Land use and freshwater resource management on small islands

A social ecological metabolism method

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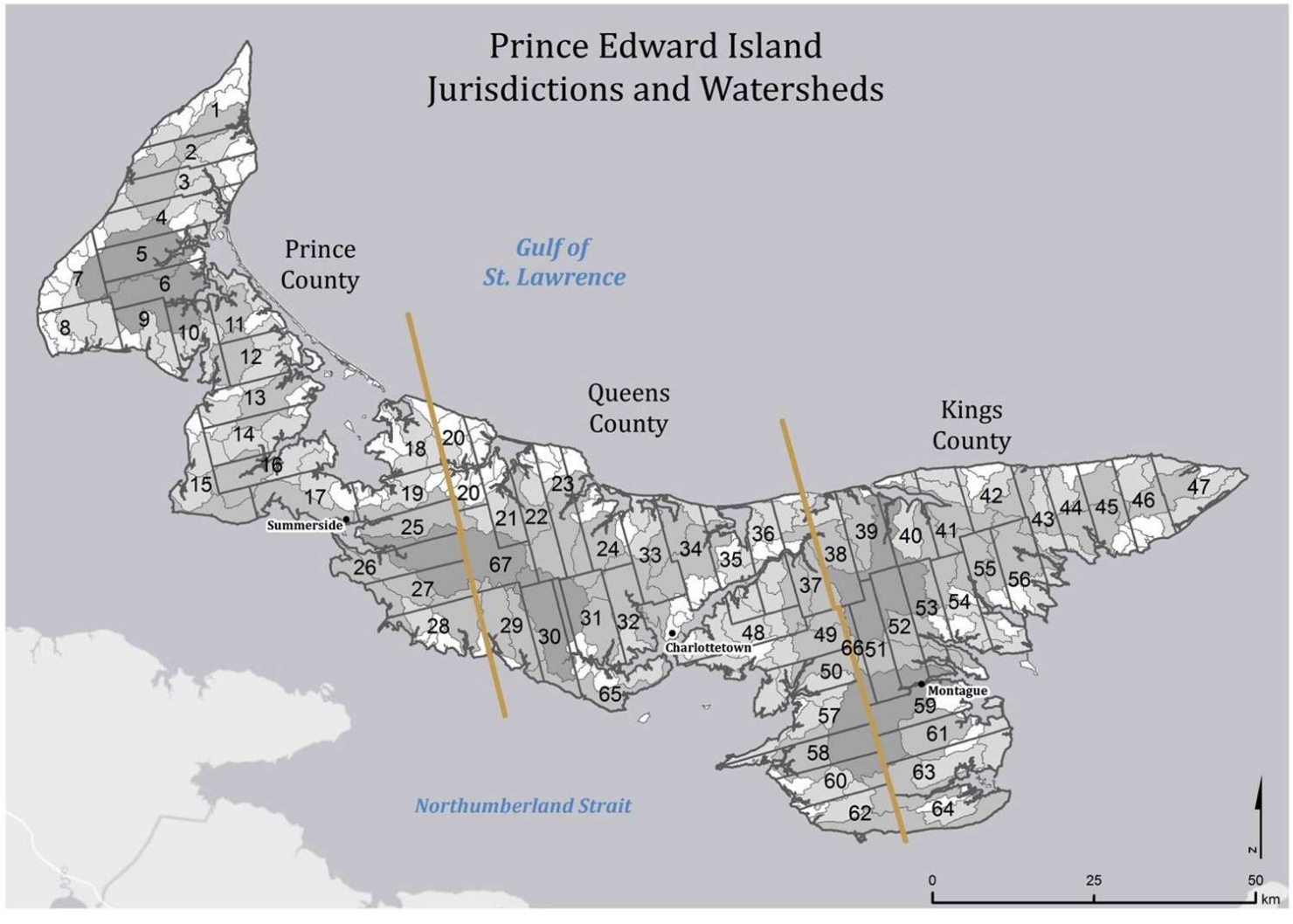
The UPEI GeoREACH Lab

INTERNATIONAL WATER RESOURCES ASSOCIATION'S
1st ISLANDS WATER CONGRESS
FAROE ISLANDS - SEPTEMBER 4-6, 2024

Geospatial **Re**search in **A**tlantic **C**anadian **H**istory

- 5-8 Undergrad students
- Visiting faculty, students
- Guest practitioners



Atlantic Canada

Government of Canada, IRCC

GeoREACH Lab Research

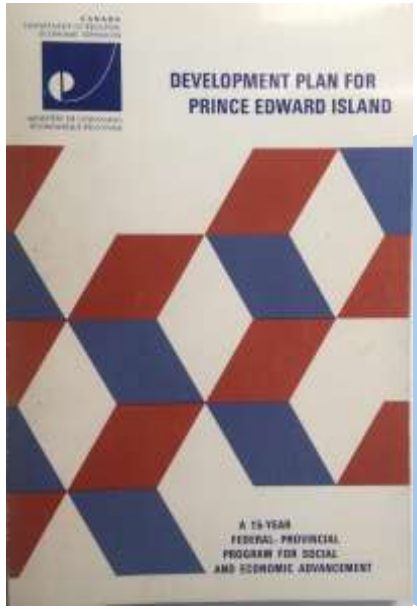
How has land use changed in Atlantic Canada over 50-75 years?

