approximately six months to fulfil the initial stages of research objective, study design, recruitment, and survey method in collaboration with the Curve Lake Lands Committee, a 10-member group with a cross-section of members[118].

CHAPTER 3, TABLE 2: COMMUNITY-BASED PARTICIPATORY RESEARCH (CBPR)
adapted from Hartwig et al (2006)

Research Objective	Full participation of the community to identify issues of greatest importance, e.g., input from town hall meetings, social gatherings, committees, Council.
Study Design	Community representative involved with the land-use survey, e.g., Lands Manager, Lands Committee, and various other committees.
Recruitment & Retention	Community representatives provided guidance on recruitment and retention strategies and aided in recruitment efforts, e.g., via social media, town hall meetings, and committees.
Instrument Design (e.g., surveys, questionnaires, interviews)	Instruments were developed and tested with community input, e.g., land-use survey/questionnaire using SurveyMonkey and face to face options.
Intervention Design	Community members helped guide intervention development, e.g., the land-use survey as a guide for land-use planning and policies.
Analysis and Interpretation	Data was shared; Lands Committee, community members and researchers worked together to interpret results
Dissemination	Community assisted researchers to identify appropriate venues to disseminate results; community members involved in dissemination; results were also published in a peer-reviewed journal.

[116] CLFN Lands Committee on what by-laws or policies exist regarding land-use.
[117] Appendix B outlines 27 of 52 questions asked in the land-use survey. The remaining questions were about individual information not made available.
[118] CLFN Lands Committee (2019) consisted of 10 members, consisting of CP, and non-CP holders, on- and off-Reserve members, younger to older adults (Elder), Council member & Lands Manager

During the development stage of the survey, consultation took place at numerous community events (e.g., Community Center meeting, Spring clean-up), committee meetings (e.g., Public Works, Education, Youth, and Economic Development), and included a land-use planning workshop with CLFN students at their high-school. Pre-sampling and testing of the survey was completed by the CLFN Lands Committee. Notice about a land-use study was provided at CLFN social functions, through flyers, and on social media (e.g., Facebook). The notice indicated that a land-use survey was going to be undertaken by the CLFN Lands Committee in collaboration with researchers from the University of Waterloo (ORE 40248)[119] in April of 2019 with approval by Chief and Council. The preferred method of delivery for the CLFN was an online questionnaire service called SurveyMonkey[120]. However, a face-to-face option was also available.

Respondents were anonymous, were assigned a reference number, and were required to be an adult member of CLFN. A 52-question land-use survey was held over four weeks, which was undertaken by 160 participants (156 provided sufficient responses for analysis). Non-member leaseholders were not canvassed because all leases are on CP land held by members and we wished to focus on members' knowledge and opinions. Following the Community-Based Participatory Research approach, the survey data were compiled and a preliminary report was provided to CLFN members one month after closing the survey, and a detailed report was provided nine months later. This journal article will also be circulated to provide additional analysis of our results to the CLFN community and to the broader science, planning, and First Nation communities.

3.5 Land use survey summary

Survey responses were well balanced across our dimensions of interest. The breakdown by CP/non-CP holder was 44.2/55.8% respectively and by adult members living on/off-Reserve (18 years and over), which was 51.9/48.1% respectively. The Curve Lake First Nation (CLFN) Lands Committee (2019) indicated that the number of off-Reserve responses was typical based on previous studies conducted with the community. By category, 51.9% of responses were from 35% of the members living on-Reserve; 44.2% of the responses were from approximately 40% of the members living within a CP household (331)[121], and 48.1% of responses were from 65% of

[119] University of Waterloo, Office of Research Ethics, https://uwaterloo.ca/research/office-research-ethics
[120] SurveyMonkey is a cloud based on-line survey software, surveymonkey.com
[121] 40% of membership living within CP held dwellings is based on the number of members (2,177), the Statistics Canada (2016) average of 2.3 persons per household at CLFN, and the number of CP households (331). This number may be a bit high based on the CCP, 2009 (e.g., 35%), that indicates 65% of members would rely on non-family members for on-Reserve CP housing.

the membership living off-Reserve. Analysis of the study by household population data (24% on-Reserve[122]), at the 95% confidence level, revealed an approximate margin of error of 9%, which is acceptable for an exploratory study (Valliant et al, 2013; Litter, 2015). The CLFN Lands Committee[123] regarded the number of respondents as excellent relative to previous surveys which support the validity of this analysis.

The land-use survey was composed of two sections of questions. The first section, comprising 27 questions (Appendix B), focused on land management - land-use planning, land tenure and socio-economic development. The second section, comprising 25 questions, elicited information about other land-related aspects such as services (e.g., wells) for the lands Committee, and were excluded from our analysis.

Summary statistics associated with the 27 relevant questions (Chapter 3, Appendix A) identified the following 10 key findings about CLFN members "wants and needs" about land management:

1. 88% (of respondents) desired more community land
2. 84% were not familiar with land-use policies
3. 81% desired land-use zoning as part of land-use planning
4. 76% were unaware of the CLFN land management system
5. 66% indicated a need for leasing restrictions
6. 64% were not happy with the leasing system
7. 64% were unaware of the Canada Lands Survey System
8. 59% desired more protected areas (30% were unsure of the situation)
9. 44% were unaware ISC maintains a system of land title registration, i.e., for the Indian lands registry system (ILRS)
10. 42% were unaware of the differences between title to land on- and off-Reserve

The high proportion of respondents associated with key findings 1, 2, 3, and 4 suggest agreement among members about land-use planning. Fewer members agreed about land-tenure components as demonstrated with key findings 5, 6, 7, 9 and 10. The significance of these findings provide an indication as to what areas all members were more or less in agreement.

3.6 Statistical analysis

To assess any correlation between members' connect/disconnect with formal/informal land-use practices, survey responses were divided into four CFLN membership categories: 1) CP

[122] The number of on-Reserve households is 331, which agrees with the 2.3 persons per household, StatsCan,2016. Therefore, respondents are approximately 24% of the Reserve households, and using 77%, of the approximate adult being 591 (or 14%) of the 768 on-Reserve member population, and for off-Reserve, using 77% of the adult member being 1085 (or approximately 7%) and using 2.3 persons per household it is approximately 613 or 12%.

[123] supra note 121

holders (44.2% of respondents), 2) those who do not hold land or are non-CP holders (55.8% of respondents), 3) members living on-Reserve (51.9% of respondents), and 4) members living off-Reserve (48.1% of respondents) (Chapter 3, Appendix B). A Chi-squared analysis was used to determine if significant differences existed among these membership categories across 19 responses (of the 27 lands questions) that were a categorical or binary response (e.g., yes, no, and where applicable - unsure) (Chapter 3, Tables 3 and 4). While thresholds and the role of p-values differ by research domain (Andrade, 2019), we used an alpha value of 0.05 to provide an objective threshold to identify whether substantial differences existed between responses from different membership categories.

When survey responses were not categorical or binary (e.g., a rating system or percent values), a Student's t-test (2 tail, and alpha of 0.05) was used (4 of the 27 responses, Appendix D). The Student's t-Test compared the t-statistic value (t-stat) with the t-critical value (t-crit) on the rating or average information. If the t-stat value was less than the t-crit value (at alpha 0.05), then there was no significant difference (suggesting no disconnect) between the averages of the data being tested. The Chi-square and Student's t-test used 23 of the 27 land related responses. The four responses (of the 27 relevant questions) not used were either supplemental to a previous question, or could not be tested. A regression analysis was also conducted and various matrices of the correlation coefficients of the survey results tested, which corroborated the presented findings[124].

3.6.1 CP holders versus non-CP holders

In our comparison of CP and non-CP holders, a disconnect was found in 10 of 19 questions, which included awareness and knowledge of CFLN's land management regime, land-use policies, land-use planning and leases (Chapter 3, Table 3). Further, a disconnect about preferences for different land uses and housing types (e.g., preference for houses or apartments) also existed, which may have been partially driven by CP holders having a higher preference for mixed housing, possibly for business purposes (e.g., leasing).

No significant difference (or no-disconnect) was found in 9 of 19 responses that favoured more land-use policy (on both CP and community lands), setting aside more traditional-use areas, acquiring more land, increase of controls on protecting wildlife habitats and water-front lands, and concerns about leasing (Chapter 3, Table 4). Furthermore, there was no-disconnect in how satisfied members were (using four satisfaction levels tested and ranked in agreement from

[124] The regression analysis was excluded to provide the simplest analysis for comprehension by a wide audience of stakeholders and decision-makers.

highest to lowest) in their standard of living (51.1% sd 0.6), the current land management regime (46.5% sd 0.9), the current leasehold system (35.6% sd 1.8), and the quality and availability of housing (32.9 sd 1.5) (Appendix D).

The overall outcome of the analysis suggests that there is no-disconnect between CP/non-CP holders on the need for formal land-use policy. However, there is a disconnect between CP/non-CP holders in their knowledge and awareness of land management and land-use policies, and to a lesser extent in their knowledge and awareness about housing.

3.6.2 Members living on-Reserve versus off-Reserve

The same 23 responses were tested (19 by Chi-square, and 4 by Student's t-test) for differences between CLFN members living on- and off-Reserve and then related to results from CP and non-CP holder comparisons. A disconnect was found in 9 of 19 responses, 7 of which are the same for CP and non-CP holders, which included awareness and knowledge of CFLN's land management regime, land-use policies, and leases (Chapter 3, Table 3). The two responses that were different from CP and non-CP holders were found in responses about lease areas and wildlife habitats with a disconnect among members living on- and off-Reserve. No significant difference (or no-disconnect) was found in 10 of the 19 responses, 7 of which are the same for CP and non-CP holders, that favoured more land-use policy (on both CP and community lands), and setting aside or acquiring more land for traditional land-use areas and business, increase of controls on protecting wildlife habitats and water-front lands (Chapter 3, Table 4). The three responses that were different than the CP and non-CP holders were found in responses on the desire for land use planning, preference in housing types, and knowledge about leases.

The 19 Chi-square test results (Chapter 3, Tables 3 and 4) indicated that 14 of the responses (between members living on and off-Reserve, and between CP, non-CP holders) did not change in disconnect and no-disconnect. Of the five responses that had differing results, four of the responses had p values close to the threshold of alpha 0.05 (Chapter 3, Appendix C). The significance of these five results suggests uncertainty in knowledge base about land-use policy, planning, and leasing among all member types.

The Student's t-test (on the four satisfaction levels in the standard of living, the current land management, the current leasehold system, and the quality and availability of housing) produced the same results as for CP and non-CP holders, or no-disconnect (Chapter 3, Appendix D).

CHAPTER 3, TABLE 3: DISCONNECT TABLE:

Chi-square results (p values) for CP members (land holders) versus non-CP members (non-land holders), and for on-Reserve versus off-Reserve members. The threshold for disconnect is p values less than alpha = 0.05. The table indicates that survey questions (Appendix B), 1, 3, 4, 8, 9, 10 and 11, had a disconnect for both CP/non-CP members, and for on/off-Reserve members. Questions 13, 14, 15, 16 and 18 had differing results between member types. Numbers 13, 15 and 16 had a disconnect in CP/non-CP members, whereas questions 14 and 16 had a disconnect for on/off Reserve members. The differing results are outlined in Appendix C.

	Disconnect Test is statistically different (or fails to reject) p value < alpha 0.05		Survey Question (Appendix B)
Land Use Survey Question	**CP / non-CP p value**	**On / off Reserve p value**	
Do you know the land management regime (or land governance system) that Curve Lake First Nation is managed under?	2.46E-20	2.38E-06	1
Should CLFN lands be managed under a different land management regime such as the First Nations Land Management Act (FNLM) or a Self Government?	0.0080	0.0177	3
Are you familiar with CLFN's band administration policies on land-use?	0.0099	9.35E-05	4
Do you know that the Government of Canada, Surveyor General Branch (SGB) maintains the CLFN's survey records?	8.195E-05	0.0046	8
Do you know that the Government of Canada, Indigenous Services Canada (formerly INAC) maintains title information for CLFN, in a system called the Indian Lands Registry (ILR)?	8.63E-05	0.0026	9
Do you know what a certificate of possession is?	1.81E-09	2.7E-08	10
Did you know that the Reserve title system is different than how title is held off Reserve? e.g., fee simple vs. certificate of possession?	0.00044	0.00445	11
Do you know that lessees pay yearly service fees to CLFN?	0.0069	See Table 4 and Appendix C	13
Are you in favour of a land-use plan that designates land (e.g, zoning) for different types of land-uses, such as housing (residential), business (commercial), parks, traditional use, and wildlife habitats?	0.0331	See Table 4 and Appendix C	15

Do you prefer individual houses or apartment units, or both?	0.0176	See Table 4 and Appendix C	16
Are there places within CLFN territory that you think leasing should not be allowed?	See Table 4 and Appendix C	0.0189	14
Do you think there are enough protected wildlife habitats within CLFN?	See Table 4 and Appendix C	0.0005	18

CHAPTER 3, TABLE 4: NO DISCONNECT TABLE:

Chi-square results (p values) for CP members (land holders) versus non-CP members (non-land holders), and for on-Reserve versus off-Reserve members. The threshold for no- disconnect is p values greater than alpha = 0.05. The table indicates that for survey questions (Appendix B) 5, 6, 17, 19, 20, 23 and 24 there is no-disconnect for both CP/non-CP members, and for on/off-Reserve members. Questions 13, 14, 15, 16 and 18 had differing results between member types. Numbers 13, 15, and 16 had no-disconnect in on/off-Reserve members, whereas questions 14 and 18 had no-disconnect for CP/non-CP members. The differing results are outlined in Appendix C.

	No disconnect Test is not statistically different (or does not fail to reject) p value > alpha 0.05		Survey Question (Appendix B)
Land Use Survey Question	CP / non-CP P values	On / off-Reserve P values	
Do you think CLFN should have more or less policy on the use of community or band land?	0.1294	0.8193	5
Do you think CLFN should have more or less policy on what you can do on "private" reserve land? (CP)	0.3959	0.1660	6
Do you think there are enough traditional land use areas in the community?	0.1310	0.2448	17
Do you think there are enough areas for business in CLFN? e.g., gas stations, banks, stores, etc?	0.2247	0.1664	19
Would you be in favour of CLFN acquiring more land for community use?	0.3411	0.5158	20
Do you think more controls should be put in place on CP held lands for environmental protection? e.g., Wildlife habitats, wetland protection, pollution controls.	0.8664	0.2653	23

Do you think more environmental controls should be put in place for the waterfront areas. e.g., landscaping, swamp and marsh protection?	0.7779	0.7216	24
Are there places within CLFN territory that you think leasing should not be allowed?	0.4960	See Table 3 and Appendix C	14
Do you think there are enough protected wildlife habitats within CLFN?	0.0938	See Table 3 and Appendix C	18
Do you know that lessees pay yearly service fees to CLFN?	See Table 3 and Appendix C	0.0600	13
Are you in favour of a land-use plan that designates land (e.g., zoning) for different types of land-uses, such as housing (residential), business (commercial), parks, traditional use, and wildlife habitats?	See Table 3 and Appendix C	0.1800	15
Do you prefer individual houses or apartment units, or both?	See Table 3 and Appendix C	0.2403	16

3.7 Discussion

Our land-use survey analysis found areas of disconnect/no-disconnect among CP and non-CP holders, and on- and off-Reserve members in land management, land-use and policy, and land tenure. Chi-square results indicated no-disconnect among all members on the vision about their land, and on the need for sustainable land-use and effective land management. While, the Student's t-test indicated no-disconnect between member types (CP and non-CP holders, and on- and off-Reserve members) we also found no-disconnect among low levels of satisfaction (less the 50%) on: 1) the general condition, availability and suitability of housing (32.8%), 2) the leasehold system (36.0%), 3) the current land management regime (46.6%), and 4) an average score on the overall quality of living (51.3%).

Overall, the results suggest a correlation between how connected members were (i.e., no-disconnect) and formality (members prefer to know what should happen on the ground) in land management because they have a similar vision for the future of their land. Complementing this finding, our results suggest a correlation between member disconnect and informality (i.e., land-use practices not sanctioned by the First Nation government) in land management, whereby the non-CP holders and off-Reserve members have a higher level of uncertainty about community accepted or sanctioned land-use practices on the Reserve.

Analysis of member disconnect indicates a gap in the knowledge base, whereby CP holders and members living on the Reserve were more knowledgeable than non-CP holders and members living off-Reserve (Chapter 3, Appendix B). However, all respondents had similar views about the need for land-use planning, including land-use policy. The significance of this finding suggests the rationale for their desire for planning and policy might not be supported by their knowledge about land management and formal land-use policy, or their knowledge about the formal property rights system (such as the Indian Lands Registry System (ILRS) and Canada Lands Survey System (CLSS)). Rather the rationale is supported by the 2019 land use survey and the CCP (2009) that revealed a desire for land-use in accordance with informal First Nation customs and community values; a rationale based on CLFN's vision for effective and sustainable land-use.

The analysis indicates a need to enhance members' knowledge awareness of land management, in general, and a specific need to close the knowledge gap for non-CP holders and off-Reserve members. This finding is obfuscated by the significant number of non-CP holders who

live on-Reserve and by the number of CP holders who live off-Reserve[125]. When viewed from an off-Reserve perspective, provincial lands are under a formal system of land management, including land-use planning, and land-tenure, and consultation practices are found in provincial municipalities (Selwyn Township Community Consultation Policy, 2019). The significance of these results is Reserve lands are managed differently (as outlined in Section 3.2) than off-Reserve lands. This difference extends to how land is possessed/held (e.g. CP's), how lands are leased, and how lands are developed. Empirical information on land matters is significant to understanding Reserve members "wants and needs" and to allowing all members be "on the same page". These findings will assist Chief and Council, and the community, in determining why land-use planning such as enacting policy is difficult (or perceived to be difficult) and will assist in mitigating the issues (Millette, 2011; Prusak et al, 2016). This land-use study is a significant step towards a land-use plan at CLFN, designed with an ethnographic vision of the community (Prusak et al, 2016).

The fact that there is informality within land management (what actually happens on the ground, Chapter 3, Table 1) clouds the "wants and needs" of the members and being "on the same page" where all members (CP/non-CP holders, or members living on- and -off-Reserve) are entitled to an opinion. The disconnect among members (i.e., in knowledge base) presents uncertainty on how CLFN land may be used (e.g., what are the informal land-use practices) and on whether informal land-use practices are perceived as being formal (i.e., sanctioned by officials and administrators).

3.8 Conclusions

The Community-Based Participatory Research approach requires not only consultation with the community on what is taking place on the ground and on their knowledge base, but also requires understanding the ethnographic reasons for how land is being used and for the land management dynamic (as outlined in Section 3.3 for Curve Lake First Nation).

Although the matrix of land management (outlined in Section 3.2) assists in our understanding on what is meant by informality and formality as applied to CLFN lands, this article focused on the relationship of informal and formal land management by member types. How the informal/formal

[125] While the number of non-CP members that live on the Reserve is unknown, 65% of members are non-CP holders and 35% (768 of 2177) live on-Reserve (CCP, 2009).

matrix of land management applies to CLFN land-use and management will be explored in a subsequent paper[126].

Disconnect by both member types (CP/non-CP members and on/off-Reserve members) was found in 10 of the 19 responses tested by Chi-square that required knowledge on land management regimes, land tenure, and land-use policy. Despite this disconnect, a positive conclusion is that respondents agreed (or had no-disconnect) about their vision for sustainable land-use practices, with over 80% of respondents in favour of a formal system that would be specific to Curve Lake First Nation. Formal systems have proven to better levels of community well-being (CWB)[127] (Aubin, 1996; Brinkhurst, 2013; Fligg & Robinson, 2019). Across 169 First Nation communities in Ontario and British Columbia (BC) there was a positive relationship between formality and CWB – a 10% increase in formal housing led to CWB increases of 0.83 points for Ontario communities and 0.9 points for BC communities (Ballantyne & Ballantyne, 2016). Viewed through a lens of economic theory, formality increases investment incentives, lowers transactions costs, increases bargaining efficiency, internalizes negative externalities, and increases economic efficiency. From a land use planning perspective, formality promotes orderly development and sustainable land-use practices.