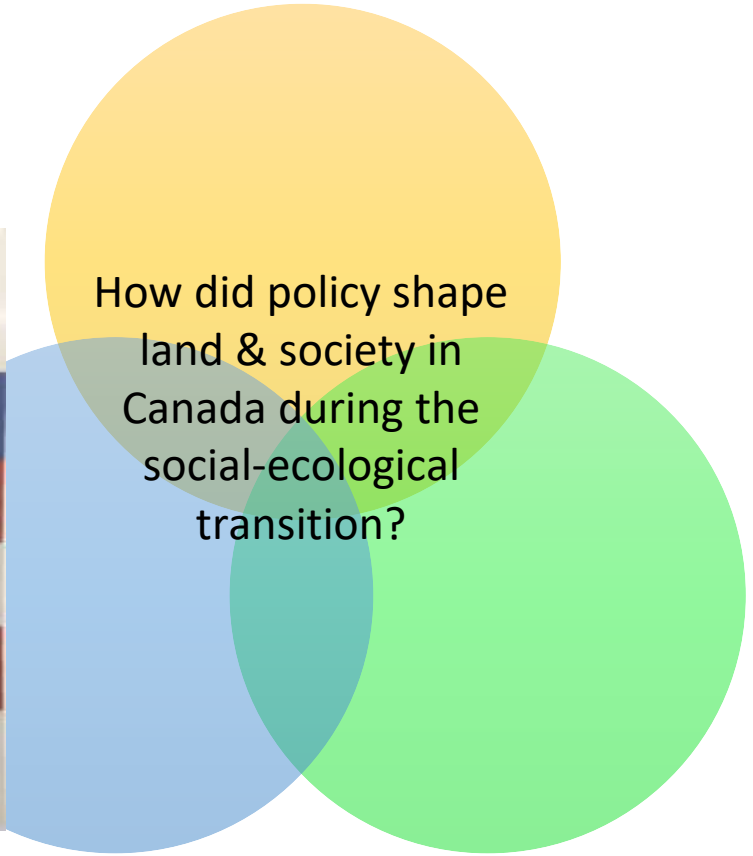
What motivated those changes?

What impacts did they have?

What key policies and programs?

- Comprehensive Development Plan
- Family Farm Program
- Lands Protection Act





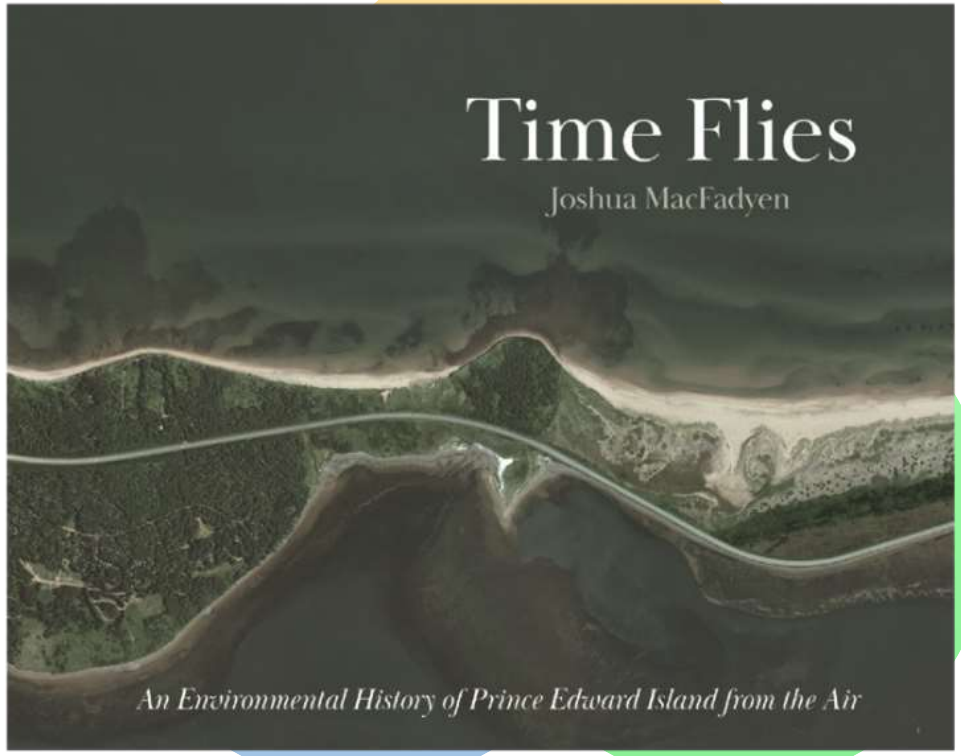
GeoREACH Lab Research

How has land use changed in Atlantic Canada over 50-75 years?

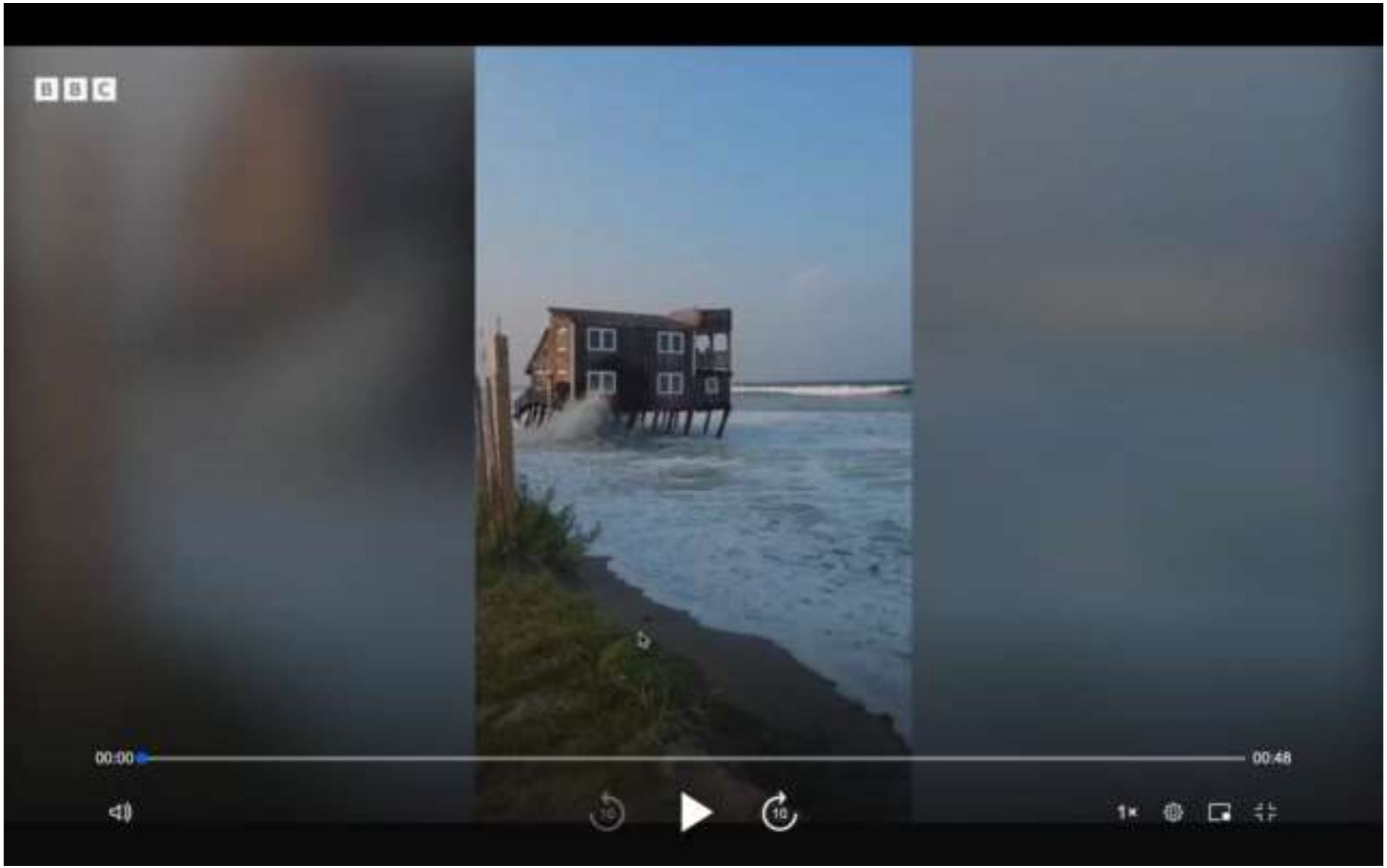
How has that land use affected **resilience**?

Coastal land use

- Tourism: coastal development and seasonal residences
- Agriculture: coastal clearing, reversion, hedgerow removal