Further work identified from the results of the land-use study at CLFN includes:

1. Investigating informal practices (e.g., what is taking place), formal systems (e.g., what should take place according to CLFN, RLEMP land management regime), and what practices are in line with CLFN customs and traditions, and situating these findings in the matrix of land management for communication with CLFN and other First Nations.
2. Increasing member knowledge about land management and narrowing the disconnect in knowledge between non-CP holders and CP holders, and between on-Reserve members and off-Reserve members.
3. Reducing the uncertainty and describing the benefits of a formal system that incorporates CLFN land values and land-use practices.
4. Addressing the lack of capacity (e.g., resources, trained staff, and funding) to implement formal land-use policies or by-laws.

[126] For example, to what extent do land use practices degrade the riparian zone?
[127] CWB index is a measure of socio-economic well-being or development, which aggregates information related to Income, Education, Housing, and Labour Force Activity (ISC, 2019).

The challenges for CLFN to move to a more formal system will likely be mitigated if informal practices (based on a community vision) are incorporated into a formal system that is embraced by the community.

Future research on land management at Curve Lake First Nation includes: exploring a land management regime that embraces the "wants and needs" of members, based on customary land values and vision; and exploring a land-use plan that formalizes those informal land-use practices that are condoned by the First Nation administration and the community.

As of July 2021, these results are being considered by the Curve Lake First Nation Lands and Environment Committee so as to inform an action plan.

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Chapter 4: Development of an agent-based First Nation Land Use Voting Model: experiments in policy adoption at Curve Lake First Nation, Canada

4.1. Introduction

The process of developing and adopting a formal (sanctioned) land-use plan and setting land-use policy on many Reserves in Canada involves a complex process of incorporating drivers of First Nation land stewardship (Kehm et al, 2019; FNLMRC, 2023) and socio-economic well-being (DCG, 2020; Ontario, 2018). The process requires an understanding of both knowledge about federal legislation governing land management and knowledge about community land-use traditions and community objectives and vision (Ecotrust, 2009; NALMA, 2023). For approximately 10% of Reserve communities that have a formal (sanctioned) land-use plan in place[128], most contain a preamble about their heritage and relationship between the First Nation and their land (e.g., Rainy River Fist Nations, Kaska Dena, Wahnapitae First Nation, Tsawwassen First Nation, Little Grand Rapids First Nation) and some include an action plan about developing policies to protect natural and environmentally sensitive areas as well as approaches to educate members about First Nation land stewardship (e.g, the Rainy River First Nation Land Use Plan).

Previous research at one First Nation community, Curve Lake First Nation, Canada (CLFN), used a social land-use survey to elicit information from members to assist with developing a potential formal land-use plan and policies (Fligg et al, 2021). Analysis of the perspectives and visions of different member types (i.e., living on-vs-off reserve, certificate of land possession (CP) holder vs non-CP holder[129]) were in agreement but disclosed a gap between member types about their understanding related to land-use policy and what actually occurred on the ground. This gap or as referred to in the research as a disconnect among members at CLFN is fostered by the various age-of-majority members of the community that may be defined under the Indian Act (R.S.C., 1985, c. 1-5, Sections 10 and 11), whereby many members may or may not understand community land management (broadly defined to include systems of land management, property rights system, land-use policy and planning).

One approach to facilitate the development of a formal land-use plan and policy is to conceptualize a proposed plan and policies in a model and investigate the role of different member relationships to community objectives in land management (as broadly defined). A search for literature using Scopus, Omni, and Google Scholar on modelling First Nation member's

[128] Based on a study of First Nation communities across Canada that made their formal (sanctioned) 'land-use plan' publicly available.

[129] A certificate of possession (CP) is evidence of title for individual land holders under the Indian Act, R.S.C., 1985, c. 1-5 (referred to as CP holders).

knowledge about their land (e.g., on land management systems, land-use policy, land-use, and property rights) or collectively as a community with respect to voting on the adoption of a proposed land-use plan and policies returned no results. A subsequent search for literature related to Indigenous[130] voting found substantial literature on First Nation voting with respect to politics. However, only three papers were found related to First Nation voting behaviour with applications to land. The first paper, specifically investigated the cultural propensity for "in group" preferences or cultural preferences in voting (Dabin et al., 2019). The second, focused on First Nation cultural and traditional voting behaviour (Goodman et al., 2018), and the third, focused on First Nation members' preferences (i.e., in decision-making) in land use alternatives (Nikolakis et al., 2016). Nikolakis et al. (2016) suggested that when First Nation individuals are placed in group communication, such as in community engagement, member interaction and influence, there is an effect on individual's preferences, or 'voting intentions' on land-use, which reflects community values about First Nation land stewardship whereby 'everything is connected'. These types of interactions and their effect on human-decision making are difficult to represent using empirical and mathematical models (Parunak et al., 1998). However, the process of decision-making, the interaction among actors, and voting can be represented well using agent-based modelling approaches (e.g., Qiu & Phang, 2020; Rounsevell et al. 2012).

A stylized prototype agent-based model (ABM) was developed to better understand how member's land knowledge about First Nation land stewardship, ambition towards socio-economic well-being, and their collective collaboration might affect support towards community objectives via the adoption of a potential formal land-use plan and policy. The ABM, called the First Nation Land Use Voting Model (FN-LUVM), is empirically informed using a 2019 land-use survey conducted at Curve Lake First Nation (Fligg et al., 2021), whereby computational agents represent the land knowledge and attitudes of survey respondents. The agents interact through community engagement and interaction with other (member) agents, which affects their behaviour toward adopting a potential formal land-use plan and policy. FN-LUVM is used to better understand how different drivers of a formal land use plan and polices may affect voting behaviour to 1) provide insight on how CLFN can best assess gaps among voters, 2) provide insight into setting and understanding community objectives and developing a formal land-use plan and policies, and 3) increase CLFN capacity to mobilize members and enhance community knowledge in specific areas of interest. To achieve these goals, computational experiments seek to answer: how different member-levels of land knowledge, and attitudes on land stewardship, ambition for

[130] Indigenous People in Canada include First Nation, Metis and Inuit

socio-economic well-being, and collaboration affect support of community objectives on the adoption of a potential formal land-use plan and policies? How changes in members' attitudes affect support of community objectives on the adoption of a potential formal land-use plan and policies? How do different member types, e.g., CP land holders and non-CP land holders, affect support for adopting a potential formal land use plan and policies? And, how important is land knowledge to decreasing member disconnect about land-use practices and policy?

Section 4.2 provides context about First Nation land management systems, socio-economic well-being and land stewardship, and Section 4.3 on background information at Curve Lake First Nation (CLFN). This is followed by a conceptual model on a relationship of member land knowledge, and their attitude towards supporting community objectives on a potential formal land-use plan and policies that could be used as the basis for computer simulation. An outline is provided on the development of an agent-based model (ABM) (with details provided in the online-appendix) followed by computational experiments and analysis of results. A discussion is then provided about the results for Curve Lake First Nation and on future research.

4.2. First Nation Land Management systems and socio-economic well-being

Approximately 630 First Nation communities across Canada manage their land under one of four land management regimes or systems (Fligg & Robinson, 2019). From lowest to highest in autonomy of governance are the Indian Act regime, the Reserve Land and Environmental Management Program (RLEMP, being a sub-set of the Indian Act), First Nation Land Management regime (FNLM) and a framework of self-government (SG) regime. Each regime varies by legislation, for example approximately 80% of First Nation communities manage their land under the Indian Act (R.S.C., 1985, c. 1-5) (including the RLEMP regime); 16% of communities under the FNLM regime by the Framework Agreement on First Nation Land Management Act (S.C, 2022, c. 19, s. 121), and 4% of communities that manage their land under a 'framework of SG regime' have their own First Nation legislation (e.g., at Westbank First Nation, The Westbank First Nation Self-Government Act, S.C. 2004, c. 17).

Socio-economic well-being for communities has been measured since 1981 by the federal government using the Community of Well-Being Index (CWB). Although increases have taken place there is still a disparity in CWB index scores between First Nation Communities with non-Indigenous communities of approximately 19 points (out of 100) (ISC, 2020). By land management regime, communities that manage their land under FNLM or SG have a higher average of CWB as compared to communities that manage their land under the Indian Act (Fligg & Robinson, 2019). Despite a relationship of land management regime with CWB scores, previous research infers that various factors that include geographic location and economic opportunities

may affect CWB scores positively (Ballantyne & Ballantyne, 2017) such that it is possible for a community under any land management regime to achieve a CWB score higher than the non-Indigenous average score (Fligg & Robinson, 2019). But, there are many short comings of the CWB with only four indicators, in housing, education, income and labour force and lacks in cultural indicators, specifically those that are related to land and critical to the well-being of First Nation Communities (e.g., cultural sacred areas, Guthro, 2021; Bouchard et al., 2021).

4.2.1 First Nation land stewardship

Land stewardship as a general concept can be described as the individual and communal acknowledgement and responsibility to conserve and preserve the worlds' natural resources, ecosystems, and biodiversity (Land Stewardship Centre of Canada, 2022; Centre for Environmental Stewardship and Conservation Inc, 2009). It also encompasses the term environmental stewardship by how society manages the goods and services of the natural capital (Barbier, 2019) in our land, air, and water. Although natural capital supports our economy (Barbier, 2019) and is significant to our well-being, land stewardship encourages sustainable land-use practices that preserve and conserve natural capital value, enhance ecosystem resilience (Land Stewardship Centre of Canada, 2022; Chapin et al., 2011) and social value of land (National Stewardship Conference, 2009).

This spiritual connection is manifested within Indigenous people by their physical, social, and cultural connection to the land. Thus, there is a need for specific land-use plans and policies for all First Nation communities, backed by best practices on environmental stewardship (AFN, 2011) and traditional and cultural land-use values and practices (NALMA, 2016, 2023).

First Nation land stewardship is a key driver in developing a community-based land-use plan and policies at Curve Lake First Nation. Therefore, a higher weight is placed on community traditional and cultural values in a modelled relationship of First Nation land stewardship with land-use practices associated with socio-economic well-being. Since natural capital sustains human well-being, an objective under land stewardship (in the general sense) is to balance "natural capital books" (National Stewardship Conference, 2009). It is this balance which forms part of the overarching objective of our research on exploring community objectives on First Nation land stewardship (land stewardship) and socio-economic well-being in a potential formal land use plan and policies. The balance between land stewardship and land-use practices that support socio-economic well-being may shift based on the actions and 'wants and needs' of the community. Some land-use practices may occur without understanding the negative environmental

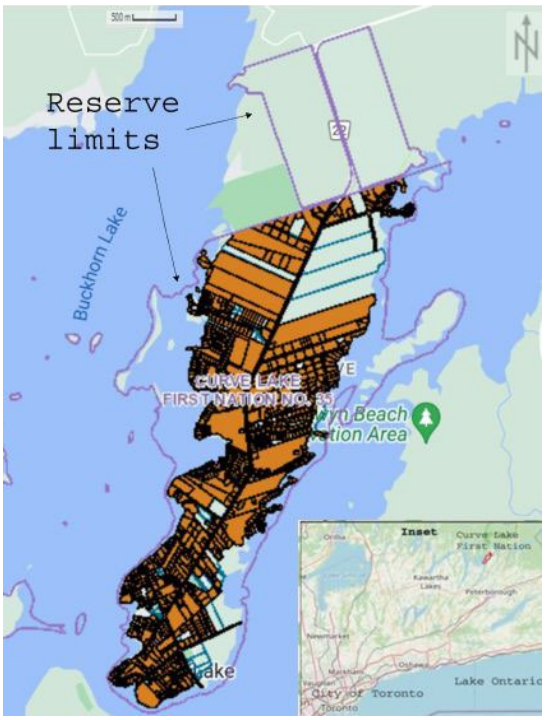
consequences, e.g., loss of wildlife habits, and these types of practices might be mitigated by education on environmental sustainability (Arora & Mishra 2019).

There are many approaches to represent and test land-use decision-making (University of Massachusetts, 2022; Edwards, 1954). The presented approach uses empirical information from the Curve Lake First Nation (CLFN) 2019 land-use survey on members' knowledge, opinions and attitude about their land, and community information derived from CLFN (2023, "Aki Lands'), CLFN governance, and the CLFN Lands and Environment Committee (previously Lands Committee) about community vision and objectives for land stewardship and socio-economic well-being. This information was then used to categorize three member-attitudes about land matters as, land stewardship, ambition and collaboration (e.g., Enqvist et al., 2018, as to members action, motivation, and ethics). This approach represents 'member land stewardship' as the attitude that drives Fist Nation land stewardship and sustainable land-use practices (e.g., Enqvist et al., 2018, as to the multiple meanings of land stewardship), 'member ambition' as the attitude that drives land-use practices in support of social-economic well-being[131] (both individual and community), and 'member collaboration' as the attitude members have regarding their interest on the topic of developing a potential formal land-use plan and policies that drives their interest on collaborating with like minded members. While land related knowledge (e.g, in land management systems, property rights, planning and land-use policies) is significant in making an informed decision about setting community objectives on developing a potential formal land-use plan and policies; cultural knowledge (i.e., First Nation relationship with the land) is a significant factor in setting community objectives, impacting member and community attitude in land stewardship that is set out in the vision statement at Curve Lake First Nation (CLFN, 2023).

4.3 Curve Lake First Nation

Curve Lake First Nation (CLFN) is located approximately 150 KM's north-east of Toronto, Ontario, Canada (Figure 1). CLFN has a First Nation membership of 2,500, with 700 members living on-Reserve and approximately 1,800 members that live off-Reserve (CLFN, 2023). While the total on-Reserve population is 1,300 it includes 600 non-First Nation people residing on leased Reserve land (CLFN, 2023; 1,245 by StatsCan, 2021).

[131] Inc. Magazine, https://www.inc.com/peter-economy/the-remarkably-positive-power-of-ambition.html



Chapter 4, Figure 1: Map showing Curve Lake First Nation with inset showing Curve Lake First Nation (top right) in relation to Peterborough and Toronto, Ontario, Canada. The brown areas shown on the map are CP lands and the Reserve limit is outlined in a heavy purple line.
Source: – Mapping showing Curve Lake First Nation Reserve Limits and parcel data is from the Government of Canada, Indian Lands Registry System (ILRS) and electronic Registry Index Plan (eRIP) maintained by Indigenous Services Canada.

Land ownership under the Indian Act sought to implement a western concept and system of property rights within reserves. As a result, informal systems of property rights are found within approximately 50% of reserve communities that do not use the Indian Act system and implement a more collective or communal approach (Fligg & Robinson, 2019), and within many reserves are informal and not sanctioned 'buckshee' transactions (Fligg et al, 2021).

Curve Lake First Nation (CLFN) manage their land under the Reserve Land and Environmental Management Program (RLEMP) a subset of the Indian Act and work with Indigenous Services Canada on land related matters such as land transactions and leases. Their formal property rights system is governed under the Indian Act whereby the Reserve is held in trust by the Crown (ISC, 2022), yet buckshee (informal unsanctioned) transactions are present (Fligg et al, 2021). Approximately 70% of the Reserve is held by individual land holders by certificate of possession (CP) (Figure 1) recorded in the Indian Lands Registry System (ILRS), with the remaining 30% of CLFN Reserve being 'Band land'.

CLFN does not have a formal land-use plan and no formal land-use policies that are sanctioned by by-law under the Indian Act, Section 81. Community land-use practices are guided by Chief and Council (and the community as a whole); however, informal (not-condoned) land-use

practices exist as there is a general belief among CP holders “we can do as we like” with their land (CCP, 2009, p. 15).

CLFN’s community well-being (CWB) score is approximately 70 out of 100, and while it is above the First Nation average of 58, it is approximately 8 points below the non-Indigenous average of 78 (2016 CWB scores). CLFN is situated within an economic region that is close to economic opportunities in southern Ontario, and within a busy recreational and tourist area (e.g., being along the Trent-Severn Waterway).

A land-use survey was conducted at CLFN in 2019 to assist in the development of a proposed formal land use plan and policies which elicited CLFN members (defined under Section 11 of the Indian Act) [132], knowledge and opinions about their land and well-being with 156 anonymous respondents (Fligg et al, 2021). According to the CLFN 2019 Lands Committee participation in the survey was regarded as excellent with survey responses well balanced by CP/non-CP holders (44.2/55.8% respectively) and the number of off-Reserve responses considered typical. Although self-selection and/or non-response bias is likely present (being responses from those members that wanted to participate), analysis of the land-use survey by household population data at the 95% confidence level has an approximate margin of error of 9% (Fligg et al, 2021) which is considered acceptable for an exploratory study (Valliant et al, 2013; Litter, 2015).

From a total of 52 land-use survey questions, 25 questions with 10 sub-questions (for a total of 35) were relevant to land matters and well-being that could assist with both model design and inform a proposed land-use voting model (Appendix 2 – The 35 land-use survey questions). The 35 questions had a variety of quantitative and qualitative responses (Johnson & Onwuegbuzie (2004), as to the benefits of using both quantitative and qualitative methods, and Thummapol et al.(2019) & Anderson (2010) as to qualitative information has challenges on being subjective) being questions with responses which could be measured, such as “yes”, “no”, “unsure” or a had a percentage rating (Appendix 1). Through discussion with the CLFN Lands Manager(s) and their Lands and Environment Committee (Committee)[133], they understood the possibility to translate the survey information into statistical information that could be used in a decision-making

[132] Section 11 sets out that the First Nation membership list is maintained by the Department of Indigenous Services Canada (ISC), and under Section 6 which defines how a member is entitled to be registered as an Indian. Also under Bill S-3: An Act to amend the Indian Act (elimination of sex based inequities in registration) in 2019, added approximately 400 members to Curve Lake First Nation

[133] Consultation with the Alison Irons-Cummings, CLFN Lands Manager (2014-2019) and CLFN Lands Committee on CLFN land management, land-uses, practices, policy and property rights system, and in collaboration with the 2019 land-use survey and study (Fligg et al., 2021). Consultation 2019 – 2022 with Delaney Jacobs and Breanna Knott, Lands Managers (acting or otherwise), and the CLFN Lands and Environment Committee (formerly the Lands Committee) on land-use planning, and feedback on the land-use voting model (FN-LUVM) presentations and material.

model[134]. A variety of methods have been used to represent decision-making in agent-based models (Parker & Robinson, 2017), e.g., rule-based (An et al, 2005; Deadman et al., 2004; Manson, 2005, Baster et al., 2013), utility function (e.g., Agrawal et al., 2013; Miller et al., 2010), statistical models,(e.g., An, 2012; Brown et al., 2008), and machine learning (An, 2012; Chu et al., 2009; Fligg & Barros, 2016, An et al. 2021). In collaboration with the Lands and Environment Committee (with representation form CLFN Council, staff and members), a simple rule-based system guided by the CLFN objective to be stewards of their land and promote sustainable land-use (e.g., according to the CLFN AKI lands mission statement, CLFN, 2023) was presented that would most effectively aid their collaboration (on a model) and understanding[135]. Land-use survey responses were point rated based on what was important to CLFN within their aforementioned context (Appendices 1 and 2), and the responses were grouped into three land-related knowledge categories that best suited CLFN: community specific planning considerations, property rights, and land management systems (Table 1).

The 156 respondents to the land-use survey were point scored on their land knowledge using the 35 responses, the level of importance based on CLFN community vision and in consultation with CLFN Lands and Environment Committee (Committee). The Committee members were also point scored and used as the 'control group' for the scoring having knowledge about the CLFN land management system, property rights systems, existing land-uses and policy (for Committee results see Appendix 2). While the point rating is subjective and biased (being based on the 'control group') there are similar point-scoring approaches that have been used elsewhere (e.g., Dobiáš, 2014; da Silva, 2009, on the LEED pointing system[136]; OECD, 2022; DAC Rio markers, 2017, on Green Point Rating (GPR)).

[134] Presentations, feedback and discussions with the CLFN Lands and Environment Committee on the land-use voting model (FN-LUVM) - scheduled meetings in the fall of 2021 and January 2022. The CLFN Lands and Environment Committee (formerly Lands Committee) is comprised of a representative of CLFN Council, CLFN staff (e.g., Lands Manager) and members of the CLFN community.

[135] Supra footnotes 133 & 134

[136] LEED Leadership in Energy and Environmental Design – green building rating system.
The OECD Development Assistance Committee (DAC) "Rio markers" if the activity targets environmental objectives.

Chapter 4, Table 1: Summary of Curve Lake First Nation (CLFN) point-rating of respondents land knowledge from the 2019 land-use survey. There are three CLFN land-use survey categories: 1) Community Specific Planning Considerations, 2) Property Rights and 3) Land Management Systems. The 'Community Specific Planning Consideration's are divided into three parts: Numbers: 1 to 9 - general planning considerations, 10 to 13 - land-use policy, 14.1 to 14.3 - well-being. Total land knowledge points per question are provided under the column (K), and total values for attitudes in land stewardship under (S), ambition (A) and collaboration (C).