Resilience in the face of severe weather and CC



Cape Hatteras National Seashore, August 2024

BBC 2024

Resilience in the face of severe weather and CC

CBC 2022

CBC 2022

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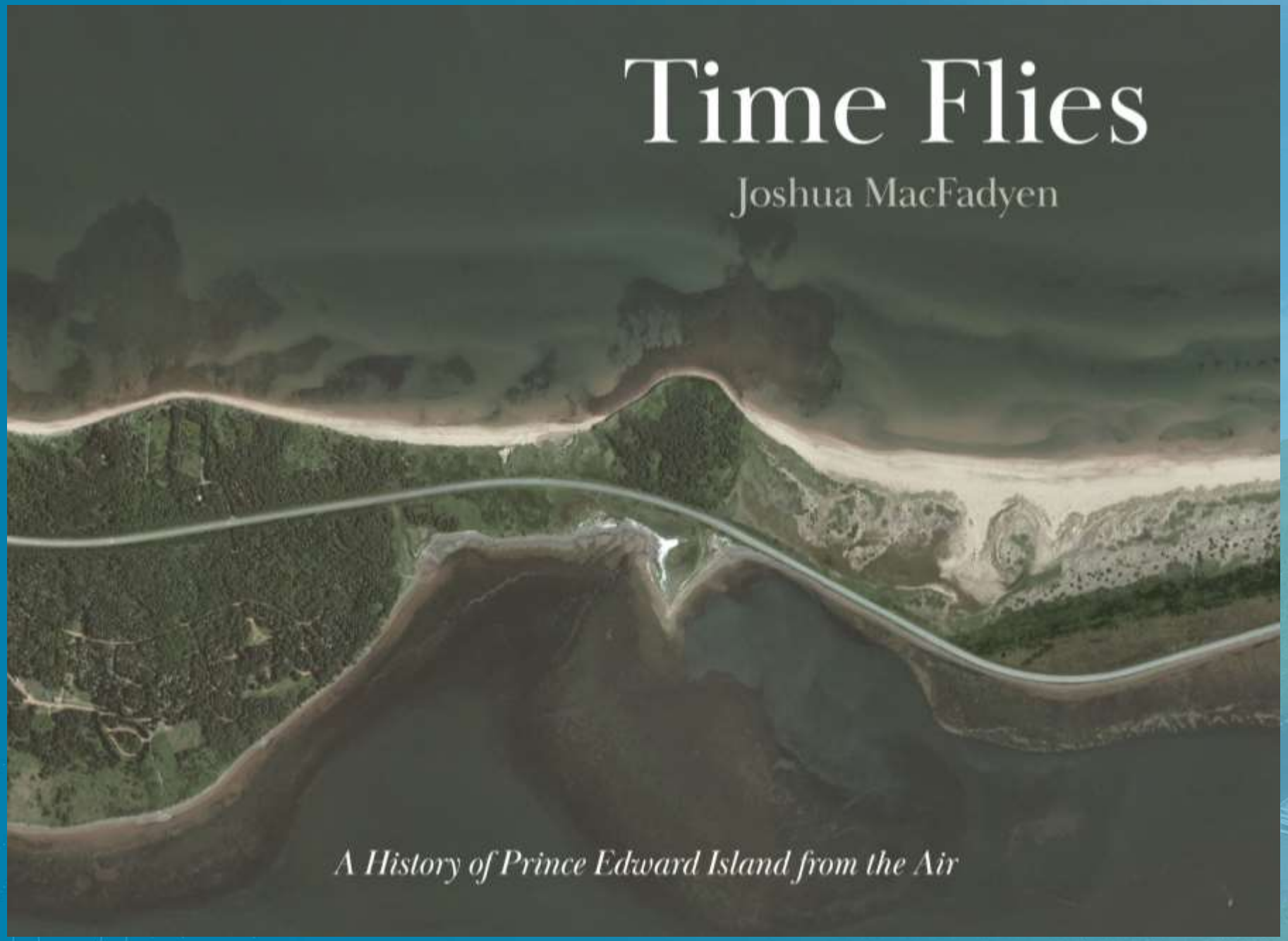
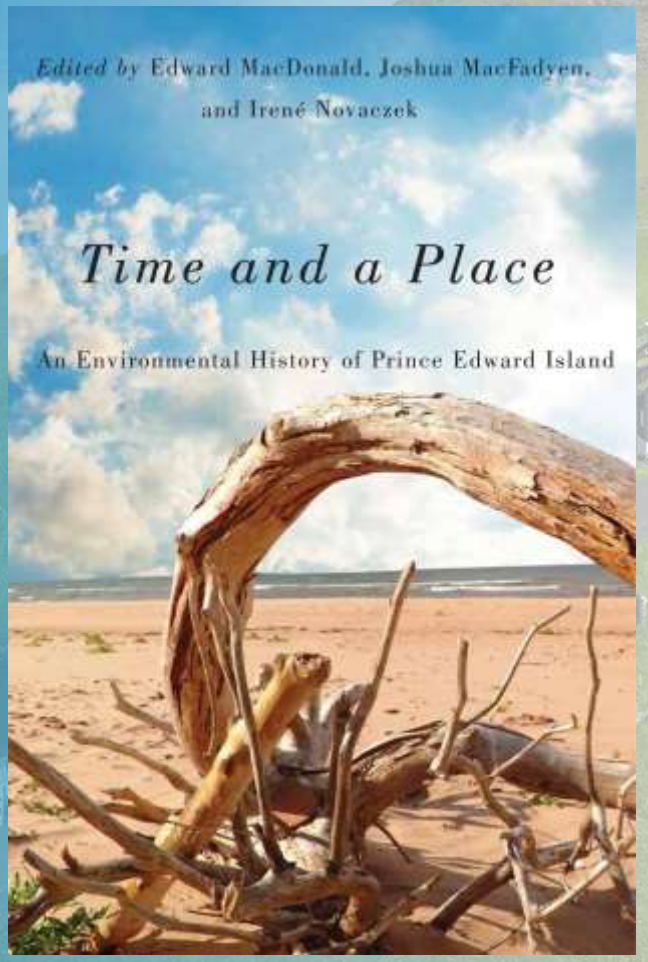
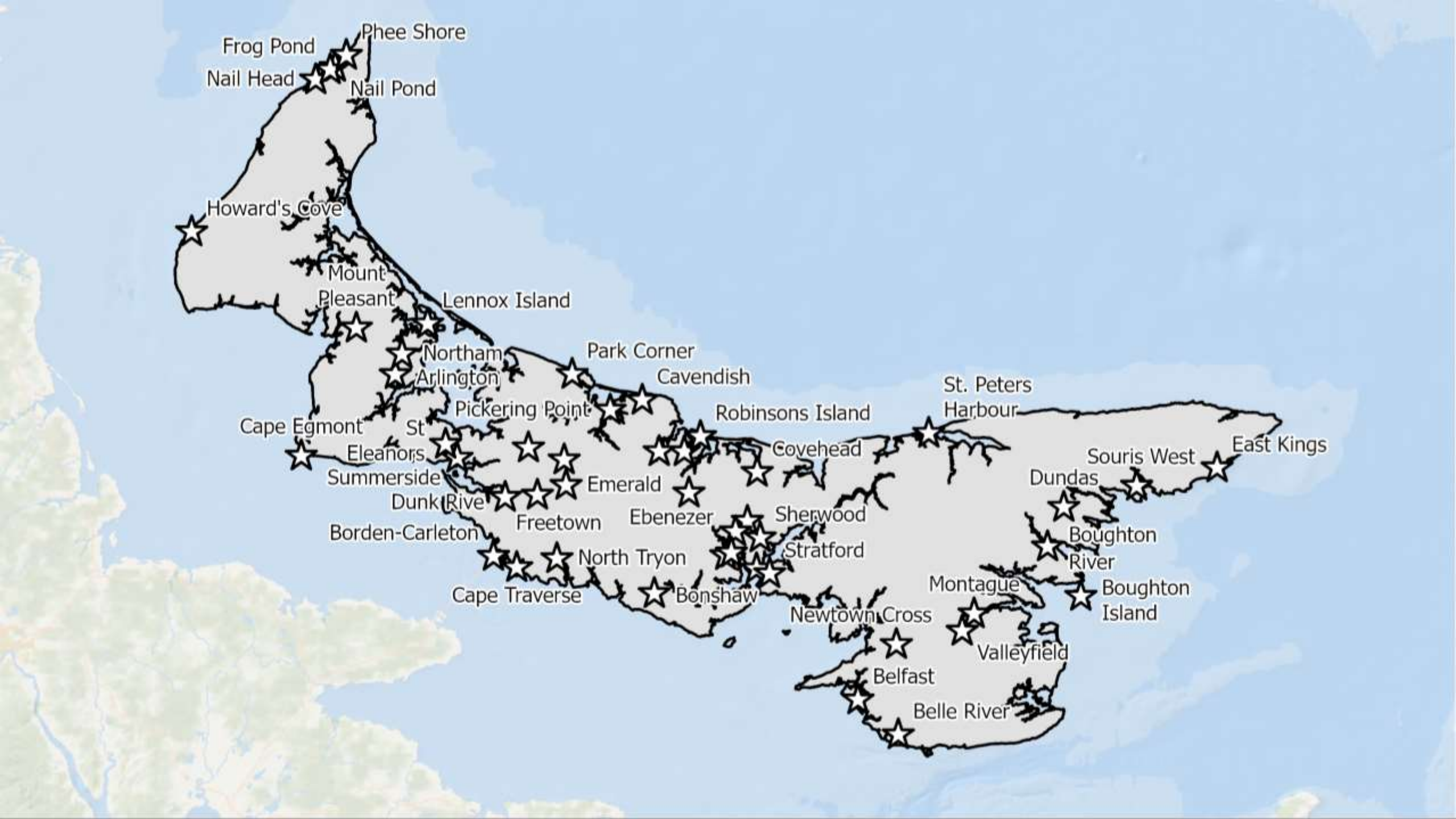





Phee Shore
Frog Pond
Nail Head
Nail Pond
Howard's Cove
Mount Pleasant
Lennox Island
Northam
Arlington
Park Corner
Cavendish
Pickering Point
Robinsons Island
St. Peters Harbour
Cape Egmont
St Eleanors
Covehead
East Kings
Souris West
Summerside
Emerald
Dundas
Dunk River
Freetown
Ebenezer
Sherwood
Boughton River
Borden-Carleton
Stratford
North Tryon
Montague
Boughton Island
Cape Traverse
Bonshaw
Newtown Cross
Valleyfield
Belfast
Belle River

Contents

Social ecological metabolism

Methods:

Social Ecological System (SES) Transitions

Material and Energy Flow Analysis (MEFA)

Environmental/Energy History

Historical Geographical Information Systems (h-GIS)

Energy Return on Investment (EROI)

Soil Nutrient Balance

Social ecological metabolism

Foundations:

Wirsenius (2000)

Cunfer and Krausmann (2009)

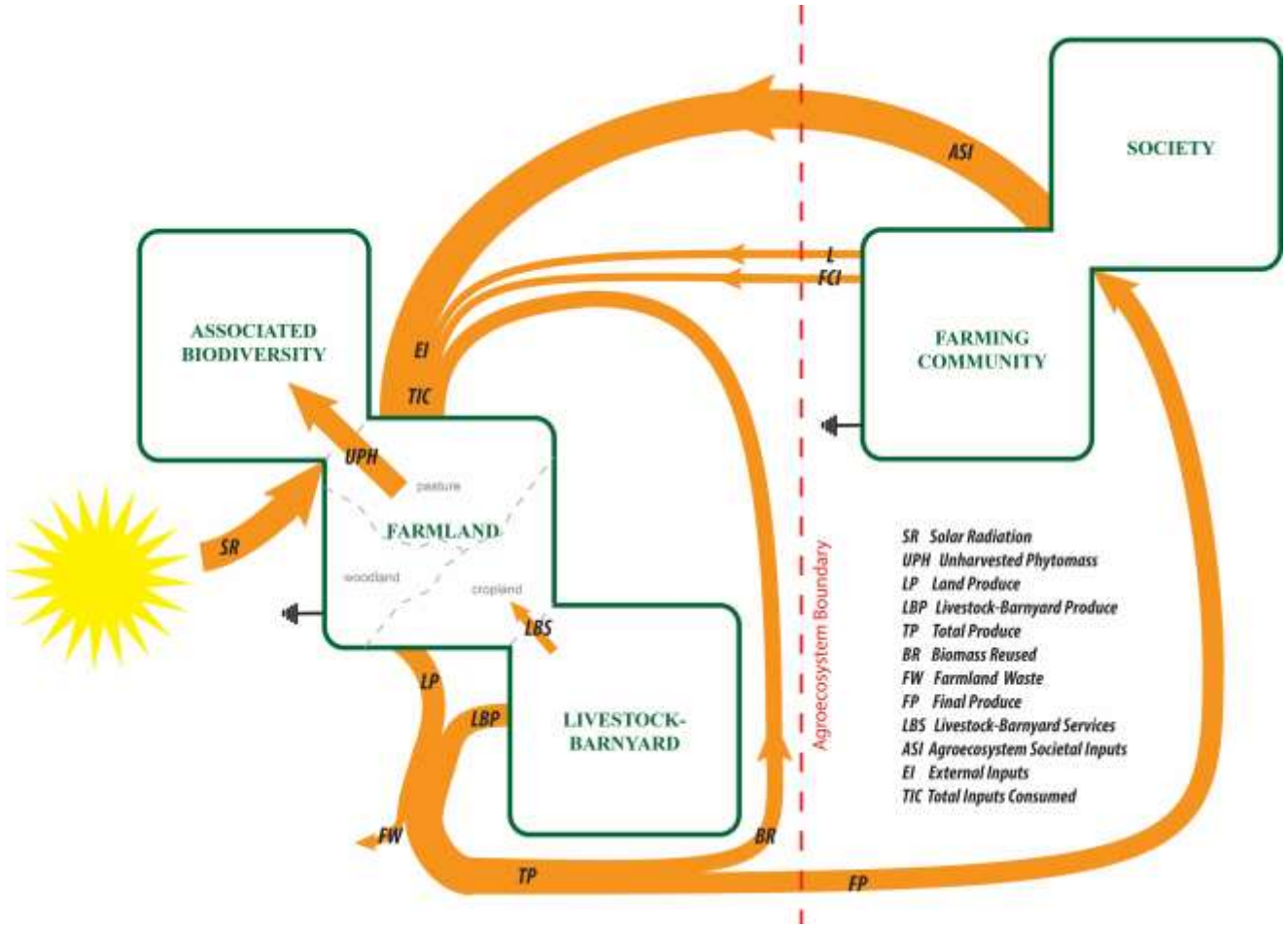
Tello et al (2015)

Gingrich et al (2018)

MacFadyen and Watson (2018)