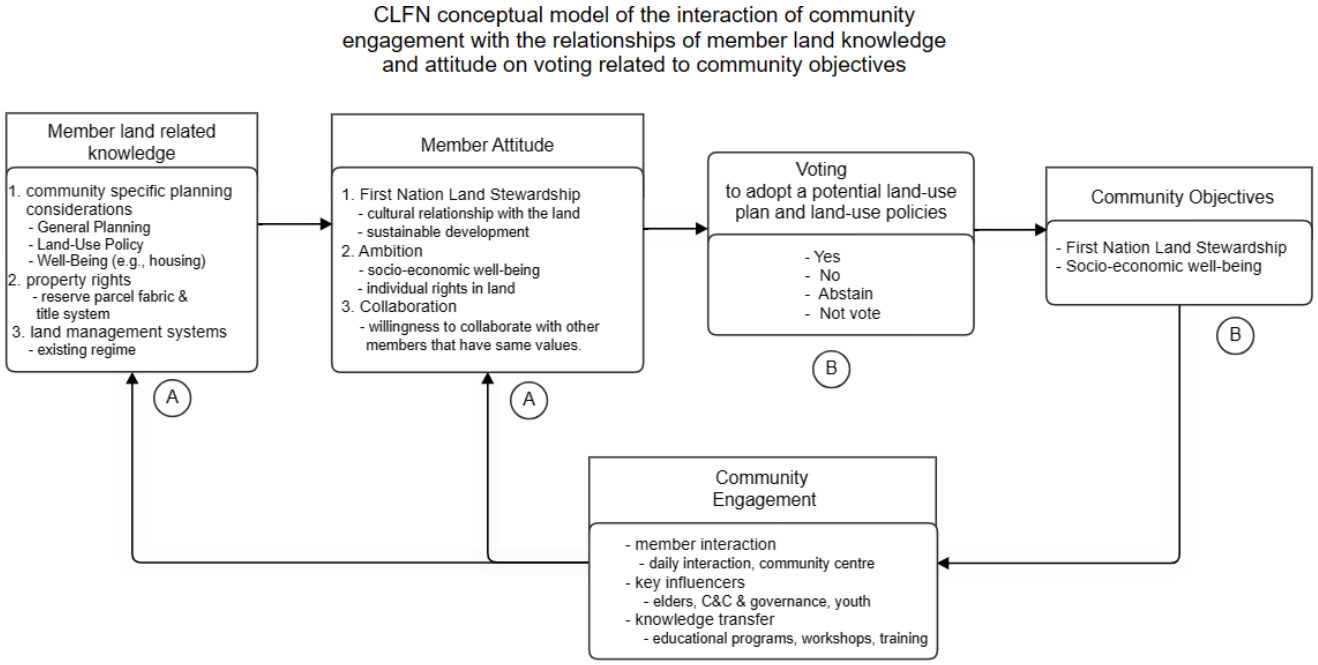
No.	Knowledge Category		Survey Question Number	General Content	K	Attitudes		
						S	A	C
1	Community Specific Planning Considerations	General Planning	19	a land-use plan with zones or designated land-use areas	5	-	-	25
2			22	Traditional/cultural areas	5	-	-	-
3			27, 28	Acquisition of lands – and addition to Reserve (ATR)	5	-	-	50
4			29	Acquisition of land - for individual and/or community use	5	-	-	25
5			24	Commercial use areas and the number of current businesses	5	-	-	-
6			31	Waterfront development controls	5	20	-	-
7			23	Protected areas / wildlife habitats	5	20	-	-
8			18	Areas for Leases	2	-	-	-
9			30	Environmental controls - over CP lands	2	-	-	-
10		Land-Use Policy	5	Awareness of formal (and informal) land-use policies	5	20	-	-
11			6	policy on land-use - over community land	5	20	-	-
12			7	Policy on land-use - over CP land	5	20	-	-
13			17	Policy on leasing and fees	5	-	-	-
14.1		Well-Being	48, 49	Housing and well-being	4	-	30	-
14.2			51	Education*	-	-	20	
14.3			52,47	Income*	-	-	20	
15	Property Rights		9	the land survey system	6	-	-	-
16			10	The federal government maintains – the survey system	4	-	-	-
17			12	The federal government maintains – the title system	4	-	-	-
18			13	knowledge of a certificate of CP evidence of title document	5	-	-	-
19			14	on/off Reserve title differences	5	-	-	-
20			15	the leasehold system	2	-	-	-
21	Land Management systems		1	The current land management regime	5	-	10	-
22			2	satisfaction with the current regime	1	-	10	-
23			3	Knowledgeable of alternate regimes	5	-	10	-

*Education and income are not included in agent land-knowledge score but are included in the initial calculation of agent attitude score on ambition.

4.4 Conceptual model

A conceptual model was developed to represent a simplified relationship between Curve Lake First Nation (CLFN) member land knowledge and their attitude(s) towards 1) community objectives related to land stewardship and socio-economic well-being, and 2) voting on the

adoption of a potential formal land-use plan and policies (Figure 2). Land-related knowledge is represented as a combination of understanding about the following three attributes associated with the coupled human-land system at CLFN: community specific planning considerations, property-rights, and land management systems (Table 1). A combination of the land knowledge attributes define a member's attitude toward First Nation land stewardship (land stewardship) in support of cultural and sustainable land-use practices; ambition, in support of land-use for socio-economic well-being; and, collaboration with other members (e.g., interested in the topic of formal land-use planning and policies, and collaborating with other members that are like minded). While land knowledge has the propensity to drive attitudes, attitudes can also motivate and derive new learning opportunities that can change a member's knowledge about the land (i.e., feedback; Finch, 2012; OECD, 2022).



Chapter 4, Figure 2: **CLFN conceptual model** depicting the relationship between members land knowledge, attitude, and community objectives. Member voting is driven by their land knowledge and attitude(s) toward First Nation land stewardship (land stewardship), ambition for socio-economic well-being, and propensity to collaborate with other members. The results of voting together with members average scores in land knowledge and attitude determine if there is alignment among members and community objectives, which can foster further community engagement with members if alignment or community objective thresholds do not occur. Where information is derived is shown as 'A' – information derived from the CLFN 2019 land-use survey and CLFN Governance | 'B' -information derived from the CLFN community, CLFN Lands Committee & Lands and Environment Committee

Each member of CLFN has the capacity to influence other members that may impact agents voting behaviour and/or setting community objectives in land stewardship and socio-economic well-being (RCAP, 1996; OECD, 2020; NCCIH, 2020). In our conceptual model, members vote

on support of community objectives on adoption of a potential formal land-use plan and policies and if community objectives are not met (e.g., support of land stewardship and socio-economic well-being) then CLFN council may continue the community engagement process. An objective of the model is to assist Chief and Council in determining member support of community objectives by assessing member voting behaviour that may also help to mitigate issues related to lack of capacity (e.g., lack of staff, funding) to enforce formal and sanctioned land-use policy (Edgar and Graham, 2008)[137].

4.4.1 Member knowledge

In the conceptual model, Curve Lake First Nation (CLFN) member land knowledge represents community specific combined knowledge and opinions associated with the coupled human-land system for adopting a potential formal land-use plan and policies on their lands (i.e., use of community or local knowledge in decision making and planning, Corburn, 2003). While land information can encompass a wide range of topics related to the land system (FAO, 2020, 1999; ISC, 2022) member land-related knowledge at CLFN is categorized into three general categories: community specific planning considerations, property rights, and land management system (NALMA, 2023; CLFN 2023) (Table 1). Community specific planning considerations includes existing and proposed land-use and cover (e.g., residential, commercial, traditional areas, wildlife and protected areas), proposed land-use areas, (e.g., designations, land-use zoning), private land holdings, band land, process of land acquisitions, housing, and land-use policy (e.g., knowledge about formal and informal policies affecting land development, the environment, waterfront areas, and land leases) (Table 1, No.'s 1 to 14). Property rights includes knowledge about the land-tenure system at CLFN and off-reserve, how land title is registered (e.g., in the Indian Lands Registry System (ILRS), CP evidence of title, and the Canada Lands Survey System (CLSS)) (Table 1, No.'s 15 to 20) . Land management systems includes knowledge about the land management regime at CLFN (RLEMP[138]), and knowledge about other types of land management regimes (e.g., FNLM and SG), and the process on how planning and policies are developed and implemented and are tied to the land-management system (e.g., sanctioned land transactions under the Indian Act and Section 81 on by-laws) (Table 1, No.'s 21 to 23).

4.4.2 Member attitude

Supporting a potential formal land-use plan and policy may be the result of a wide range of attitudes that are driven by different beliefs and outcomes associated with those beliefs (Li et al.,

[137] Discussion with CLFN Lands Committee,2019, and lands manager.

[138] Reserve Land and Environmental Management Program (RLEMP) is a subset under the Indian Act.

2022; Maloney et al., 2013; Eshetu, 2016). In the presented paper, the conceptual model focuses on three member attitudes: First Nation land stewardship (land stewardship), ambition, and collaboration. Land stewardship at CLFN is related to a member's attitude in support of cultural and environmental policies (e.g., protection of wildlife habitats and wetlands) and sustainable land-use practices (NALMA, 2023; AFN, 2011, 2022) (Table 1, No.'s, 6, 7, 10 to 12). Ambition is related to a member's attitude on land-use practices for socio-economic well-being, e.g., through land development, and a member's perceived "wants and needs" for improved housing conditions and more autonomy and control over their land (e.g., self-government) (ISC, 2022, as to socio-economic well-being of First Nation members) (Table 1, No.'s, 14.1, 14.2, 14.3, 21 to 23). Collaboration is related to a member's attitude and interest in working with others on the topic of adopting a potential formal land-use plan and policies (Rounds & Su, 2014, as to interest and behaviour) (Table 1, No.'s 1, 3 & 5).

4.4.3 Community objectives

Community objectives in the conceptual model attempt to balance social-economic well-being with land stewardship in the process of developing a potential formal land-use plan and policies. These objectives include community accepted 'informal" traditional land-use practices and policies together with "formal" land related law (e.g., under the Indian Act) and land-use policies (Fligg et al., 2021). Although community objectives may include informal land-use practices, there may be environmental aspects of land use that are governed by other formal laws outside the Indian Act, e.g., the Canadian Environmental Protection Act (S.C. 1999, c. 33). And, although formal property rights are governed under the Indian Act (R.S.C. , 1985, c. I-5) community objectives may need to consider community informal property-rights practices (e.g., "buckshee"[139]) and members attitude on land-tenure reform (Ballantyne et al., 2012).

4.4.4 Member Voting

A poll on adopting a potential formal land-use plan and policies are summarized under three voting categories: the number of yes and no votes, and the number of abstaining votes (undecided), but also included in the conceptual model is a fourth category for the number of members that do not vote (not interested). How a member votes is based on their land knowledge and their attitude in land stewardship, ambition, and collaboration towards community objectives on adopting a potential formal land-use plan and policies (e.g., CLFN vision about their land, CLFN (2023), 'Aki land'). Summarizing across the four voting categories can provide insight

[139] Buckshee refers to unsanctioned (i.e. not sanctioned under the Indian Act) informal land transactions

toward subsequent community engagement to support current and future community objectives and values. For example, members that vote 'no' may be unaware of the environmental consequences of their lack of land knowledge impacting their attitude, and their decision to not support formal land-use policies and planning. The abstaining voters are uncertain and/or undecided about their attitude in voting either yes or no which also may be the result of lack in land knowledge and unaware about the environmental consequences of some land-use practices. As abstaining members are uncertain/undecided, they are open to acquiring new land information that may impact their attitude and their desire to make an informed decision. Lastly, members that are not interested in the topic do not vote, however it is possible that new land information may change their attitude on the topic.

Polling results on community objectives for a potential formal land-use plan and policy drive the establishment or may lead to changes to community objectives. In the presented model, the First Nation council inform members about the polling results (e.g., on community objectives) and through community engagement can affect member land knowledge and their attitude to better inform members about community objectives.

4.4.5 Community engagement

Community engagement within the CLFN community is represented in our conceptual model by three factors which may impact a member's land knowledge and attitude about their land that may impact their support towards community objectives on adopting a potential formal land-use plan and policies. The three factors are knowledge transfer, member interaction, and key influencers[140]. The three factors may occur individually, in combination, or by all three depending on community objectives. Knowledge transfer can increase a member's knowledge in the areas of community specific planning consideration, property rights and land management systems. How this is accomplished is determined by the First Nation community, e.g., by community engagement and educational sessions. Member interaction and influence are actions which also impact a member's knowledge and attitudes in land stewardship and ambition. As members interact with each other and with key influencers (e.g., elders/seniors, local governance (as in Chief & Council, staff, committee members) and youth[141]) land knowledge and attitude may be transferred (i.e., between members, and influencers on members).

[140] In consultation with the Curve Lake First Nation Lands and Environment committee, October to December 2021.
[141] ibid

4.5 First Nation – land use voting model

Indigenous connectivity with their land and the belief that everything is connected (Indigenous Corporate Training, 2017) is a concept embedded in our model design since all land-information and member interactions can affect member decision-making and subsequent voting outcomes. Agent-based modelling (ABM) is well suited to represent these types of interactions (Parker & Robinson, 2017). In an ABM, real-world actors (e.g., First Nation members) are represented as virtual agents (Rounsevell et al. 2012) that interact with each other in their environment (e.g., the reserve community) and make decisions.

A simple First Nation Land Use Voting Model (FN–LUVM) was constructed based on our conceptual model that may improve societies' and First Nations understanding about how different types of members and their attributes in land knowledge, attitudes and collaboration can affect member-behaviour towards community objectives and developing a formal land-use plan and policies (Online-Appendix 3, FN-LUVM NetLogo program and code[142]). Our simplified model is composed of "unitary agents" (e.g., individuals, Agrawal et al ,2013) that make bounded rational decisions (e.g., agent decision-making based on limited information, Simon, 1997) and have the potential to interact with other agents in the absence of spatial constraints (i.e., a 'soup' model Macal & North 2009, pg. 155). How the model works and how agents behave in this model is just one approach to implementing the conceptual model (Figure 2).

The model is initialized with a population of agents along with their attributes in land knowledge and attitudes. An initial poll is taken and based on the land knowledge and attitudes of an agent, they may decide to vote 'yes' or 'no' to adopt a potential formal land-use plan and policies, or for agents that are not interested in the topic do not vote, or for agent that are uncertain and undecided may vote to abstain. The voting results may or may not achieve community objectives (not only in voting, but in land knowledge, and attitude towards community objectives in land stewardship and ambition for improved socio-economic well-being); and the degree to which the objectives are achieved influences subsequent community engagement (Section 4.5) where each agent may be involved in knowledge transfer (Section 4.1), member interaction, influence or some combination of the three community engagement processes. As the process of community engagement may change an agents land knowledge and/or attitudes a poll is taken again with agents voting based on potentially changed land knowledge and attitudes. The voting and community engagement process is repeated until the community objective is achieved (i.e.,

[142] NetLogo is a multi-agent programmable modeling environment. Wilensky, U. (1999) NetLogo http://ccl.northwestern.edu/netlogo/.

thresholds on voting, and in land knowledge and attitudes) or possibly the results indicate that community objectives need to be changed.

The importance of understanding model implementation and agent behaviour cannot be overstated and therefore a variety of protocols have been developed for communicating model content (Parker & Robinson, 2017; Cartwright et al., 2016; Grimm & Railsback, 2012). FN-LUVM details including computational experiments to test model parameters are communicated using the 'Overview, Design Concepts and Details' (ODD) protocol (Grimm et al. 2010; Grimm et al. 2020; Online-Appendix No. 1). In the following sections the salient components of the FN-LUVM are discussed as they relate to our conceptual model (Figure 2) and then how these components are instantiated in our computational experiments.

4.5.1 Agent land knowledge

Agent land knowledge is represented as a score out of 100 comprising their knowledge about – community specific planning considerations, property rights, and land management (Table 1, and Appendices 1 & 2). In FN-LUVM, the initial land-knowledge value of an agent is derived from the point rated CLFN 2019 land-use survey (Appendix 2). The five knowledge categories (three under community specific planning considerations - land-use planning, policy and well-being, and property rights and land management systems) are described in the CLFN background information (Section 4.3).

4.5.2 Agent attitudes

Community objectives in socio-economic well-being and First Nation land stewardship (land stewardship) are key to attitude development of agents and studying their behaviour in FN-LUVM (Vaske & Donnelly (1999). During the model initialization phase, the population of First Nation agents compute their attitude scores in land stewardship, ambition and collaboration based on a point rated system on land knowledge (Appendices 1 & 2). Attitude towards land stewardship is a function of land knowledge that supports land stewardship in cultural and sustainable land-use planning policies. Attitude towards ambition is a function of land knowledge on land-use practices that supports socio-economic and individual well-being. However, in FN-LUVM the ambition function lacks in support of a formal land-use plan and policies. The collaboration attitude is about an agent's interest and intent to collaborate and support agents with similar attitudes (i.e., like-

mindedness, Hart et al., 2009). Collaboration is a function of land knowledge on like-minded agents that may or may not support a potential formal land use plan and policies[143].

4.5.3 Agent Voting

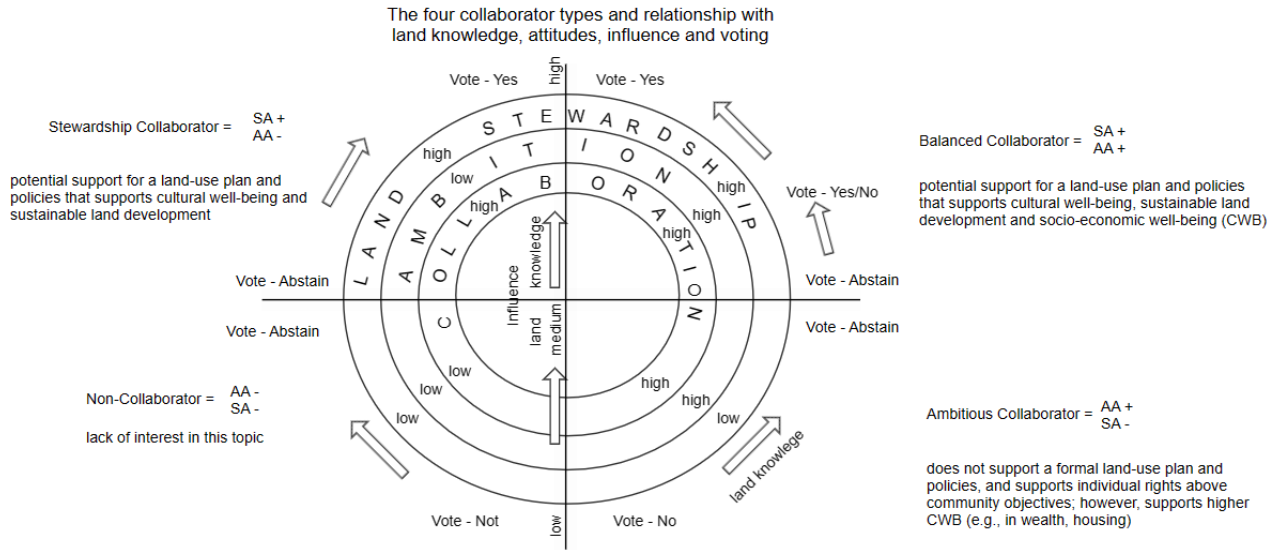
How an agent votes is driven by their land knowledge and attitude towards supporting community objectives on adopting a potential formal land use plan and policies (see Jhangiani et al., 2022; Kruglanski & Stroebe, 2005; Vaske & Donnelly, 1999, regarding the relationship between attitude and behaviour). Initially, all agents are set to abstaining voters (being undecided) until they acquire land knowledge and attitude information, and then agents make a decision to vote: yes, no, not-vote or remain to abstain. The voting decision is repeated for the entire population of agents until community objectives (e.g., user set thresholds) in voting and/or agent averages in land knowledge and attitude (e.g., in land stewardship) are achieved.

In FN-LUVM, agents are assigned to one of four collaborator types which are initialized based on information from the CLFN 2019 land-use survey (Appendix 2). The four collaborator types are one of four combinations of an 'ambitious-agent' (AA) and 'land stewardship-agent' (SA) (Figure 3). The collaborator type may change throughout a model run as their attitudes change by community engagement (Section 4.5). Through this process, the model creates a relationship between an agent's interest and behaviour (Rounds & Su, 2014) and who they collaborate with. The four collaborator types are: 1) stewardship collaborator: the agent has an interest to collaborate with and support other agents that have above average 'stewardship agent' scores (SA+) and also have below average 'ambitious agent' scores (AA-); 2) ambitious collaborator: the agent has an interest to collaborate with and support other agents that have above average 'ambitious agent' scores (AA+) and also have below average 'stewardship agent' scores (SA-); 3) balanced collaborator: the agent has an interest to collaborate with and support other agents with both above average 'stewardship agent' and 'ambitious agent' scores (SA+ and AA+); 4) non-collaborator: the agent has a lack of interest in the topic and there has below average 'stewardship agent' and 'ambitious agent' scores (SA- and AA-) (Figure 3).

The yes voting agents that support community objectives on a potential formal land-use plan and policies are found within the stewardship collaborator agents and the balanced collaborator agents (being a combination of stewardship and ambitious agent types) (Figure 3).The no voting agents that do not support community objectives for a potential formal land-use plan and policies are usually found within ambitious collaborator agents. The not-voting agents are found in non-

[143] May also be referred to as Integrated land-use planning or land relationship planning, Reconciling Ways of Knowing https://www.waysofknowingforum.ca/dialogue-9

collaborator agents where an agent has a lower-than-average score in land knowledge and attitude(s) and therefore not interested in participating. Abstaining agents are undecided about voting either yes or no and have medium land knowledge scores (e.g., 50 – 60) and low attitude scores (e.g., lower than 80 in land stewardship, and lower than 50 in ambition) however, the abstaining agents have potential to change their vote based on their above average score in collaboration (Figure 3).



Chapter 4, Figure 3 – The FN-LUVM four collaborator types, depicts a relationship with land knowledge, attitudes, influence and voting that are a combination of their scores as an Ambitious Agent (AA) and Stewardship Agent (SA), where AA+ has above average scores in the attitudes on ambition and collaboration, SA+ has above average scores in the attitudes on land stewardship and collaboration, AA- has below average scores in the attitudes on ambition and collaboration and SA- has below average scores in the attitudes on land stewardship and collaboration. 'Balanced Collaborators' have both SA+ and AA+; 'Stewardship Collaborators' have SA+ and AA-; 'Ambitious Collaborators' have AA+ and SA- and the 'Non-Collaborators' have AA- and SA-. The figure depicts an interactive relationship of influence, land knowledge, and attitudes in First Nation land stewardship, ambition, and collaboration with agent voting behaviour towards support of community objectives in adopting a potential formal land-use plan and polices (e.g., support in land stewardship for cultural and sustainable land use, and support for land related socio-economic well-being as measured by the Community Well-being Index (CWB)). See Appendix 4 – Table 1 agent voting behaviour by land knowledge, attitudes and collaborator type.

4.5.4 Community objectives

In FN-LUVM, thresholds for community objectives are set by the user to reflect CLFN community objectives, i.e., in the number of yes votes needed, average land knowledge, and averages in land stewardship and ambition related to land driven socio-economic well-being. These thresholds are based on empirical information from the Curve Lake First Nation (CLFN) Lands

and Environment Committee (e.g., committee land survey results) that were used as the 'control group' (Section 3 & Appendix 2); 'CLFN Aki land' on their vision (CLFN, 2023), and "stylized fact' as to community beliefs[144]. The thresholds are assessed to determine whether community objectives have been achieved. Voting thresholds may include a simple majority, where at least 50% (e.g., 50% + 1) of voters are needed or possibly it may require an absolute majority, and not just those agents that voted but all eligible voters, such as a quorum (Dougherty & Edward, 2010). FN-LUVM assesses the absolute majority vote results and compares voting results to community objectives for First Nation land stewardship (represented by the land stewardship average score) and on land related drivers of socio-economic well-being (represented by the ambition average score). For example, in FN-LUVM, if the poll indicates no-voters, abstaining and not-voters are more than 50%, such that the number of yes voters does not reflect a majority of eligible voters, the agent voting behaviour might suggest agents' attitude scores in land stewardship and ambition do not meet community objectives, and feedback about the results of the poll are sent to community engagement for the land knowledge areas to prioritize.

4.5.5 Community engagement

Community engagement in FN-LUVM is composed of the following three processes: knowledge transfer, member interaction and influence. Knowledge transfer increases a member's knowledge by setting a level of importance in each of the five areas. This is accomplished by assigning a rate of knowledge increase for each agent (e.g., 0 to 5, lowest to highest) which may be weighted according to agent type (e.g., CP land holder or non-CP land holder). For example, the CLFN non-CP members have a lower land knowledge score than CP holders (Appendix 2) and therefore a higher weight (or focus) is placed on non-CP agents (e.g., 1 for CP agents and 1.5 for non-CP agents) to meet community objectives (Online-Appendix 1 - ODD).

Member Interaction represents how an agent interacts and impacts other agents and is a function of agent collaborator type and land knowledge (Figure 3, and for further explanation see Online-Appendix 1, Section 2.8). The 'non-collaborator agent' (being those that have a lack of interest on this issue) will not likely vote, and therefore, have no interaction formula. The 'ambitious collaborator agents' (being those which have an above average level of ambition) have a stochastic process by randomly interacting with other agents and the interaction may impact other agents' ambition score (See Online-Appendix 1, ODD, Sec. 2.5 Stochasticity, and Sections 3.21 and 3.22 on FN-LUVM functions). This is accomplished by increasing their ambition attribute score by increasing land knowledge attributes scores on well-being and land management, and

[144] Supra notes 133 & 134

decreasing their land knowledge attribute scores in policy and planning (that has the effect of lowering the agent's land stewardship attitude towards the community objective in support of adopting a potential formal land-use plan and policies). The 'stewardship collaborator agents', being those which have above average scores in land stewardship also have a stochastic process by randomly interacting with other agents and may impact the other agents' land stewardship score. This is accomplished by increasing the other agent's attitude score in land stewardship by increasing their land knowledge scores in policy and planning. The 'balanced collaborator agents', being those which have above average scores in both land stewardship and ambition, randomly interact with other agents and may impact other agents' land stewardship and ambition scores. This is accomplished by increasing other agents' land knowledge attribute scores that impact both land stewardship and ambition (e.g., for a more balanced attitude).

Influence on agents is accomplished by three Influencer groups that is based on CLFN perception on their level of wisdom in the community, in order are: 1) Elders/seniors, 2) local governance (Chief and Council, staff, committee members) and 3) youth. The Elders and governance agents may influence member agents on attitudes and land knowledge, however Elders have greater influence with community trust and wisdom on the cultural needs of the community (Viscogliosi et al., 2020), whereas governance has greater influence on land-use policies, processes, and systems of land management and property rights. Youth do not have the same level of land knowledge as governance but can influence attitudes in land stewardship and vision (Lines & Jardine, 2019).

Although influence in FN-LUVM is subjective (being Curve Lake First Nation specific), the degree of influence on other agent attributes is based on a stochastic process of interaction that may impact other agent's land knowledge about existing formal land matters (e.g., land management regime, property rights systems, legislation), and their land knowledge about community accepted informal land-use practices. To address bias in community specific objectives, the Influencer function has parameter settings that may be adjusted to represent different frequencies of interaction as well as how much intensity of influence may be carried out. How these parameters are set are discussed in Section 7 (e.g., the 37 computational experiments, and Online-Appendices 1 - ODD, and 3 – Interface Settings).

4.6 Agent initialization

Agents are parameterized to align with respondents from CLFN 2019 land-use survey which includes 69 certificate of possession (CP) and 87 non-CP holders (n = 156) (Appendix 2). A sampling of the agent population was generated by randomly selecting 100 of the 156 respondents and translating the survey responses to initialize their land knowledge and attitude

scores, and collaborator types. Since more agents can lead to different outcomes (Anderson, 1972), FN-LUVM was run with random 100, 500, and 1000 agents for 30 model runs each (Online-Appendix 1). The outcomes of agent attribute averages for the three different population sizes varied by approximately 1.3%, demonstrating that increasing the population size beyond 100 agents had little effect on modelled outcomes. Despite the minor variation in outcomes due to population size, agents with the same initial parameters may take different pathways due to stochastic interaction among agents (during the random selection of agents during the community engagement functions for interaction and influence) and the frequency of their interaction with different types of Influencer agents. For computational experiments, the same 100 random agents (known as the experimental group), composed of 46 CP and 54 non-CP formulated the agent population, which aligned to our land-use survey responses to within 2% of the 69/87 (CP/non-CP holders).

4.7 Computational experiments

To capture the variation in FN-LUVM outcomes due to endogenous stochastic components (e.g., random agent selection during member interaction and influence functions), 37 experiments were run 30 times (e.g., as in Deadman et al., 2004, and Agrawal et al., 2013) and data about agent land knowledge, attitudes, collaborator types (Sections 4.1 and 4.2) and voting (Section 4.4) were summarized across all 30 runs (Appendix 3). Additional runs (i.e., > 30) had little impact on output summaries (< 2% on standard deviation of output metrics).

Each of the 37 model runs in FN-LUVM was initialized with the same 100 agents (Section 4.6) and each agent have attribute data on land knowledge and attitudes (Sections 4.1 and 4.2) that is empirically informed based on the 2019 Curve Lake First Nation (CLFN) land-use survey (Section 4.5 and Appendix 2). These empirically informed attributes include agent land knowledge related to land management, planning, policy, property rights and well-being as well as agent attitude attributes related to land stewardship, ambition, and collaboration.

Also included is how each agent would vote at the initialization of the model (e.g., not vote, vote no, vote yes, or abstain). The initial population comprises 23 yes-voting agents, 10 voting no, 58 abstain, and 9 agents that are unlikely to vote (or not vote) and the initial average scores on land stewardship, ambition and collaboration were calculated (Table 2). These initial conditions, which represent the 2019 conditions at CLFN, are referred to as LUS19 (or the ‘experimental group’, Section 4.6, initialization of the 100 agents) and are used to compare agent voting behaviour, land knowledge and attitudes that may change following different parameter settings that comprise our computational experiments with FN-LUVM. The purpose of these experiments are to gain insight (e.g., behaviour of the agents) into how and why agents may vote yes, no or

abstain, and may change from abstaining to a yes or no vote to support community objectives on the adoption of a potential formal land-use plan and policies, and insight into thresholds that may be used for community objectives. Summaries of the 37 computational experiments were used initially to set model parameters on thresholds for community objectives, not only for the threshold of majority of yes votes of the eligible voters (e.g., 50% +1), but for thresholds on member averages in land knowledge (e.g., higher than initial average value of 64.5) and in land stewardship (e.g., higher than initial average value of 66.4) (Table 2), and calculations for the four collaborator types (Figure 3).

Using the aforementioned initial conditions, two of the 37 computational experiments were selected (Appendix 3) to answer four research questions laid out in the Introduction. Computational Experiment 1 implements the three community engagement functions; land knowledge transfer, member interaction and influence functions (Online-Appendix 1, ODD). This experiment investigates the relationship of 1) land knowledge, 2) the three attitudes (land stewardship, ambition, and collaboration), 3) different collaborator types, and 4) interaction of member-agents and with influencers has on voting behaviour and their outcomes.

In Experiment 2 the knowledge transfer function is excluded during community engagement (Section 4.5). However, there is an aspect of knowledge transfer that occurs through member interaction and the role of influencers, which in this experiment have a stronger influence on members with whom they interact (see FN-LUVM ODD, Online-Appendix 1 for experiment settings). Experiment 2 required a longer period (measured in NetLogo[145] ticks) to achieve comparable results with Experiment 1 and terminated at 100 ticks for all 30 runs, whereas Experiment 1 terminated at 30 ticks for all runs. Both experiments terminated when there were no significant changes in the outcomes, e.g., no significant changes occurred after 30 ticks in Experiment 1 and after 100 ticks in Experiment 2.

The results of both Experiments 1 and 2 are used to investigate agent behaviour in land knowledge and attitudes (e.g., land stewardship, ambition, and collaboration) as well as how changes in those attitudes affect agent voting behaviour on the support of community objects on the adoption of a potential formal land-use plan and policies.

Descriptive analysis and box plot visualizations demonstrated that experiment results related to agent variables (e.g., land knowledge, and the five knowledge variables in land management, policy, planning, property rights, well-being, and the three attitude variables in land stewardship, ambition, and collaboration) were non-normally distributed. Furthermore, the dependent variables

[145] Supra note 142

of interest, voting outcome and collaborator type are nominal. Therefore, experiment results were analyzed using non-parametric statistics. A Spearman's Rank correlation was used to test for relationships among agent attributes (e.g., in land knowledge and the three attitudes) and multinomial logistic regression (MLR) was used to investigate probable voting outcomes and model accuracy (Section 4.8.1.1, and Online-Appendix 1, Section 3.4.7)

To explore the effects of individual land holders represented by members with a certificate of possession (CP) versus non-CP members and their support of community objectives on adopting a potential formal land-use plan and policies (our third research question), the experiment results specifically looked at how land knowledge and attitudes (e.g., land stewardship, ambition, and collaboration) impacted voting behaviour by CP and non-CP holders. In addition to plan and policy support, the effects of land knowledge on First Nation member disconnect (i.e., their understanding about land-use policy and practice) among CP and non-CP holders and how changes in disconnect affect support for land-use policy and planning was investigated. Member disconnect between CP and non-CPs uncertainty related to land-use policy, as discussed in Fligg et al (2021), is represented as the difference between CP and non-CP agents average score (Section 4.8.2.1) using the point-scoring land use survey in land knowledge (Appendix 2).

4.8 Results and analysis

Both computational experiments 1 and 2 attained an absolute majority yes vote of at least 50% + 1, with 61% yes votes in Experiment 1 and 67% yes votes in Experiment 2. While yes votes appear to be due to an increase in member attitude toward community objectives in Fist Nation land stewardship (land stewardship) (Table 2) agent voting behaviour is based on a complex interaction of various factors during community engagement that includes land knowledge and attitudes on community objectives. Although a majority of yes votes is a significant statistical outcome, the reason for using FN-LUVM (an agent-based model) was to investigate agent voting behaviour by land knowledge, and attitudes in land stewardship, ambition, and collaboration and how changes may impact agent voting behaviour.

Chapter 4, Table 2: LUS19 values for the 100 agents and final results for Experiments 1 and 2. All final results are reported as averages across 30 runs for Experiments 1 and 2. Therefore, voting averages were rounded to the nearest voter and attitude and land knowledge scores were retained to one decimal place. Multinomial logistic regression (MLR) analysis on voting outcomes (alpha 0.05) are shown in brackets based on the independent variables of land knowledge, land stewardship, ambition, and collaboration using pairwise logistic regression..

	Voting 100 agents total				Attitude avg/100			Land knowledge avg/100
	Unlikely to vote (MLR)	Vote NO (MLR)	Vote YES (MLR)	Abstain (MLR)	Land Stewardship	Ambition	Collaboration avg/100	Land Knowledge
LUS19	9 (9.8)	10 (7.3)	23 (22.0)	58 (61.0)	66.4	47.0	81.8	64.5
Experiment 1	13 (14.9)	4 (5.0)	61 (45.1)	22 (35.0)	82.8	49.6	76.9	87.2
Experiment 2	9 (9.7)	13 (13.5)	67 (72.1)	11 (11.8)	80.5	60.4	88.0	76.7

4.8.1 Plan and Policy Adoption

The outcomes of Experiment 1 were used to investigate the first research question on how different levels of member's land information knowledge and attitudes toward land stewardship, ambition and collaboration affect support for community objectives on a potential formal land-use plan and policies. Among the four collaborator types (Non-Collaborator, Balanced, Stewardship, and Ambitious, Figure 3), the Balanced and Stewardship collaborators yielded the highest propensity to vote yes, at 80.8% and 44.8%, respectively (Table 3) but it is the balanced agents that have highest attitude scores in support of both land stewardship and ambition (in support of land related socio-economic well-being) (Figure 3, & Appendix 4). In contrast, Ambitious collaborator agents had the highest propensity to vote no (77.9%) and did not support community objectives on a formal land-use plan and policies on land stewardship, and sustainable development, however, supported objectives in socio-economic well-being. Although increasing land knowledge increased attitude in land stewardship and yes votes, there is a 54.3% propensity for the stewardship collaborators to abstain and therefore the focus might be to achieve more balanced collaborator types with abstaining voters that support community objectives in both land stewardship and socio-economic well-being (as represented by ambition).

Chapter 4, Table 3: Propensity by agent collaborator type on voting for Experiment 1. Each row provides summary information on voting (by %) according to collaborator type. A breakdown by collaborator type and agents averages in land knowledge and attitude may be found in Online-Appendix 1.

Collaborator Type	Not vote %	Vote no %	Vote yes %	Undecided %	Total % by row
Non-collaborator	39.8	8.3	0.0	51.9	100
Ambitious	0.0	77.9	0.0	22.1	100
Stewardship	0.0	0.9	44.8	54.3	100
Balanced	0.0	2.6	80.8	16.6	100

Propensity of agent voting behaviour on community objectives were assessed by agent attitudes in First Nation land stewardship (land stewardship) and by ambition independent of each other. Attitude toward land stewardship had to achieve a score of 60/100 and ambition had to achieve a score of 20/100 for agents to have any propensity to vote yes in support towards adoption of a potential formal land use plan and policy (Table 4). As attitude toward land stewardship increased, from a score of 60 to 100, the propensity for agents to vote yes increased rapidly from 18% to 94%. As attitude toward ambition increased, from a score of 20 to 100, the propensity for agents to vote yes was less with increases ranging from 2% to 79%. While attitudes in land stewardship and ambition were positively correlated with a propensity to vote yes, only the highest levels of attitude for land stewardship could secure a yes vote whereas attitude for ambition was more distributed and reached a maximum propensity to vote yes of 79% (Table 4). These observations suggest “individuals make decisions based on the expected change in their level of well-being” (Howley et al., 2015, pg 2: Edwards-Jones, 2006), and/or based on the proposition in Amadae (2021), whereby individuals make decisions based on personal preference.

Chapter 4, Table 4: Illustrates agent voting behaviour by land stewardship and ambition acting independent of each other and by average category for Experiment 1. The left side depicts land stewardship according to intervals of avg. 10 and the right side depicts ambition by intervals of avg. 10. Voting percentages by each row (for land stewardship and ambition) totals 100%, therefore the probability of votes will change significantly when one voting category changes. For example, when ambition is between 70 – 80, there is a probability of 0% not-votes, therefore the probability distribution changed with an increase in no votes to 39% and abstaining to 7.6%, however, when ambition is 80 – 90, no votes drops to 9.3% and the probability of abstaining increased significantly to 53.4, and then when ambition is between 90 to 100, there is only a probability to have yes or no votes. Note: some agent scores may be close to a voting threshold that will impact changes.

	Land Stewardship					Ambition (Independent of each other)				
avg	% Not vote	% No vote	% Yes vote	% Abstain vote	% total	% Not vote	% No vote	% Yes vote	% Abstain vote	% total
0-10	16.8	72.0	0.0	11.2	100	35.9	1.6	0.0	62.5	100
10-20	33.2	32.1	0.0	34.7	100	19.3	13.1	0.0	67.6	100
20-30	37.6	17.1	0.0	45.3	100	17.7	10.6	2.2	69.4	100

30-40	42.3	11.0	0.0	46.7	100	15.7	3.6	36.0	44.7	100
40-50	37.4	16.4	0.0	46.2	100	14.0	2.9	51.4	31.7	100
50-60	39.8	14.0	0.0	46.2	100	12.1	4.0	64.1	19.8	100
60-70	40.6	11.3	18.2	29.9	100	14.7	12.0	65.3	8.0	100
70-80	26.2	1.5	54.3	18.0	100	0.0	39.0	53.4	7.6	100
80-90	0.0	0.0	41.6	58.4	100	0.0	9.3	37.3	53.4	100
90-100	0.0	0.0	94.0	6.0	100	0.0	21.5	78.5	0.0	100

Assessing agent voting behaviour with a relationship between agent attitudes (i.e., between land stewardship, ambition and collaboration), the average attitude scores in support of community objectives on a potential formal land-use plan and policies, ranked from highest to lowest, were: land stewardship (89.8 avg.), followed by collaboration (85.7 avg,), and then ambition (50.2 avg,) (Table 5). The significance of these average attitude scores suggests that agents with higher averages in collaboration and land stewardship attitudes are more likely to vote in support.