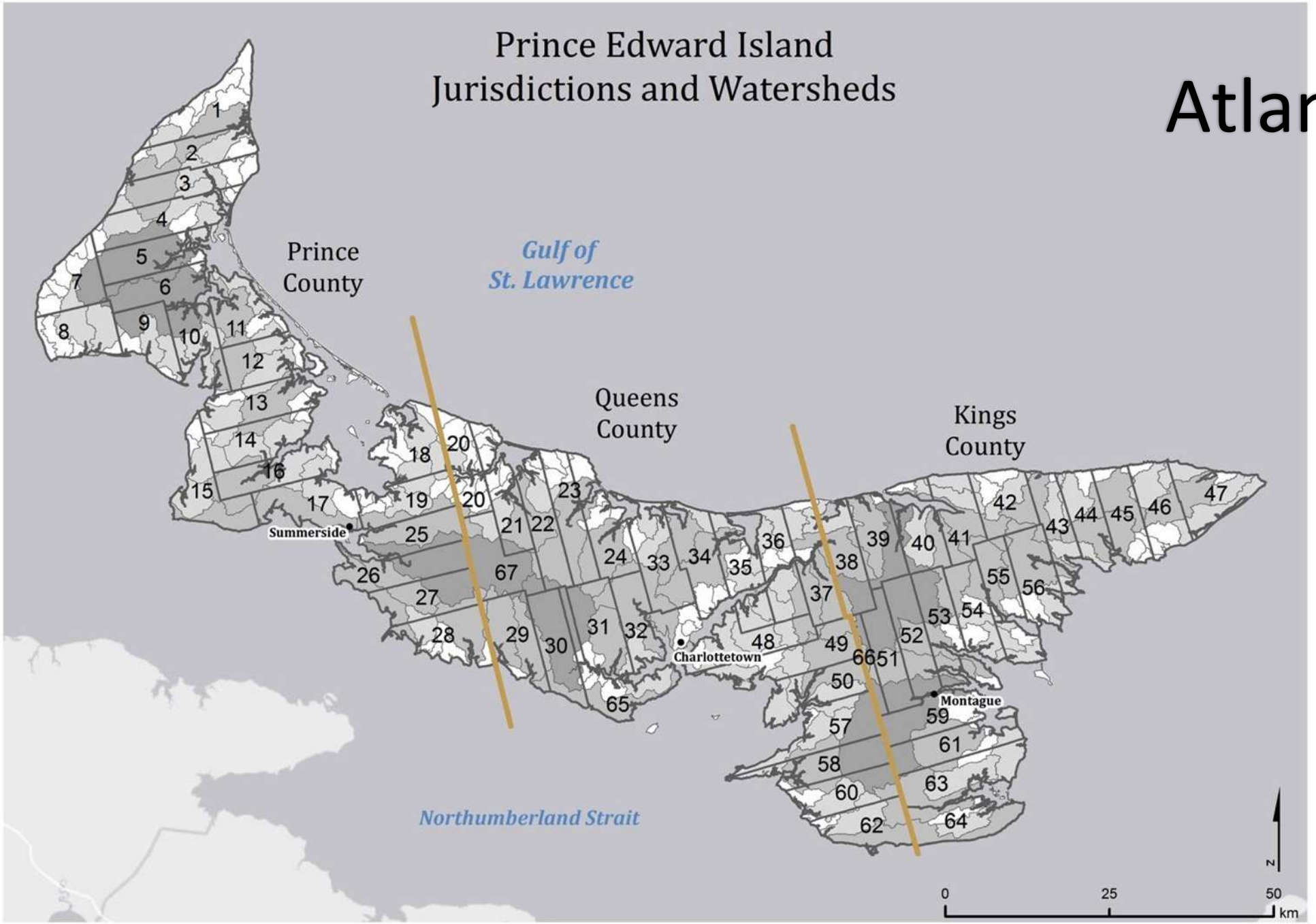
Berners-Lee et al (2018)

Marshall and Brockway (2020)