Chapter 4, Table 5: Voting category by average scores in attitudes for the final results in Experiment 1.
Average scores for collaboration, ambition, and land stewardship are shown for each voting category.

Voting categories	collaboration avg/100	SD	ambition avg/100	SD	land stewardship avg/100	SD
not vote	37.1	14.4	38.2	14.7	49.1	17.5
vote No	78.4	10.4	45.2	22.6	35.3	21.5
vote Yes	85.7	7.6	50.2	11.7	89.8	8.5
undecided	74.6	15.9	37.9	17.5	69.4	20.4

The effects of agent land knowledge on voting behaviour suggest support of a formal land-use plan and policies occur when average scores were greater than 70 (Table 6); however, agent attitude toward land stewardship was also high (e.g., greater than 87). To achieve an absolute majority of yes votes, land knowledge was above 80, land stewardship above 90,and ambition above 51 (Table 6), having similar scores of the 'control group'.

Chapter 4, Table 6: Propensity of agents to vote yes by average ambition and land stewardship attitude scores in relation to land knowledge (Experiment 1). Knowledge is shown in intervals of 5 above the average of 70. As knowledge increases, together with high land stewardship scores (e.g., above 90) and ambition scores in the 50 to 60 range, would achieve a majority of yes votes.

land knowledge	ambition	land stewardship	Percent of yes votes
	averages/100		
0-70	-	-	
70-75	45.2	87.0	13.0%
75-80	48.1	91.8	35.6%
80-85	51.6	93.2	61.6%
85-90	56.9	91.0	81.2%
90-95	54.3	90.9	94.3%
95-100	53.1	90.4	100.0%

When the five components comprising land knowledge were interrogated (land management, policy, planning, property rights, and well-being) (Table 7), each component affected the

propensity to support a potential formal land use plan and policies differently. Increases in land management (lm) and policy (Po) together with high levels in planning (Pl) increased the propensity to support land use plans and policy, whereas property rights (Pr) and well-being (WB) did not have a clear relationship in support of a yes or no vote.

Chapter 4, Table 7: Propensity of agents to vote yes or no by Land Management for Experiment 1. Averages in Policy (Po), Planning (Pl), Property rights (PR) and well-being (WB) are shown by Land management (LM) in intervals of 10. Summary information by No vote is on the left, and Yes vote on the right. As knowledge in land management increases, together with an increase in scores in policy (to a score above 86), and property rights (to a score above 65), and maintaining well-being above 67, and a high score in planning above 90, changes no votes to yes.

No Vote (averages/100)						**Yes vote** (averages/100)					
LM	Po	Pl	PR	WB	%No	LM	Po	Pl	PR	WB	%Yes
20-30	49.4	66.6	16.7	53.9	100.0	20-30	75.9	93.1	72.6	57.6	5.0
30-40	50.0	70.1	21.3	57.8	73.9	30-40	84.7	94.1	68.2	69.5	21.2
40-50	61.8	74.6	29.3	75.1	52.3	40-50	92.0	94.8	65.3	86.0	40.4
50-60	63.9	80.9	30.0	77.8	43.0	50-60	97.1	93.6	57.9	97.4	54.8
60-70	63.5	78.4	26.8	89.7	30.8	60-70	96.3	92.0	65.5	96.5	61.3
70-80	76.9	73.9	55.3	75.4	22.9	70-80	86.4	93.1	78.0	67.8	70.1
80-90	93.2	74.8	78.9	72.1	12.2	80-90	88.3	95.7	80.7	69.2	85.5
90-100	99.8	77.2	88.9	80.8	2.8	90-100	94.0	95.5	80.6	84.9	100.0

Analysis of agent propensity to support a potential formal land-use plan and policies was based on agent averages in land knowledge and attitudes which can have high standard deviations (SD) (Table 5) due to various combinations of the five land knowledge scores. High variations and non-parametric data will affect agent-voting behaviour and may account for some unusual observations.

4.8.1.1 Impact of change in knowledge and attitude

The LUS19 data and results of Experiments 1 and 2 were used to investigate the second research question on how relationships and changes in members' land knowledge and attitudes affect support of adopting a potential formal land-use plan and policies. A Spearman's rank correlation test ($\alpha = 0.05$) between agent attitudes, land stewardship or ambition with collaboration, demonstrated that agents with higher average land stewardship attitude scores tend to collaborate more than ambitious agents (Table 8). This result suggests that an increase in the undecided abstaining agent's attitude toward land stewardship is likely to increase their propensity to collaborate with others that support CLFN community objectives in formal land use plan and policies initiatives.

Chapter 4, Table 8: Spearman's rank test correlation coefficients for land stewardship with collaboration, ambition with collaboration, and land stewardship with ambition.

	land stewardship & collaboration	ambition & collaboration	land stewardship & ambition
LUS19	0.261	0.038	0.168
Experiment 1	0.471	0.127	0.300
Experiment 2	0.313	0.023	0.162

Multinomial logistic regression (MLR) analysis[146] of the LUS19 data and results of Experiment 1 was used to estimate probabilities of agent support of a potential formal land-use plan and policies. MLR probabilities demonstrate that yes votes are likely to increase with increases in land knowledge and in attitudes toward land stewardship and collaboration (Table 9). In Experiment 2, land knowledge, which typically had a strong influence on voting yes, was weaker and instead attitude toward collaboration held a stronger influence. This observation is partly due to the suspension of direct knowledge transfer during community engagement in Experiment 2.

Chapter 4, Table 9: Summary of MLR probabilities (alpha 0.05) to vote yes on LUS19 and the final results of Experiments 1 and 2. Probability of yes votes are categorized by 25% intervals, with land knowledge, collaboration, ambition and land stewardship averages out of 100.

	LUS19 (avg)				Experiment 1 (avg)				Experiment 2 (avg)			
Yes vote Probability %	Land knowledge	collaboration	ambition	land stewardship	Land knowledge	collaboration	ambition	land stewardship	Land knowledge	collaboration	ambition	land stewardship
0-25	59.4	78.2	45.5	59.7	74.2	60.0	36.5	53.4	65.2	73.8	49.7	50.0
25-50	73.9	83.5	55.0	81.0	80.6	78.4	39.4	80.2	78.2	91.9	39.0	79.4
50-75	77.6	89.8	50.7	82.3	79.4	83.2	48.5	84.8	71.9	92.3	51.5	82.7
78-100	82.2	91.8	53.7	92.7	83.8	87.9	54.5	94.1	72.2	95.2	55.9	90.4

4.8.2 Plan and policy adoption by CP and non-CP member types

Aligning LUS19 with aforementioned results for experiments 1 and 2 (Sections 8.1 and 8.1.1), CP and non-CP agents supporting community objectives towards adopting a formal land-use plan and policies have average scores in their attitude toward collaboration and land stewardship above 84, and land knowledge scores above 74. Also similar to the aforementioned results, abstaining agents had lower land stewardship averages (e.g., 60's and 70's) (Table 10).

Investigating the five land knowledge categories (i.e., land management, policy, planning, property rights and well-being, (Table 11) the non-CP holders had greater increases in Experiment 1 than in Experiment 2 and average scores in land knowledge and attitude were more aligned with CP agents in Experiment 1. Both CP and non-CP agents increased their scores in

[146] Multinomial logistic regression (MLR) analysis uses pairwise regression on the four dependent variables, not vote, vote no, yes and abstain using the four independent variables on knowledge, collaboration, ambition, and land stewardship.

the following order: well-being, policy, land management, property rights, and planning. Increases in well-being scores contributed to a more 'balanced collaborator' agent type (i.e., the combined ambitious-stewardship collaborators) being a key factor in changing abstaining agents attitudes in support of community objectives on a potential formal land-use plan and policies. However, increases in well-being scores contributed to little or no change in agents not supporting a formal land-use plan and policies with a combination of low land stewardship and/or collaboration scores, and higher ambition scores. The aforementioned results (with little changes in no and not voters) suggest parameter settings in FN-LUVM for Experiments 1 and 2 may only be relevant in cases such as Curve Lake First Nation (CLFN) where the majority of agent-voters are abstaining, and also balanced collaborators, i.e., approximately 48% (22/46) of CP holders and 66% (36/54) of non-CP land holders of the LUS19 fall within the abstaining voting category (Table 10).

Based on the results of Experiments 1 and 2, recommendations include increasing land knowledge about land-use policy followed by land management for both CP and non-CP holders. As property rights remained the greatest difference between CP and non-CP holders scores in LUS19, and in Experiments 1 and 2, a further recommendation is to increase land knowledge in property rights for the non-CP holders. Although planning scores had the lowest increase in Experiments 1 and 2, (relative to the aforementioned five land knowledge attributes) the low increase was likely due to planning having the highest land knowledge score in LUS19. The high land knowledge scores in planning may suggest a high interest among respondents to the Curve Lake First Nation 2019 land-use survey relative to developing a formal land-use plan. Maintaining a high land knowledge score in planning would be important to maintaining a high collaboration score, a key attitude in adopting a formal land-use plan and policies.

Both experiments provided insight on how changes in CP and non-CP holders five attributes of land knowledge are key in their support of community objectives towards adopting a potential formal land-use plan and policies. Experiment 1 provided insight on agent voting behaviour with attitude change based on land knowledge transfer (e.g., educational and training programs), member interaction and influence, whereas Experiment 2 provided insight on agent voting behaviour based on the key CLFN influencers having a more significant role during community engagement.

Chapter 4, Table 10: LUS19, Experiments 1 and 2 for CP and non-CP voting categories. Averages are shown for land knowledge, collaboration, ambition, and land stewardship, and summary by all voting categories. Voting results have been rounded off to the nearest vote for CP and non-CP agents and are within 1% of Table 2 results for all agents. The yes vote standard deviation is 1.3 for the final results. Summary averages are for all 46 CP and 54 non-CP agents.

			CP averages/100					Non-CP averages/100			
		Total votes (n=46)	Land knowledge	collaboration	ambition	land stewardship	Total votes (n=54)	Land knowledge	collaboration	ambition	land stewardship
LUS19	not vote	5	56.7	33.5	49.4	54.0	4	45.2	42.9	37.7	46.0
	vote no	2	59.2	64.8	53.8	36.0	8	46.9	71.0	45.8	38.5
	vote yes	17	80.0	91.6	53.3	87.8	6	78.0	87.7	49.5	89.3
	undecided	22	68.3	89.8	45.6	63.3	36	60.0	85.6	45.1	66.3
	Summary		71.0	83.2	49.2	70.1		59.0	80.5	45.2	63.2
Experiment 1	not vote	7	91.6	36.1	47.6	52.5	6	89.6	43.1	37.2	61.5
	vote no	1	87.1	78.1	82.2	62.7	3	70.9	82.9	65.5	49.8
	vote yes	29	89.5	85.1	54.9	92.0	33	85.4	84.1	54.3	95.3
	undecided	9	88.2	89.2	32.5	69.3	12	85.9	67.5	38.2	75.9
	Summary		89.5	78.3	49.9	80.7		85.1	77.1	51.3	86.1
	Diff with LUS19		+18.8	-4.9	+10.6	+10.6		+26.1	-.3.4	+6.6	+22.9
Experiment 2	not vote	5	86.4	40.8	56.5	60.7	4	82.7	50.1	45.1	53.9
	vote no	2	71.5	77.0	80.6	62.2	11	47.5	85.2	53.2	42.8
	vote yes	33	78.6	95.4	61.0	91.3	34	74.2	93.6	62.5	89.5
	undecided	6	83.2	92.4	44.3	60.9	5	77.8	79.0	47.1	77.3
	Summary		81.8	89.1	60.7	83.9		72.4	87.1	60.1	77.7
	Diff with LUS19		+10.8	+5.9	+11.5	+13.8		+13.4	+6.6	+14.9	+14.5

Note: a '+ ' indicates a difference that is higher than LUS19, and '–' indicates a difference that is less than LUS19.

Chapter 4, Table 11: LUS19, Experiments 1 and 2 for CP and non-CP knowledge, and the five land knowledge categories (land management, policy, planning, property rights and well-being). Differences are shown for Experiments 1 and 2 with LUS19, and difference between CP and non-CP agents.

		Knowledge avg/100	Land management avg/100	Policy avg/100	Planning avg/100	Property rights avg/100	Well-being avg/100
LUS19	CP	71.0	52.3	66.0	84.6	66.4	44.3
	Non-CP	59.0	32.2	59.5	79.7	40.7	45.9
	Difference CP/non-CP	+12.0	+20.1	+6.5	+4.9	+25.7	-1.6
Experiment 1	CP	89.5	81.0	94.7	93.1	83.2	93.0
	Difference with LUS19	18.8	28.7	28.7	8.5	16.8	48.7
	Non-CP	85.1	73.1	97.1	94.1	65.0	99.1

	Difference with LUS19	26.1	40.9	37.6	14.4	24.3	53.2
	Difference CP/non-CP	+4.4	+7.9	-2.4	-1.0	+18.2	-6.1
Experiment 2	CP	81.8	67.1	83.5	91.1	75.4	65.1
	Difference with LUS19	10.8	14.8	17.5	6.5	9.0	20.8
	Non-CP	72.4	48.9	80.4	87.2	55.0	65.6
	Difference with LUS19	13.4	16.7	20.9	7.5	14.3	19.6
	Difference CP/non-CP	+9.4	+18.2	+3.1	+3.9	+20.4	-0.5

Note: '+ ' indicates a difference where CP is higher, and '–' indicates a difference where non-CP is higher.

4.8.2.1 The CP and non-CP holder disconnect

The LUS19 pointed rated information identified a substantial difference of 12 average points in land knowledge between CP and non-CP holders (Tables 10 and 11). In Fligg et al. (2021) the uncertainty between Curve Lake First Nation (CLFN) CP/non-CP members in land matters was referred to as a disconnect. This difference may reflect that non-CP agents do not hold land and may not have the same need to know about land management, land-use policy and planning, or property rights.

Results from Experiments 1 and 2 showed a disconnect between CP and non-CP land holders of 4.4 and 9.4 average points, respectively (Table 11). The level of disconnect in the two experiments was less than what was observed LUS19. In Experiment 1 higher land knowledge average scores (average 87.2, Table 3) were attained by the entire population. However, the increase in land knowledge scores for non-CP land holders was much greater and more closely aligned the two types of community members. Although the disconnect in Experiment 2 was greater than Experiment 1, the greater impact by influencers in Experiment 2 encouraged change in member attitudes which led to an increase in support of formal plan and policy adoption that was similar to Experiment 1. These results suggest reducing the effects of disconnect may be accomplished by aligning land knowledge and/or attitudes, however, support of community objectives on a potential formal land-use plan and policies is suggested by agent behaviour discussed in Sections 4.8.1 and 4.8.1.1.

4.9 Discussion

4.9.1 Experiments and analysis

Computational experiments 1 and 2 provided insight on member-voting behaviour and pathways towards support of community objectives on the adoption of a potential formal land-use plan and policies at Curve Lake First Nation (CLFN). Experiment 1 included all three FN-LUVM community

engagement functions whereas in Experiment 2 only two of the community engagement functions were used, excluding the land knowledge transfer function. However, in Experiment 2, community influencers had a greater impact on agents attitude in both land stewardship and ambition (in support of socio-economic well-being). Although agent propensity in support of community objectives was associated with average scores: greater than 80 in both collaboration and land stewardship, approximately 70 - 80 in land knowledge, and approximately 50 - 60 in ambition, agent collaborator type was key to support of community objectives in both land stewardship and socio-economic well-being (Figure 3 and Appendix 4) with the highest probability for support of community objectives being among the balanced collaborators followed by the stewardship collaborators. As agents with a high average in land stewardship tend to collaborate more than other agents, the analysis suggests there is both a high potential and probability that the abstaining (undecided) agents may change their attitude towards support of community objectives with most being balanced or stewardship collaborator types. Whereas, the 'not voting' agents had low collaboration averages and were the 'non-collaborator' type, and have the lowest potential towards support and probability to change their attitude (Vaske & Donnelly, 1999) (Figure 3 and Appendix 4).

Broken down by the five land knowledge attribute average scores; planning and policy were the most significant attributes affecting support of community objectives for the adoption of a potential formal land-use plan and policies, followed by land management, property rights, and well being. This is not surprising considering the importance in community objectives on developing a formal land-use plan and policies at CLFN and the results of the CLFN 2019 land-use survey.

While propensity to support community objectives by CP and non-CP agents was found to be similar, by aligning land knowledge and attitudes both reduced the disconnect (or uncertainty about land-use policy and practices) and increased support towards community objectives on adopting a potential formal land-use plan and policies.

4.9.2 The potential role of FN-LUVM and behavioural modelling for First Nations

To date there has been little to none behaviour modelling[147] about First Nations and their lands in Canada or on Indigenous peoples elsewhere. The First Nation – Land-use Voting Model (FN-LUVM) is a behavioural model that expands on the concept of the First Nation 'collective reflection'

[147] See Section 1 regarding literature search and three papers, 1) cultural propensity for "in group" preferences or cultural preferences in voting (Dabin et al., 2019) First Nation cultural, 2) traditional voting behaviour (Goodman et al., 2018), and 3) First Nation members' preferences (i.e., decision-making) in land use alternatives (Nikolakis et al., 2016)

(Nikolakis et al. 2016) to represent community actors as virtual agents (Rounsevell et al. 2012). By the community engagement process agents interact and exchange land knowledge that may impact attitudes about land stewardship and sustainability and ambition about land related socio-economic well-being, and also a process where like-minded members collaborate (Figure 3). As community engagement must consider member heterogeneity, FN-LUVM incorporates functions for the exploration of different and changing agent attitudes and the impact it may have on voting behaviour towards support of community objectives on the adoption of a potential formal land-use plan and policies.

The FN-LUVM model was inspired by Agrawal et al. (2013), whose conceptual model outlines interactions among formal organizations, informal social networks, rule and norm based policy, and the effects of individual decision-making on the outcome of a common pool resource. The Agrawal model was adapted to Curve Lake First Nation where their land is a sacred community resource (common pool), and land-use practices are guided by organizations (governance) and social networks (members) and land-use practices that may be sanctioned and/or community accepted (e.g., by formal policy) or unsanctioned and/or not community accepted (e.g., by informal policy, Fligg et al., 2021).

Although in agent based models (ABM), spatial approaches are often used, e.g., in 'land-use and cover change models' (LUCC) (Parker et al., 2002; Brown et al., 2014), the First Nation – Land Use Voting Model (FN-LUVM) uses a non-spatial, or aspatial ABM approach (e.g., soup model, & Macal & North, 2009). In spatial models agent location is important as agents move over a spatial environment, whereas in a 'soup model' agent location "is not important" (Macal & North, 2009, p. 155) and in FN-LUVM the focus is on agent-behaviour with changes in agent land knowledge and attitudes towards community objectives on land stewardship and ambition on land-related socio-economic well-being.

FN-LUVM also has a visual component whereby the user is able to visualize and monitor agent-behaviour and observe outputs in the interface during a scenario (see online-appendix No. 3. - FN-LUVM NetLogo Interface, and No. 4.- the two 'explanation videos' on how FN-LUVM works). Being able to monitor a scenario and evaluate agent-voting behaviour as agents move among the various voting categories, and monitors that depict information on collaborator type, agent average variables on the five land knowledge areas and attitudes, such that when levels are maximized and/or thresholds achieved it may assist the community on what factors to focus on, including community objectives [148].

[148] Evaluation by Alison Irons-Cummings (previous CLFN lands manager)

Although land knowledge is key to making an informed decision, implementing community education on First Nation land management systems, property rights, land-use planning and policies, and well-being (e.g., on land related factors such as housing) may have its challenges e.g., difficulties in understanding the complex nature of land information, training logistics and funding. Experiments 1 & 2 suggest there is more than one pathway to affect member attitudes towards support of adopting a potential formal land-use plan and policies. While FN-LUVM has been applied to the Curve Lake First Nation, it is flexible, e.g., in parameter settings related to community engagement functions, member interaction and influence, and may be modified to represent other Reserve communities and their community objectives on land-use planning and policies.

4.10 Conclusions

Although First Nations have a unique cultural relationship with the land, e.g., to protect 'Mother Earth' (AFN, 2022), it is uncertain how the many years of governance under the Indian Act, and acts of assimilation (Coates, 2008) has impacted First Nations relationship with their land.

Increasing recognition of the role of the environment in human health and well-being (Brusseau et al., 2019) and the provision of ecosystem services that provide economic benefits to individuals and communities (e.g., food, water, recreation (Barbier, 2019)), are among many other ways the environment provides added value e.g., aesthetic quality (Carlson, 2020); house prices, (Wittowsky, 2020; Camargo, 2016). However, these benefits are weighted against other societal needs and desires, e.g., sustainable development that fosters well-being[149]; sustainable economic growth (Alberta Land Stewardship Act, S.A. 2009, c.A-26.8) [150]; sustainability goals versus essential needs (Soergel et al., 2021; Arora & Mishra, 2019). The well-being of a community is primarily represented by the socio-economic well-being, exemplified by the community well-being (CWB) index (ISC, 2020). However, the CWB lacks the representation of cultural characteristics, and specifically those related to land, which are critical to First Nation communities (Guthro, 2021; Bouchard et al., 2021).

The process for adopting community-based land-use policies and planning is somewhat complex and unique for each First Nation community (e.g., as outlined in the NALMA (2016) planning toolkit). Therefore, the model presented in this paper is not just about getting 'yes' votes

[149] United Nations, Department of Economic and Social Affairs, Sustainable Development, https://sdgs.un.org/goals, United Nation's 'sustainable development goals' (SDG) 2030 includes fostering human well-being

[150] provides legislative authority for the Government of Alberta's Land-use Framework (2008) to develop a "land use decision-making process that promotes sustainable economic growth by balancing economic activities with social and environmental goals".

but about a relationship between member voting behaviour and community objectives (in this case at Curve Lake First Nation) about their vision on land stewardship and sustainability (CLFN, 2023), as well as their desire for improvement in socio-economic well-being (as measured by the CWB). For some members formal land-use policies may restrict their perceived individual right to do as they please with their land (CCP, 2009) but for many members, adopting a formal land use plan and policies may lessen their uncertainty about what land-use practices are sanctioned and/or community approved.

Future research and development of FN-LUVM include: 1) expand and improve on the land use survey questions that are used to empirically inform the agents; 2) expand the research to other First Nation communities (in particular Reserve communities), and schedule community land use surveys on a regular basis; 3) expand the research to include other member types such as members which live on or off Reserves, by gender, and age; 4) assess and improve model formulas on land knowledge and attitude, and model thresholds and parameters; 5) include a spatial component (e.g., land-use attributes about parcel fabric, title, land-use and cover, and land-use changes) that might assist First Nations in understanding 'what happens where' and land-use behaviour over specific areas (e.g., protected lands, water front properties, traditional sites) and for policy development; 6) conduct validation tests and model performance to move the model from one having a 'subjective approach' and used for 'thought experiments' to one that has an 'objective approach' and used to assist in the process of developing a lands related action plan on setting community objectives and for developing formal land-use plans and policies.

FN-LUVM is a stylized prototype model, in other words, the first attempt for a Reserve based First Nation agent-voting-behaviour model using empirical data. The open-source program and description (e.g., ODD) for FN-LUVM are included in the 'Online-Appendix' so that others may continue to use and improve on it. The use of models to synthesize existing knowledge that act as a medium for discussion can be more important than their use for prediction or generation of quantitative outputs. While the presented research showed that statistical modelling such as multinomial logistic regression may be used to forecast the probability of voting, the presented approach using agent-based modelling (ABM) may assist First Nations and societies to better understand the complexity of voting behaviour within the 'Reserve based community land-use planning and policy' process. It is hoped that this first prototype model on First Nation voting behaviour offers a proof of concept that can be built upon and used by various First Nation communities in setting community objectives and developing land-use plans and policies.

Online-Appendix

https://doi.org/10.17632/2p3x7cvsp9.3

1. Overview, Design concepts and Details (ODD) ABM protocol for FN-LUVM
2. Calculations for agent scores in land stewardship, ambition, and collaboration.
3. FN-LUVM NetLogo code and Interface - NetLogo Executable file, and 1000 agents,
4. FN-LUVM flowchart and two 'explanation videos' on how FN-LUVM works.
5. Bar Charts of the 37 computational experiments results by various functions
6. Computational experiment information, multinomial logistic regression, & Spearmans rank

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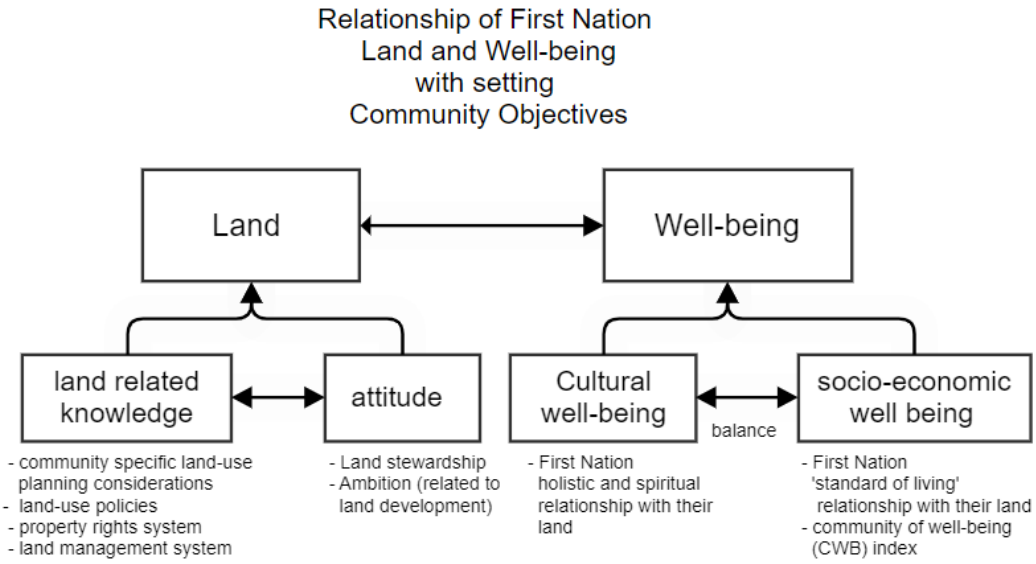
Chapter 5. Conclusions

5.1 Summary

To improve societies' understanding of First Nations, their land, and the relationship between how their land is managed and well-being involved ethnographic research on First Nation systems of land management, property rights, land-use policies, planning and practices; and research that might assist First Nations with the setting of community objectives on socio-economic and cultural well-being (Chapter 5, Figure 1). It is also hoped this research may improve societies' understanding on the importance of pathways in land management for reconciling First Nations with their land as evident in the 'calls to actions' under the Truth and Reconciliation Commission of Canada (TRC, 2015) and 'articles' under the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP, 2007)) [151].



Chapter 5, Figure 1. Relationship of land and well-being on setting community objectives.
Factors that impact land use (i.e., land knowledge and attitude) and well-being (i.e., cultural and socio-economic well-being) impact the setting of community objectives about lands and well-being.

The overarching goal of this thesis was to research gaps in societies' understanding about the relationship between First Nation land management (broadly defined, as in systems of land management and property rights, and land-use policies and planning) and their well-being guided by questions and objectives outlined in Chapter 1. Although various First Nation land

[151] Specific 'calls to action' related to land under the TRC and articles under the UNDRIP are outlined in Chapter 1

management regimes (e.g., RLEMP, FNLM, and frameworks of self-government (FSG))[152] facilitate pathways for more control over their land than under the Indian Act[153], understanding how First Nations manage their land for socio-economic well-being (e.g., as a commodity, and measured by the CWB index), and cultural well-being (e.g., as land stewards) remains not well understood. This lack of understanding is complicated by actions to restore cultural loss in land related knowledge and attitude on land-use that might impact setting community objectives (e.g., changes to community objectives as new land information portrays consequences of land-use practices).

Chapter 2 explored the relationship of socio-economic well-being of First Nation communities (as measured by the community well-being CWB index[154], ISC, 2019) with land management regimes (e.g., Indian Act, RLEMP, FNLM and frameworks of self-government FSG). Results of that research suggests communities that manage their land under any of the aforementioned land management regimes may, under certain economic circumstances (e.g., by their geographic location), achieve an above average score in CWB (i.e., above the non-Indigenous average). However, communities that have transitioned from under the Indian Act Regime to FNLM and frameworks of self-government on average have higher CWB index scores (Fligg & Robinson, 2019). CWB scores for First Nation communities on average are approximately 19 points (out of 100) lower than scores for average non-Indigenous communities (ISC, 2019, 2020a) and with most of the lower scoring First Nation communities residing under the Indian Act regime (Fligg & Robinson, 2019).

As new CWB index data becomes available (approximately a few years following a census), analysis by land management regime may be able to assist communities in making a decision about a transition from under the Indian Act regime to FNLM or a framework of self-government and anticipate how transition may affect their community's CWB score. While Chapter 2 does not address cultural well-being specifically (e.g., in relation to gaps in the CWB index, Guthro, 2021), First Nation communities that have land codes or constitutions (e.g., under FNLM or FSG) usually contain statements that recognize a cultural relationship with the land (e.g., FNLM Land codes of Henvey Inlet, Georgina Island, McLeod Lake, Tsawwassen), and may contain statements about their inherent rights (e.g., FNLM land code of Tzeachten; First Nation Constitutions of Westbank, Vuntut Gwitchin, Nipissing). Although there is no measure for cultural well-being, communities

[152] RLEMP refers to Reserve Lands and Environment Management Program, a subset under the Indian Act; FNLMA refers to Framework Agreement on First Nation Land Management Act, SC 2022, c 19, s 121 (prior to December 15, 2022, First Nations Land Management Act, S.C. 1999, c. 24),

[153] Indian Act (R.S.C.,1985, C. 1-5)

[154] CWB index refers to Community of Well Being Index, see https://www.sac-isc.gc.ca/eng/1100100016579/1557319653695

that manage their land under FNLM or FSG recognize (e.g., under their land code) the importance of both socio-economic and cultural well-being.

Chapter 3 investigated informality in land management and land-use practices at Curve Lake First Nation, being practices that are not sanctioned by law and may or may not be condoned by Chief and Council, and community. Informality in land management and land-use practices suggests a community's land management system does not meet the needs of the community and questions the impact that informality has on community objectives for socio-economic and cultural well-being.

Results of the research in Chapter 3 found a correlation between informality of land-use practices and uncertainty about land-use policies. Although uncertainty was greater among non-CP holders (i.e, the non-land holders) than CP holders (i.e., the land holders), the 2019 Curve Lake First Nation (CLFN) land-use survey found a general lack of knowledge related to systems of land management and property rights, and in land-use policy among most members. These findings suggest a formal land-use plan and policies, that are sanctioned by law such as by-laws under Section 81 of the Indian Act, versus an informal Band Council Resolution (BCR)[155], and land-use practices that are condoned by the community, may decrease member (CP and non-CP holders) uncertainty; lessen member disconnect (between CP and non-CP holders) and that the process of developing a formal land-use plan and setting community objectives[156] may increase member awareness about their land.

Many First Nation communities are working on a formal land-use plan (Kehm et al, 2019; CFM/CDI 2015) or as some communities now refer to as a 'land relationship plan' to better reflect their vision with the land (e.g., Carcross/Tagish Nation, Yukon Land Use Planning Council[157]). Even though a formal land-use plan supports land management objectives (FAO,1999; LABRC, 2023), only approximately 10% of First Nation communities have one in place.

[155] In the Hiawatha First Nation v Cowie, 2023 ONCA 524 case - a Band Council Resolution (BCR)) is not sanctioned under the Indian Act such as a by-law under Section 81, and policy set by BCR could be challenged in a court of law by the rights of a Certificate of Possession (CP) holder.

[156] For example, CLFN community objectives in land-use planning would consider customary and traditional land relationships with areas set aside for their powwow and ceremonial/sacred grounds (including their islands), burial grounds, areas for hunting, gathering, and fishing, protected areas, and land-use practices that includes vegetation used in conjunction with ceremonial and medicinal purposes.

[157] Carcross/Tagish Nation – 'How We Walk with the Land and Water" https://www.howwewalk.org/our-promise, https://www.howwewalk.org/maps (2023); Tagish – 2019 on the Land Gathering, June 7-8 2019, Tagish, Yukon Yukon Land Use Planning Council - Land Relationship Planning Gathering: Using Indigenous Knowledge to Improve Regional Planning In Yukon, Executive Summary And Proceedings, 2022

Chapter 4 investigated the relationship of member knowledge and attitude about their land and support for land-use plan and policy adoption and community objectives in well-being (e.g., for a balance in socio-economic and cultural well-being, Chapter 5, Figure 1). By modeling this relationship using FN-LUVM, the interactions and feedback among the agents representing community members could be interrogated to improve societies' understanding about how differing levels of member land knowledge and attitude impacts their behaviour on voting to support land-use policy and plan adoption. Within this context, the presented research is unique in that, to the best of the author's knowledge, no other behaviour models related to First Nation land use, land management, or voting can be found in the literature. Therefore, it is hoped that the presented work in Chapter 4 will foster others to make improvements upon the research conducted within to make additional scientific and societal gains.

5.2 Linking Community objectives with First Nation relationships with their land

Most land-use models are primarily concerned with representing aspects of reality by a combination of empirical information and land system components (e.g., Voigt and Troy, 2008). Modelling the complex relationships of land system components (e.g., member knowledge about systems of land management and property rights, policy and planning) with socio-economic and cultural well-being (e.g., member attitude about land-use practices) was explored in Chapter 4 by the First Nation – Land Use Voting Model (FN-LUVM). Whereas in Chapters 2 and 3 linkages in the relationship of First Nation land and well-being that supported the development of FN-LUVM were explored. Chapter 2 provided us with a better understanding on how systems of land management links to setting community objectives in socio-economic well-being (e.g., by CWB Index scores), and in Chapter 3 on how informality in land management and land-use practices links to setting community objectives in cultural well-being (e.g., by the uncertainty and disconnect among members on community accepted land-use practices).

Empirical information, such as the 2019 Curve Lake First Nation land-use survey, linked FN-LUVM with reality, however, FN-LUVM is subjective as certain key factors are not included. These factors include the difference in how First Nation communities across Canada manage their land (e.g., under the Indian Act, RLEMP, FNLM and FSG) and the relationship each land management system has on well-being, e.g., communities that manage their land under FNLM and FSG on average have higher CWB index scores (indicating a higher level of socio-economic well-being) than communities that manage their land under the Indian Act (Fligg & Robinson, 2019; Chapter 2). Another key factor not incorporated in FN-LUVM is the impact of geographic location to economic centres on the socio-economic well-being of a community (Blankinship & Lamb, 2022, Ballantyne et al., 2012). FN-LUVM attempts to model the linkages

between community objectives in socio-economic and cultural well-being as per the CLFN lands committee feedback, CLFN community website, and First Nation members' land knowledge and attitude about their land as derived from the 2019 CLFN land-use survey. The results suggest that member land knowledge and attitude about land-use, and on how the members collaborate, together with engaging the community key influencers (e.g., the Elders) would be instrumental in support of policy and plan adoption, and in setting community objectives for both cultural and socio-economic well-being.

5.2.1 Linking the relationship of First Nation lands and well-being to the aspatial land-use voting model

Most voting models, in political theory, are either deterministic where the voters "make decisions with certainty" or probabilistic models where voters are uncertain and have a stochastic element that contributes to the decision-making (Burden, 1997). Deterministic models assume that what is being voted on is near their ideal, however, uncertainty among Curve Lake First Nation respondents to the 2019 land-use survey about acceptable land-use practices suggests a probabilistic model. With more land-use research and model validation, and greater certainty in knowledge and attitude among members about their land and land-use - a shift may occur to a more deterministic model.

In Chapter 4, the objective of the voting model is not just about determining the probability of how many members may vote yes to adopt a land-use plan (e.g., change their vote from uncertain/abstaining to yes) but also about gaining insight about voting behaviour and understanding the linkages in the relationship of First Nation land management and well-being. A greater understanding of these linkages may assist with community discussions about setting community objectives in land-use policies and planning, and assist on potential community discussions on a transition of working with Indigenous Services Canada / Crown-Indigenous Relations and Northern Affairs Canada on managing their land, e.g., under the Indian Act, and RLEMP, to one that allows a community the freedom to manage their own land, e.g., under FNLM or FSG.

5.3 Future Research

The thesis made novel contributions to societies' understanding about the relationship between First Nation land management and well being. However, there is a large gap in literature and research on the subject and much that can be done. The following sections identify some of the further research.

5.3.1 Further Work Identified in Chapters 2, 3 and 4.

5.3.1.1 Community Research

Chapters 2, 3 and 4 indicate the next step would be to acquire more information (in collaboration with First Nation communities) on the relationship between First Nation land and well-being (i.e., socio-economic and cultural well-being). This would involve research at a broader scale (across many First Nation communities) on the linkages of well-being to systems of land management and property rights, land-use policies and planning, and may also include other land related areas, such as, community infrastructure. At a broader scale, the research may extend beyond First Nation communities for comparison with non-Indigenous communities across the country, and possibly with communities at the global level.

Chapter 2 identified the need for continued research about the relationship of First Nation CWB scores (when released after census) with land management systems of First Nation communities across Canada, and Chapter 3 on the need for community research to identity the "what and where" of informal land-use practices. By the continued research it is hoped the information will improve modelling the relationship of member land knowledge and attitude about their land with developing community land-use policies and planning that support both community socio-economic and cultural well-being.

5.3.1.2 **Technical Developments**.

Non-spatial data may be used in both spatial and non-spatial land use modelling approaches (Beguin et al, 2017; Guo et al, 2017), however, in agent based models (ABM) spatial approaches are typically used, e.g., in 'land-use and cover change models' (LUCC) (Parker et al, 2002; Brown et al, 2014). The First Nation – Land Use Voting Model (FN-LUVM) is a non-spatial, or aspatial ABM approach (e.g., soup model, Macal & North, 2010) that was developed to further research identified in Chapters 2 and 3 (e.g., in Chapter 2, research about socio-economic well-being with systems of land management and property rights, and in Chapter 3, research about land-use policies and planning). The conceptual model for FN-LUVM was developed from research conducted for Chapters 2 and 3, and the empirical data from the 2019 Curve Lake First Nation land-use survey which interrogated members on their land related knowledge and attitude for the purpose of developing community land-use policies and planning. Although the land-use survey was subjective and limited (specific to the CLFN community) the results indicated many members were not knowledgeable or well informed about land-related information. By continued research and further land-use surveys, the results of the respondents to such surveys and results of agent behaviour in the ABM process could be compared to previous results for model validation.

The next steps in the development of FN-LUVM are two approaches. One approach is to develop the aspatial ABM to include more variables, investigate model parameters, and accommodate other types of community information (e.g., infrastructure). The second approach is to integrate a spatial component that would associate the non-spatial respondent information by location (e.g, similar to a 'land use land cover change' (LUCC) model. The benefits would allow spatial analysis to better understand respondent answers that would assist with setting land related community objectives.

5.3.1.3 Application

FN-LUVM is a prototype model that may be modified and implemented for other First Nation communities across Canada which may assist in setting community specific objectives related to land management (broadly defined) and socio-economic and cultural well-being. Various parameters in FN-LUVM or new functions could be added to accommodate different priorities of communities.

5.3.2 Further research about First Nation land and well-being not yet addressed

Further research questions about First Nation land and well-being not addressed by this thesis include:

- *What is the relationship of land management regimes (i.e., frameworks of self-government, FNLM, RLEMP, and the Indian Act with cultural well-being (as guided by First Nation land stewardship)?*

In Chapter 2, a relationship was investigated between land management regimes and socio-economic well-being as measured by the CWB index. There is a need for academic research on how First Nation land management regimes impact both socio-economic and cultural well-being, and how academic research on land management regimes may benefit individual First Nation communities. Although this is a huge task, this task may be done in collaboration with Statistics Canada during census of First Nation communities. Since the census already includes metrics (e.g., on housing, education, labour force, and income) that are used in the CWB index scores, additional information about cultural well-being might be included either with the existing CWB or by a separate measure.

- *How have the actions under the TRC and adoption of the UNDRIP been embraced in land management regimes, and in land-use policies and planning?*

Research to answer this question requires input from First Nation communities across Canada about their land management system, and where applicable wording that embraces the TRC and

UNDRIP in their land code, laws, by-laws, policies and planning, and further may also be supported and embraced by member land-use practices.

- *How does the First Nation property rights system (e.g., holding title to land, property fabric, system of recording title to land, and land transactions) impact First Nation cultural well-being?*

This question was touched on in Chapter 2, however only in relation to socio-economic well-being as measured by the CWB index (Ballantyne & Ballantyne, 2016). There is a need for academic research on how First Nation property rights impact both socio-economic and cultural well-being.

- *What is the relationship between First Nation geographic location of their land base and socio-economic and cultural well-being?*

This question was touched on in Chapter 2 in relation to socio-economic well-being as measured by the CWB index (Ballantyne et al. 2012). There is a need to further the research done by Ballantyne et al., 2012, that includes other drivers of socio-economic well-being and on how geographic location affects a First Nation's cultural well-being. A spatial relationship between reserves and drivers of socio-economic and cultural well-being could be explored using similar modelling techniques that were used to develop the 'First Nation Land-Use Voting Model'.

- *and, further to the above question about geographic location what research opportunities exist in spatial analysis?*

Research opportunities exist in spatial analysis of First Nation communities using existing information such as the CWB index, available parcel datasets, title information of First Nation communities, and where available remote sensing data about the environment. And that when investigated using GIS mapping and spatial analysis might reveal spatial 'patterns and trends'. These patterns and trends may be assessed for auto correlations where clustering exists among communities with similar social structures and histories (Rucks-Ahidiana, 2015) and investigated for distance to economic areas, remoteness and distance between communities, and impact of environmental issues. Time series remote sensing data could be used to investigate a relationship of spatial and temporal characteristics of environmental and socio-economic factors and the likelihood of what happens in one community may happen in another (e.g., spatial lag) (Liu, 2022).

- *How does a First Nation's land base impact their land management, planning and policies, property rights, in addition to well-being?*

Further to the above question on land base, there is a need for research on how geographic location affects the approach to land management (broadly defined, as in systems of land management and property rights, land-use policies and planning).

- *How does the processes of acquiring land to expand their land base and/or restore traditional land base impact First Nation well-being?"*

Further to the land base question (above), research is also needed on how the process to acquire land (e.g., the addition to reserve process) affects both socio-economic and cultural well-being. Secondly, as new lands are being acquired under the addition to reserve (ATR) process or for new reserves, research opportunities may be explored on what was learned in this research on the relationship of land management with First Nation land-stewardship and cultural well-being, and on how modelling these relationships, and adapting the conceptual model for FN-LUVM to assist with land acquisition and land-use policy process (e.g., for protected and conservation lands).

- *and further to the above, research on the effects of forceable translocation of bands to new reserve lands*

Based on what has been learned in this thesis on the importance of the land as a source of "identity, spirituality, governance and sustenance" (Walking together, 2020), research opportunities exist on the impact that forceable translocation has on First Nation socio-economic and cultural well-being.

- *What changes are needed to the CWB to measure both First Nation socio-economic and cultural well-being?*

This question was touched on in Chapters 1, 4 and 5, and was outside of the scope of this research, however, the CWB index lacks in cultural well-being metrics (Guthro, 2021). Further, the CWB index includes only metrics related to housing, education, income and labour, and the government of Canada aims to improve measures of well-being (ISC, 2019). Although research is ongoing on how to improve the CWB index, the research should include how the CWB index may be improved by well-being metrics related to First Nation land management.

- *How could this research be applied to and support 'Indigenous Protected and Conserved Areas' (IPCAs)?*

"IPCAs are lands and waters where Indigenous governments have the primary role in protecting and conserving ecosystems through Indigenous laws, governance and knowledge systems" (Conservation through Reconciliation partnership; Mansuy et al, 2023). While the IPCAs initiative has not been addressed in this paper, research opportunities may include how land management and the FN-LUVM model might support First Nation land stewardship and cultural well-being with developing IPCA areas in Canada, and within reserves on protected areas.

- *How could this research be applied to provide advice to First Nations about transition from under the Indian Act / RLEMP land management regime to the First Nation Land Management (FNLM) or framework of self-government (SG) land management regimes?*

Making an informed decision about transition of land management of reserve land from under the Indian to either the FNLM or SG land management regimes requires a good understanding about the ramifications of changing land management systems and knowing when a reserve community is ready for transition. While information was provided in Chapter 2 that highlights some of the characteristics and benefits of the two alternatives there are many considerations that a reserve community needs to research to make a well-informed decision. For example, at Curve Lake First Nation, the case study in this thesis (Chapter 3), suggests that a key issue and consideration of transition is the lack of capacity (e.g., continued capacity of educated / trained staff) to manage their own land (e.g., on land transactions and leases) without the assistance of Indigenous Services Canada and the lack of capacity to enforce land-use policy by-laws (when formal planning and policy is developed). Further, as approximately 70% of their reserve land is CP (individual) land holdings (subject to ATR taking place), and at the present time all leases are on CP held lands, there may not be the same economic benefit to the community as compared to reserve communities that have leases on community (band) land (e.g., Chippewas of Georgina Island First Nation) and therefore, at the present time, suggest remaining under the Indian Act / RLEMP land management regime and work on (or continue to work on) a strategy for transition, whether to FNLM or SG.

5.4 Concluding remarks

Clearly there is much research that can be done about the relationship between First Nation land management and well-being. It is hoped research will follow up on the important questions identified in Chapters 2 to 4, and on the questions identified in Chapter 5, Section 5.3.2, that were not addressed in this thesis, and further, on the questions that have not yet been identified as research continues. By investigating the research questions identified in this thesis it is hoped the presented information will improve societies' understanding and assist First Nations in setting community objectives about land related matters that are important to their well-being.

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Appendices

Chapter 1, Appendix 1: Summary of the 94 TRC "Calls to Action"

Actions No.	Overview of actions "call upon"
1 - 5	... various governments (within Canada) on the legacy of the residential school system
6-12	... various governments on education
13-17	... various governments and institutions on language and culture
18-24	... various governments and health professionals on health
25-42	... various governments, law societies and schools on justice
43, 44	... various governments on rights of Indigenous people
45-47	... the federal government for a Royal Proclamation and covenant of reconciliation
48, 49,	... church parties on the settlement agreement[158],
50-52	... the federal government on equity for Aboriginal people in the legal system
53-56	... the Parliament of Canada, in consultation and collaboration with Aboriginal peoples, to enact legislation to enact legislation to establish a National Council for Reconciliation
57	... various governments for professional development and training of public servants
58-61	... religious denominations on spiritual matters
62-65	... various governments and Ministers of Education, on education for reconciliation
66,	... the federal government on youth programs ...
67-70	and Library and Archives Canada on museums and archives
71-76	... various people and governments on missing children and burial information
77-78	... various levels of governments on a National Centre for Truth and Reconciliation
79-83	... various governments on heritage and commemoration
84-86	... the federal government, media, and journalism programs on media and reconciliation
87-91	... various governments and officials and host countries of international sporting events on sports and reconciliation
92	... the corporate sector on business and reconciliation
93-94	... the federal government on newcomers to Canada

[158] A settlement between various Churches, the Assembly of First Nations, other Indigenous organizations, and the Government of Canada on the legacy of the residential school system rcaanc-cirnac.gc.ca/eng/1100100015576/1571581687074

Chapter 1, Appendix 2: 15 UNDRIP 'Articles' supporting First Nation reconciliation with their land

No.	Article	Statement or partial statement
1	8	1. Indigenous peoples and individuals have the right not to be subjected to forced assimilation or destruction of their culture, and, 2.States shall provide effective mechanisms for prevention of, and redress for: (b) Any action which has the aim or effect of dispossessing them of their lands, territories or resources;
2	11	1. Indigenous peoples have the right to practise and revitalize their cultural traditions and customs. This includes the right to maintain, protect and develop the past, present and future manifestations of their cultures …
3	12	1. Indigenous peoples have the right to manifest, practise, develop and teach their spiritual and religious traditions, customs and ceremonies
4	20	2. Indigenous peoples deprived of their means of subsistence and development are entitled to just and fair redress.
5	25	Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard.
6	26	1. Indigenous peoples have the right to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired……. 2 & 3.
7	27	States shall establish and implement, in conjunction with indigenous peoples concerned, a fair, independent, impartial, open and transparent process, giving due recognition to indigenous peoples' laws, traditions, customs and land tenure systems, to recognize and adjudicate the rights of indigenous peoples pertaining to their lands, territories and resources, including those which were traditionally owned or otherwise occupied or used. Indigenous peoples shall have the right to participate in this process.
8	28	Indigenous peoples have the right to redress, by means that can include restitution or, when this is not possible, just, fair and equitable compensation, for the lands, territories and resources which they have traditionally owned or otherwise occupied or used, and which have been confiscated, taken, occupied, used or damaged without their free, prior and informed consent.
9	29	1. Indigenous peoples have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources….. 2.& 3.
10	31	1. Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts. They also have the right to maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions. 2. In conjunction with indigenous peoples, States shall take effective measures to recognize and protect the exercise of these rights.
11	32	1. Indigenous peoples have the right to determine and develop priorities and strategies for the development or use of their lands or territories and other resources…. 2. & 3.
12	34	Indigenous peoples have the right to promote, develop and maintain their institutional structures and their distinctive customs, spirituality, traditions, procedures, practices and, in the cases where they exist, juridical systems or customs, in accordance with international human rights standards.

13	37	Indigenous peoples have the right to the recognition, observance and enforcement of treaties, agreements and other constructive arrangements concluded with States or their successors and to have States honour and respect such treaties, agreements and other constructive arrangements.
14	40	… as well as to effective remedies for all infringements of their individual and collective rights. Such a decision shall give due consideration to the customs, traditions, rules and legal systems of the indigenous peoples concerned and international human rights
15	43	The rights recognized herein constitute the minimum standards for the survival, dignity and well-being of the indigenous peoples of the world.

Chapter 3, Appendix A: Summary of the Land Use Survey:

This table is organized by policy on land-use on the left, and systems of land management and property rights on the right. The 10 key findings in Section 3.5 are based on the summary results of the land use survey outlined in this table.

Policy on land-use		**Systems of land management and property rights**	
Land use	1. 84% indicated they are not familiar with land-use policy. 2. 56% would like to see more policy on community land (26% no change). 3. 46% would like see more policy on CP land (28% no change); whereas, 4. 55% would like to see more policy on traditional lands, (30% unsure). 5. 38% vs 35% (yes vs no, respectively) regarding more Reserve land used for business.	Land Tenure system	1. 66% are aware of what a CP is. 2. 58% are aware of differences in on-off Reserve land tenure system.
Addition lands bought by CLFN	1. 75% would prefer additional lands be used for both private and community purposes, however, 2. 88% indicated a need for more community land. 3. 83% indicated that additional land be added to the Reserve (not leave in the Provincial system as fee simple land).	Land registry system	1. 56% are aware the government (ISC) manages the Reserve land registration system (ILRS).
Environmental protection	1. 59% indicated there is not enough protected areas (30% unsure). 2. 79% indicated generally, more environmental protections is needed, and, 3. 79% indicated more protection of waterfront areas.	Leasing system	1. 36% are satisfied with the current leasing system.

housing	1. 63% would like housing more than 50 ft apart. 2. 65% indicated both types of housing, houses and apartments	Land management system at CLFN (IALM, RLEMP)	1. 76% are unaware of the LM system type and need more info. 2. Approximately 50% are satisfied with the current system, with 59% not sure about changing and need more information (e.g., about FNLM, SGLM) followed by yes/no (28% / 13%) for change.
leasing	1. 73% are aware there are fees. 2. 66% indicated there should be restrictions on leasing areas	Survey system	1. 64% are unaware of the system (Canada Lands Survey System) 2. 24% are satisfied, and 66% neutral or uncertain.
Planning (both policy and system)	1. 81% indicated yes to zoning (including 52 comments indicating land-use planning and policy is needed within the system of land management)		

Chapter 3, Appendix B: Land Use Survey:

Summary of the 2019 CLFN land-use survey of 156 respondents that summarizes 27 of 52 questions that pertain to land-use policy, land management and socio-economic development. The information in the table is categorized by CP and non-CP owner, and by on-Reserve and off-Reserve members. Green shading (in the first column) indicates disconnect by both member types (CP/non-CP & on/off Reserve members) (Chapter 3, Table 3). Grey indicates no-disconnect by both member types (Chapter 3, Table 4, and Appendix D) and blue indicates a difference by member type (Appendix C). Non-shaded responses were not used in the Chi-square and Student's t-test.

	Land-Use Study Question	Question type	All CP (69)	CP Reserve (59)	CP off Reserve (10)	non CP (87)	non CP Reserve (22)	non CP & off Reserve (65)	on Reserve (81)	off Reserve (75)	on Reserve %	off Reserve %
1	Do you know the land management regime (or land governance system) that Curve Lake First Nation is managed under?	Yes	31	29	2	8	4	4	33	6	21.2	3.8
		No	38	30	8	79	18	61	48	69	30.8	44.2
2	How satisfied are you with CLFN's current land management system?	percent	47.43	48.40	41.22	45.60	46.00	45.45	47.20	43.34		
3	Should CLFN lands be managed under a different land management regime such as the First Nation Land Management Act (FNLM) or a Self Government?	Yes	25	22	3	20	2	18	24	21	15.4	13.5
		No	13	12	1	7	4	3	16	4	10.3	2.6
		Unsure	31	25	6	60	16	44	41	50	26.3	32.1
4	Are you familiar with CLFN's band administration policies on land-use?	Yes	17	16	1	8	6	2	22	3	14.1	1.9

		No	52	43	9	78	16	62	59	71	37.8	45.5
5	Do you think CLFN should have more or less policy on the use of community or band land?	More	42	33	9	38	8	31	41	40	26.3	25.6
		Less	9	9		16	5	12	14	12	9.0	7.7
		No change	13	13		24	8	16	21	16	13.5	10.3
6	Do you think CLFN should have more or less policy on what you can do on "private" Reserve land? (CP)	More	32	27	5	37	9	29	36	34	23.1	21.8
		Less	14	11	3	26	6	20	17	23	10.9	14.7
		No change	20	19	1	21	7	14	26	15	16.7	9.6
		No	0		0	87	22	65	22	65	14.1	41.7
7	How satisfied are you with the current land survey system?	Very satisfied	5	5	0	5	3	2	8	2	5.1	1.3
		Satisfied	18	16	2	10	4	6	20	8	12.8	5.1
		Neither satisfied nor dissatisfied	26	21	5	43	9	34	30	39	19.2	25.0
		Dissatisfied	9	8	1	4	1	3	9	4	5.8	2.6
		Very dissatisfied	2	2	0	1	0	1	2	1	1.3	0.6
		Unsure	9	7	2	24	5	19	12	21	7.7	13.5
8	Did you know that the Government of Canada, Surveyor General Branch (SGB) maintains the CLFN's survey records?	Yes	36	31	5	19	6	13	37	18	23.7	11.5

		No	33	28	5	68	16	52	44	57	28.2	36.5
9	Did you know that the Government of Canada, Indigenous Services Canada (formerly INAC) maintains title information for CLFN, in a system called the Indian Lands Registry (ILR)?	Yes	51	44	7	37	11	26	55	33	35.3	21.2
		No	18	15	3	50	11	39	26	42	16.7	26.9
10	Do you know what a certificate of possession is?	Yes	63	55	8	39	14	25	69	33	44.2	21.2
		No	6	4	2	47	7	40	11	42	7.1	26.9
11	Did you know that the Reserve title system is different than how title is held off Reserve? E.g. fee simple vs. certificate of possession?	Yes	51	46	5	40	10	30	56	35	35.9	22.4
		No	18	13	5	47	12	35	25	40	16.0	25.6
12	Are you satisfied with the current leasehold system?	percent	33.79	33.91	33.1	37.48	40.57	36.45	37.24	34.78		
13	Did you know that lessees pay yearly service fees to CLFN?	Yes	58	50	8	55	14	42	64	50	41.0	32.1
		No	11	9	2	30	7	23	16	25	10.3	16.0
14	Are there places within CLFN territory that you think leasing should not be allowed?	Yes	46	43	3	50	15	35	58	38	37.2	24.4
		No	21	14	7	29	6	23	20	30	12.8	19.2

15	Are you in favour of a land-use plan that designates land (e.g, zoning) for different types of land-uses, such as housing (residential), business (commercial), parks, traditional use, and wildlife habitats?	Yes	55	47	8	70	16	54	63	62	40.4	39.7
		No	8	7	1	2	1	1	8	2	5.1	1.3
		Unsure	6	5	1	14	5	10	10	11	6.4	7.1
16	Do you prefer individual houses or apartment units, or both?	Individual houses	15	14	1	35	10	25	24	26	15.4	16.7
		Apartments	1	1	0	4	0	4	1	4	0.6	2.6
		Both	53	44	9	48	12	36	56	45	35.9	28.8
17	Do you think there are enough traditional land use areas in the community?	Yes	10	10	0	13	4	9	14	9	9.0	5.8
		No	44	36	8	41	11	30	47	38	30.1	24.4
		unsure	15	13	2	30	6	24	19	26	12.2	16.7
18	Do you think there are enough protected wildlife habitats within CLFN?	Yes	13	13	0	8	3	5	16	5	10.3	3.2
		No	40	34	6	47	14	30	48	36	30.8	23.1
		unsure	16	12	4	31	2	29	14	33	9.0	21.2
19	Do you think there are enough areas for business in CLFN? E.g. gas stations, banks, stores, etc?	Yes	25	20	5	33	13	20	33	25	21.2	16.0
		No	28	24	4	26	6	20	30	24	19.2	15.4

		Unsure	14	13	1	27	3	24	16	25	10.3	16.0
		No	3	2	1	10	4	5	6	6	3.8	3.8
		No	61	21	10	80	19	61	40	71	25.6	45.5
20	Would you be in favour of CLFN acquiring more land for community use?	Yes	61	51	10	74	20	54	71	64	45.5	41.0
		No	6	6	0	12	2	10	8	10	5.1	6.4
21	If you answered yes to the above question, would you be in favour of adding that land to Reserve status?	Yes	61	51	10	66	16	50	67	60	42.9	38.5
		No	2	2	0	5	1	4	3	4	1.9	2.6
		Unsure	4	4	0	14	3	11	7	11	4.5	7.1
22	If CLFN acquired more land, should that be for community use or private use (CP) or both?	Private Use (CP)	2	2	0	2	0	2	2	2	1.3	1.3
		Community Use	10	10	0	16	7	9	17	9	10.9	5.8
		Both	54	44	10	63	15	48	59	58	37.8	37.2
		Unsure	2	3	0	6	0	6	3	6	1.9	3.8
23	Do you think more controls should be put in place on CP held lands for environmental protection? E.g. Wildlife habitats, wetland protection, pollution controls.	Yes	52	45	7	66	18	48	63	55	40.4	35.3
		No	14	11	3	19	3	16	14	19	9.0	12.2

24	Do you think more environmental controls should be put in place for the waterfront areas. E.g. landscaping, swamp and marsh protection?	Yes	54	45	9	70	19	51	64	60	41.0	38.5
		No	5	4	1	4		4	4	5	2.6	3.2
		Unsure	10	10	0	12	3	9	13	9	8.3	5.8
		Off	10	0	10	65	0	65	0	75	0.0	48.1
25	What type of dwelling do you live in ?	House	66	57	9	75	22	53	79	62	50.6	39.7
		Apartment or Quad	3	2	1	12		12	2	13	1.3	8.3
		Trailer	0	0	0	0		0	0	0	0.0	0.0
26	What would you say is the overall quality of the standard of living in Curve Lake (i.e. level happiness and well being in Curve Lake)	percent	51.79	54.02	37.67	50.5	55.10	48.81	54.56	43.24		
27	Rate what you consider is the general condition, availability and suitability of housing on the Reserve.	percent	34.45	35.61	27.22	31.37	37.63	29.25	36.62	28.24		

Chapter 3, Appendix C: Differing results in disconnect / no-disconnect:

This table summarizes the five differing results shown in Chapter 3, Tables 3 and 4 (survey questions 13, 14, 15, 16 and 18). The threshold for disconnect is p values less than alpha = 0.05 and for no-disconnect p values greater than alpha = 0.05. Chi-square results (p values) for numbers 13, 15 and 16 - indicate a significant difference (disconnect) in CP/non-CP holders and no significant difference (no-disconnect) for on/off Reserve members, and for numbers 14 and 18 – show no significant difference (no-disconnect) for CP/non-CP holders and significant difference (disconnect) for on/off-Reserve members.

	CP / non-CP Holders p value	On / off Reserve members p value
Land Use Survey Question	**Disconnect p value < 0.05**	**No Disconnect p value > 0.05**
Number 15. Are you in favour of a land-use plan that designates land (e.g., zoning) for different types of land-uses, such as housing (residential), business (commercial), parks, traditional use, and wildlife habitats?	0.0331	0.1800
Number 13. Do you know that lessees pay yearly service fees to CLFN?	0.0069	0.0600
Number 16. Do you prefer individual houses or apartment units, or both?	0.0176	0.2403
	No Disconnect p value > 0.05	**Disconnect p value < 0.05**
Number 14. Are there places within CLFN territory that you think leasing should not be allowed?	0.4960	0.0189
Number 18. Do you think there are enough protected wildlife habitats within CLFN?	0.0938	0.0005

Chapter 3, Appendix D: Student's t- test:

CP and non-CP holder results are on the left and on/off-Reserve members results are on the right. The four questions in the land-use survey had a rating out of 100 (See Appendix B – survey questions 2, 12, 26 and 27). The results indicate all four questions had no significant difference (no-disconnect). The threshold for no-disconnect was found when the t-statistic (t-stat) value was less than the t-critical (t-crit) value at alpha 0.05 (2 tail).

Land Use Survey Question	**CP / non-CP Holders** Student's t- test (alpha 0.05)			Average of CP and Non-CP in %	**on-Reserve / off-Reserve member** Student's t-test (alpha 0.05)			Average of on and off-Reserve in %
	Statistically Different (t-stat is less than t-crit)	CP Average in %	Non-CP Average in %		Statistically Different (t-stat is less than t-crit)	On-Reserve Average in %	Off-Reserve Average in %	
No. 2 How satisfied are you with CLFN's current land management system?	No	47.4 (sd 32.0)	45.6 (sd 23.4)	46.5 (sd 0.9)	No	47.7 (sd 32.3)	44.9 (sd 20.4)	46.3 (sd 1.4)
No. 12 Are you satisfied with the current leasehold system?	No	33.8 (sd 27.1)	37.5 (sd 24.8	35.6 (sd 1.8)	No	35.7 (sd 27.9)	36.0 (sd 23.1)	35.8 (sd 0.2)
No. 26 What would you say is the overall quality of the standard of living in Curve Lake (i.e., level of happiness and well being in Curve Lake)?	No	51.8 (sd 25.1)	50.5 (sd 24.5)	51.1 (sd 0.6)	No	54.3 (sd 27.2)	47.3 (sd 21.8)	50.8 (sd 3.5)
No. 27 Rate what you consider is the general condition, availability and suitability of housing on the Reserve.	No	34.4 (sd 22.8)	31.4 (sd 22.1)	32.9 (sd 1.5)	No	36.1 (sd 24.2)	29.0 (sd 19.5)	32.5 (sd 3.6)

Chapter 4, Appendix 1 - Explanation of the point rating system

The CLFN 2019 land use survey (survey) described in Fligg et al, (2021) was used for a land knowledge point rating system (0 to 100). The point rating measured the perceived level of land knowledge or lack of knowledge in five land related areas: land management, land-use policies, property rights system and well-being. How the areas were point rated is described in the Online-Appendix 1 – Overview, Design Concepts and Details (ODD protocol for describing ABMs).

The survey consisted of 52 questions of which 25 questions (Appendix 2) were used for the point rating system. The 25 questions had responses that could be measured, such as yes, no, unsure or a percentage rating. 10 of the 25 questions that had 2 responses that could be used, such as, “no” and “unsure”, and therefore, 35 responses were used altogether.

The point rating system measured member level of uncertainty and/or lack of land related knowledge in the five areas. Responses were used that measured uncertainty and lack of knowledge that had the option for “no” “unsure”, “less” “no change” and “neither satisfied or unsatisfied” in particular where the response indicated a lack of knowledge to answer the question, a negative response or uncertainty. In some cases, a “yes” answer was used that indicated a level of uncertainty among member types. The reverse percentile was used for questions that asked for a positive response by percent (in 4 instances).

The 35 responses were given a weight of 1 to 5 of importance, for a total of 100 (Appendix 1, Table 1). Since the negative or uncertain response was used, the lower the score (e.g., closer to 0) would indicate a higher level of understanding or less uncertainty about the question being asked.

Appendix 1, Table 1: Weighting of the questions in the CLFN 2019 land-use survey.

Weight (number of responses)	LUS question number	Question Description (number of responses in brackets).
5 (5)	1, 5, 13, 14, 17	Questions pertaining to the knowledge base about Curve Lake First Nation - land management system, land-use, land-use policies, and individual land holdings and leases. The “no” option for a lack of knowledge was used (5).
4 (2)	19, 12,	Questions pertaining to the knowledge base on government managed land systems, such as land tenure and registration, and survey system. The “no” option for a lack of knowledge was used (2).
3 (12)	3(c), 6(c), 7(c), 9(c), 9(f), 19(c), 22(c), 23(c), 24(a), 28, 29(d), 31(c)	Questions pertaining to opinions on categories 1 to 4, that have a response option of uncertainty such as “unsure” (9) “neither satisfied or dissatisfied” (1) or “no change” (2) that are used in conjunction in a question with a 2nd response for a total weight of 5.
2 (15)	3(a), 6(b), 7(b), 15, 18, 19(b), 22(a), 23(a), 24(c), 27, 29(b), 30, 31(b), 48, 49	Questions pertaining to opinions on categories 1 to 4, with a definite response, such as: 1) yes (6), no (3), less (2), or community use (1) or; 2) an opinion on the percent level of satisfaction on leasing (1) or; 3) for questions pertaining to category 5, community well-being (2) measured in percentile.
1 (1)	2	Supplementary question to a previous question where the response is an opinion measured by a percentile (1)

Point rating and weighting on level of importance is based on collaboration between authors and Curve Lake First Nation that took place over many years (since 2014). The point rating and model is derived from 1) the CLFN 2019 land use survey (Appendix 2); 2) feedback from CLFN Lands Committee (2014 to 2019) and CLFN Lands and Environment Committee (2020 to 2023), 3)

Lands Manager(s), and other First Nation staff and committees, and 4) attendance at community meetings, and 5) CLFN published material, e.g., website, 2009 Comprehensive Community Plan, and Mae Whetung-Derrick CLFN member publications.

Chapter 4, Appendix 2 – The land knowledge point rated table

The land knowledge point rating system is based on responses to 35 questions from the 2019 Curve Lake First Nation (CLFN) Land Use Survey by 1) the 156 CLFN respondents broken down by 69 CP holders, 87 non-CP holders (as outlined in Fligg et al, 2021) with a random sample of 100 agents used in the computational experiments as the experimental group, and 2) by the CLFN Lands and Environment Committee as the control group. The questions highlighted in green were used for members land knowledge and attitude calculations and the questions highlighted in grey (numbers 51 and 52) were used only for attitude calculations. Information about the calculations is provided in the Online-Appendix 1 – Overview, Design Concepts and Details (ODD protocol for describing ABMs).

Note: The following information is for the 156 respondents to the CLFN 2019 land use survey from which the LUS19 100 random agents were derived from and used in FN-LUVM. Average values for CP and non-CP holders for LUS19 are similar with an average land knowledge score of 71.0 CP holders and 59.0 non-CP holders whereas the breakdown for the 156 respondents for average land knowledge score are 72.0 CP holders and 59.8 non-CP holders.

	Question	Weight	Answer	CP holders (69)	non-CP holders (87)	committee (5)
1	Do you know the land management regime (or land governance system) that Curve Lake First Nation is managed under?		Yes	31	8	5
			No	38	79	0
		5		2.75	4.54	0
2	How satisfied are you with CLFN's current land management system?		percent	47.43	48.62	47
		1	reverse calc	0.53	0.51	0.53
3	Should CLFN lands be managed under a different land management regime such as the First Nation Land Management Act (FNLM) or a Self Government?		Yes	25	20	3
		2		0.72	0.46	1.2
			No	13	7	0
			Unsure	31	60	2
		3		1.35	2.07	1.2
5	Are you familiar with CLFN's band administration policies on land-use?		Yes	17	8	2
			No	52	78	3
		5		3.77	4.48	3

6	Do you think CLFN should have more or less policy on the use of community or band land?		More	42	38	5
			Less	9	16	
		2		0.26	0.37	0
			No change	13	24	
		3		0.57	0.83	0
7	Do you think CLFN should have more or less policy on what you can do on "private" reserve land? (CP)		More	32	36	5
			Less	14	26	
		2		0.41	0.6	0
			No change	20	0	
		3		0.87	0	0
9	How satisfied are you with the current land survey system?		Very satisfied	5	5	
			Satisfied	18	10	
			Neither satisfied nor dissatisfied	26	43	2
		3		1.13	1.48	1.2
			Dissatisfied	9	4	1
			Very dissatisfied	2	1	
			Unsure	9	24	2
		3		0.39	0.83	1.2
10	Did you know that the Government of Canada, Surveyor General Branch (SGB) maintains the CLFN's survey records?		Yes	36	19	5
			No	33	68	0
		4		1.91	3.13	0
12	Did you know that the Government of Canada, Indigenous Services Canada (formerly INAC) maintains title information for CLFN, in a system called the Indian Lands Registry (ILR)?		Yes	51	37	5
			No	18	50	0
		4		1.04	2.3	0

13	Do you know what a certificate of possession is?		Yes	63	39	5
			No	6	47	0
		5		0.43	2.7	0
14	Did you know that the reserve title system is different than how title is held off reserve? E.g. fee simple vs. certificate of possession?		Yes	51	40	4
			No	18	47	1
		5		1.3	2.7	1
15	Are you satisfied with the current leasehold system?		percent	33.79	23.57	49
		2	reverse calc	1.32	1.53	1.02
17	Did you know that lessees pay yearly service fees to CLFN ?		Yes	58	55	5
			No	11	30	0
		5		0.8	1.72	0
18	Are there places within CLFN territory that you think leasing should not be allowed?		Yes	46	50	3
			No	21	29	2
		2		0.61	0.67	0.8
19	Are you in favour of a land-use plan that designates land (e.g, zoning) for different types of land-uses, such as housing (residential), business (commercial), parks, traditional use, and wildlife habitats?		Yes	55	70	5
			No	8	2	0
		2		0.23	0.05	0
			Unsure	6	14	
		3		0.26	0.48	0
22	Do you think there are enough traditional land use areas in the community?		Yes	10	13	1
		2		0.29	0.3	0.4
			No	44	41	4
			unsure	15	30	0
		3		0.65	1.03	0

23	Do you think there are enough protected wildlife habitats within CLFN?		Yes	13	8	1
		2		0.38	0.18	0.4
			No	40	47	3
			unsure	16	31	1
		3		0.7	1.07	0.6
24	Do you think there are enough areas for business in CLFN? E.g. gas stations, banks, stores, etc?		Yes	25	33	3
		2		0.72	0.76	1.2
			No	28	26	1
			Unsure	14	27	1
		3		0.61	0.93	0.6
27	Would you be in favour of CLFN acquiring more land for community use?		Yes	61	74	5
			No	6	12	0
		2		0.17	0.28	0
28	If you answered yes to the above question, would you be in favour of adding that land to reserve status?		Yes	61	65	5
			No	2	5	0
			Unsure	4	14	0
		3		0.17	0.48	0
29	If CLFN acquired more land, should that be for community use or private use (CP) or both?		Private Use (Certificate of Possession)	2	2	0
			Community Use	10	16	1
		2		0.29	0.37	0.4
			Both	54	63	3
			Unsure	2	6	1
		3		0.09	0.21	0.6
30	Do you think more controls should be put in place on CP held lands for environmental protection? E.g. Wildlife habitats, wetland protection, pollution controls.		Yes	52	66	5
			No	14	19	0

		2		0.41	0.44	0
31	Do you think more environmental controls should be put in place for the waterfront areas. E.g. landscaping, swamp and marsh protection?		Yes	54	70	5
			No	5	4	0
		2		0.14	0.09	0
			Unsure	10	12	0
		3		0.43	0.41	0
47	What is your level of income		Under $15K	7	10	-
			Between $15K and $29K	10	15	-
			Between $30K and $49k	15	19	-
			Between $50K and $74K	13	11	-
			Between $75K and $99K	9	6	-
			Between $100K and $150K	4	11	-
			Over $150K	1	2	-
48	What would you say is the overall quality of the standard of living in Curve Lake (i.e. level happiness and well being in Curve Lake)		percent	51.79	52.17	63
		2	reverse calc	0.96	0.96	0.74
49	Rate what you consider is the general condition, availability and suitability of housing on the reserve.		percent	34.45	36.82	37
		2	reverse calc	1.31	1.26	1.26
51	Education is accessible within CLFN?		Strongly agree	6	7	
			Agree	40	40	4
			Disagree	14	24	1
			Strongly disagree	5	4	

52	Members have enough income to provide for their families.		Strongly agree	0	1	
			Agree	31	28	3
			Disagree	30	43	2
			Strongly disagree	5	4	
			Uncertainty level	28.0	40.2	17.4
			Knowledge score out of 100	72.0	59.8	82.6

Chapter 4, Appendix 3 - LUS19 and final 'tick' results of the 100 agents for the 37 experiments.

The first row depicts the starting values called LUS19 (100 random agent derived from the 156 respondents to the CLFN 2019 land-use survey). The subsequent rows are experiments 1 to 37, with computational experiments 1 and 2 (Exp1 and Exp 2) that were used in Sections 6 to 8 of the paper. Community engagement functions that were set to 'on' are shown in column 2, model parameters and settings in column 3, voting results (not vote, no, yes, and undecided) in columns 4 to 7, land stewardship, ambition, collaboration, and land knowledge average scores in columns 8 to 11, and level of effort in knowledge transfer (Le) in column 12. Voting results have been rounded off to 1.

Abbreviations: under the column - community engagement functions 'on': K – land knowledge, I – influence, m – member interaction | Parameter settings: MO - model operating setting (for attitude adjustment), KB -(land knowledge threshold) , wt – settings for land stewardship and ambition weights, mif – member interaction function settings, i/f – influence functions settings, Ir – influence rate, kf – land knowledge rate settings (priority rate). Def – refers to the default settings were set for the functions - land knowledge, influence, member interaction, CP/non-CP rate of learning weights, land stewardship and ambition weights (for the function on level of effort). For experiment details on default settings – see Online-Appendix No. 1, Section 3.4.2.

Experiment scenario	Community Engagement functions 'on'	Parameter settings	Unlikely to vote	Vote NO	Vote YES	Abstain	land stewardship avg/100	Ambition avg/100	Collaboration avg/100	Land Knowledge avg/100	Level of effort (Le) out of 100
LUS19			9	10	23	58	66.4	47.0	81.8	64.5	69.1
Exp 1	kim	MO1, def	13	4	61	22	82.8	49.6	76.9	87.2	86.9
Exp 2	im	MO1, ticks max (100), i/f increased in planning and policy	9	13	67	11	80.5	60.4	88.0	76.7	76.3
S3	m	MO1, def	31	8	28	33	67.1	35.1	69.5	70.3	70.8
S4	i	MO1, def	15	13	40	33	64.3	43.0	76.8	75.1	74.9
S5	k	MO1, def	13	3	42	42	73.3	45.8	74.8	79.7	79.9
S6	kim	MO30, def	7	6	66	21	85.4	60.3	86.6	87.8	95.7
S7	m	MO30, def	9	10	35	45	78.7	52.1	85.8	68.5	88.8
S8	i	MO30, def	9	10	44	37	69.8	52.3	85.9	72.7	84.4
S9	k	MO30, def	7	5	55	33	81.8	56.8	85.8	79.7	92.2
S10	kim	MO5, def	13	1	49	37	79.2	47.2	74	87.3	83.2
S11	m	MO5, def	23	8	28	41	72.0	35.8	69.8	69.5	73.6
S12	i	MO5, def	15	12	26	46	60.6	40.1	73.6	74.8	70.9
S13	k	MO5, def	13	2	38	47	72.3	44.8	73.8	79.7	78.6
S14	ki	MO30, kf max, def, (terminated at 22 ticks – Le maxed out)	7	4	70	19	86.3	70.6	86.8	92.4	100
S15	ki	MO30, k min, def	9	6	57	28	74.6	57.5	85.9	80.5	88.6
S16	k	MO1, kf max, def	10	2	71	17	87.0	68.3	79.1	96.5	97.2
S17	kim	MO1, Ir 3. def	13	3	49	35	82.1	45.2	72.8	83.8	83.4

S18	kim	MO1,def cp/ncp wt1	13	5	58	24	80.4	48.0	76.7	85.3	84.9
S19	kim	MO1, def, S A wt 1	3	9	75	14	87.9	69.8	96.5	85.1	84.7
S20	i	MO1, def, If set at 0	15	11	24	50	61.8	41.0	49.9	72.8	72.3
S21	i	MO1, def, I max	15	13	47	25	66.6	45.2	79.1	78.2	77.8
S22	m	MO1 def, mif 0	32	8	18	42	52.4	33.1	67.8	62.0	62.0
S23	m	MO1 def, mif max	21	8	36	34	76.7	35.7	69.8	76.3	75.9
S24	k	MO1 def, KB80, tick max (terminated at 31)	13	3	42	42	73.7	46.0	74.8	80.1	80.12
S25	k	MO5, def, KB80 m tick max terminated at 31)	13	2	38	47	72.8	45.0	73.8	80.1	78.9
S26	k	MO30, def, KB80m tick max (terminated at 31)	7	5	56	32	82.1	57.0	85.8	80.1	92.4
S27	m	MO1 def, mif max, S A wt max, tick max (100), kb 80	40	7	16	37	68.4	21.9	56.6	78.6	79.1
S28	i	MO1, def, KB80, tick max (terminated at 76)	13	14	46	27	67.8	46.7	80.8	79.9	79.5
S29	i	MO5, def,KB80, tick max (terminated 62)	15	12	42	30	64.2	43.3	76.8	79.5	75.0
S30	i	MO30, def,KB80, tick max (100)	9	10	48	33	69.8	52.3	85.9	77.2	84.4
S31	i	MO1, def, S A wt 2 (max)KB80, tick max (100))	33	10	16	42	54.0	31.8	65.8	79.3	79.1
S32	i	MO1, def, i/f max,.KB80, tick max (100)	14	13	48	25	67.3	46.0	79.9	79.3	78.7
S33	i	MO1, def, I/f min, kb 80, tick max (100)	15	12	35	38	66.6	45.9	79.8	78.6	78.2
S34	im	MO1, ticks max (100)	15	11	46	28	73.1	42.3	74.9	78.9	78.4
S35	im	MO30, ticks max (100)	9	11	64	16	78.5	55.6	85.9	75.2	90.1
S36	im	MO5, ticks max (100)	15	12	44	29	69.3	41.6	73.4	78.3	75.8
S37	im	MO1, ticks max (100), i/f increased planning and polic	15	13	55	18	72.3	44.4	76.8	79.6	79.5

Chapter 4, Appendix 4 – Summary of agent voting behaviour by land knowledge, attitudes and collaboration type

The results of experiment 1 were summarized by the four voting categories (yes, no, not vote, and abstain (undecided), and by the four collaboration types, T1 to T4 (Appendix 4, Table 1).

Chapter 4, Appendix 4 - Table 1: Summary of agent voting by collaboration type for Experiment 1. Under Column 1 - Voting categories | Under Column 2 - Agent collaborator Types: 1 – non-collaborators (agent does not collaborate), 2- ambitious collaborator, 3 - stewardship collaborator, 4 - balanced ambitious and stewardship collaborator. Each row provides summary information according to agent voting type and by collaborator type. For example, agents that did not vote (row 2) were collaborator type 1. For agents that voted 'no' (row 3), there were (all) four types of collaborators. For agents that voted 'yes' (row 4), there were collaborator types 3 and 4, and for agents that 'abstained' (row 5), there were (all) four types of collaborators.

Voting category	collaborator type	Knowledge avg/100	Collaboration avg/100	Ambition avg/100	Land Stewardship avg/100
All agents	1-4	78.90	74.14	43.53	72.99
not vote	1	76.96	37.10	38.16	49.11
No Vote	1	45.78	74.13	28.06	28.16
	2	70.81	80.88	67.06	30.13
	3	50.82	84.81	38.17	51.65
	4	68.65	85.04	56.93	62.24
Yes Vote	3	82.60	76.44	42.87	87.34
	4	83.37	88.65	52.53	90.56
Abstaining undecided	1	78.68	62.54	42.17	65.81
	2	85.62	86.74	43.01	32.15
	3	78.92	85.16	25.29	77.31
	4	75.45	87.73	49.45	67.48