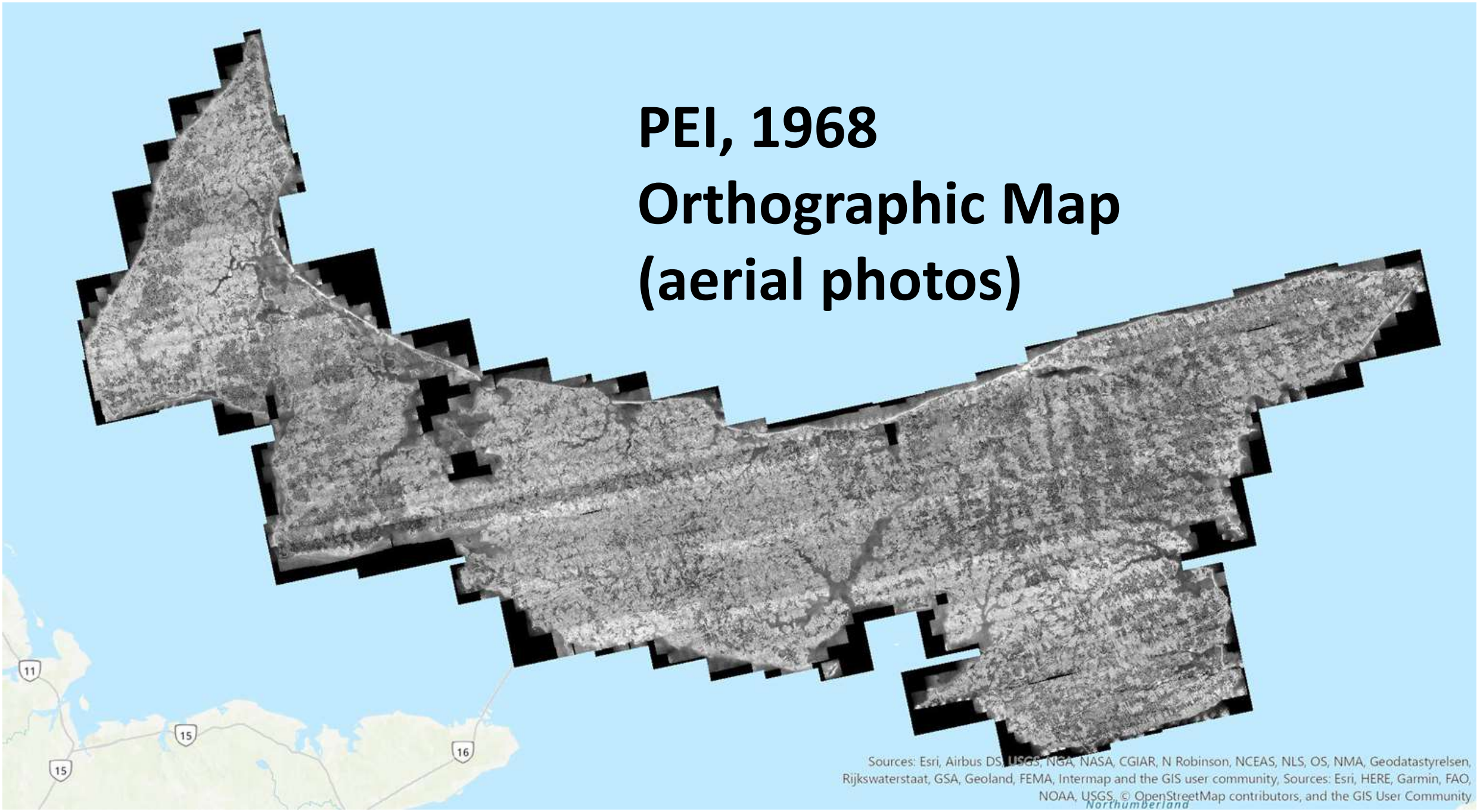


Enric Tello et al (2015)

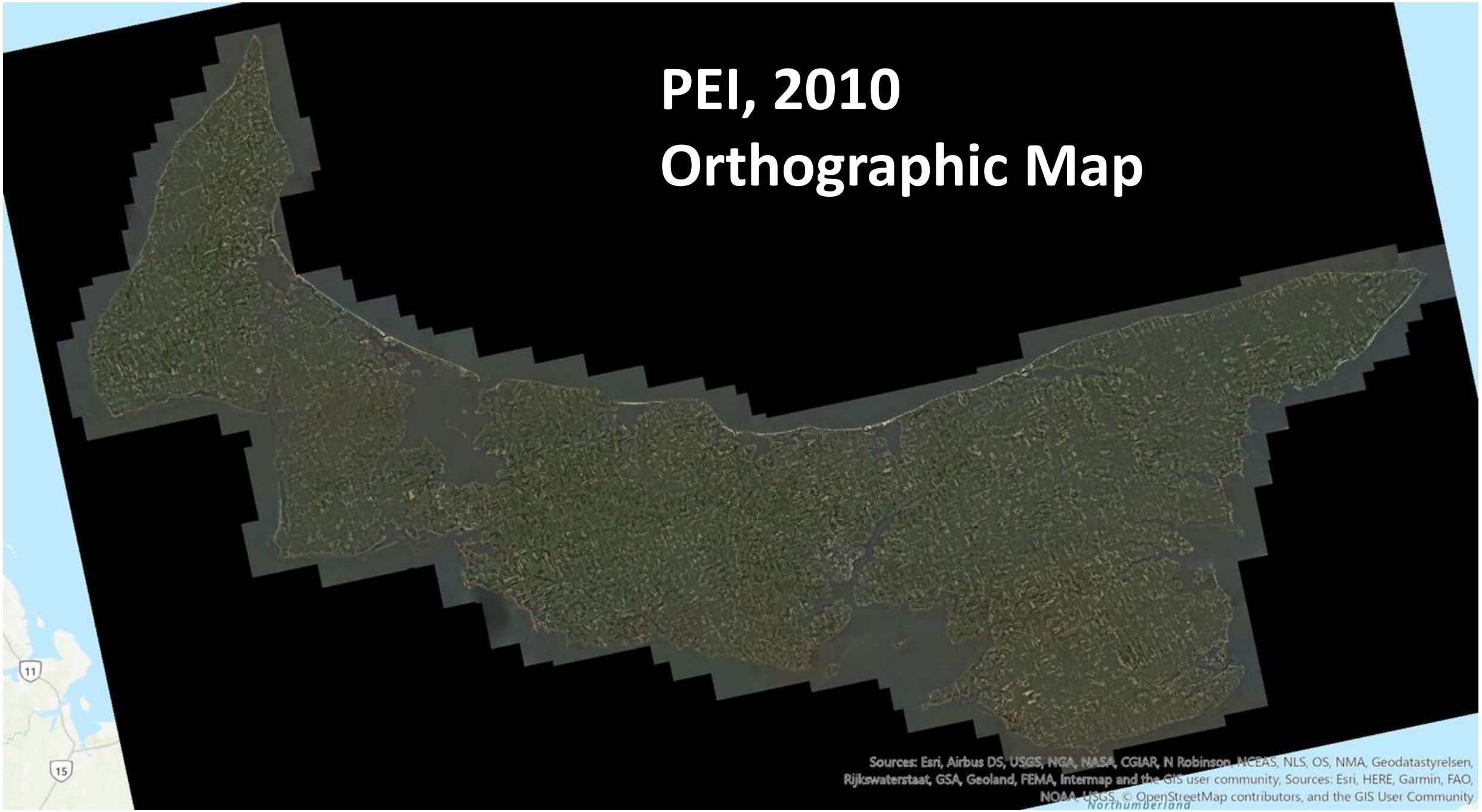
Atlantic Canada

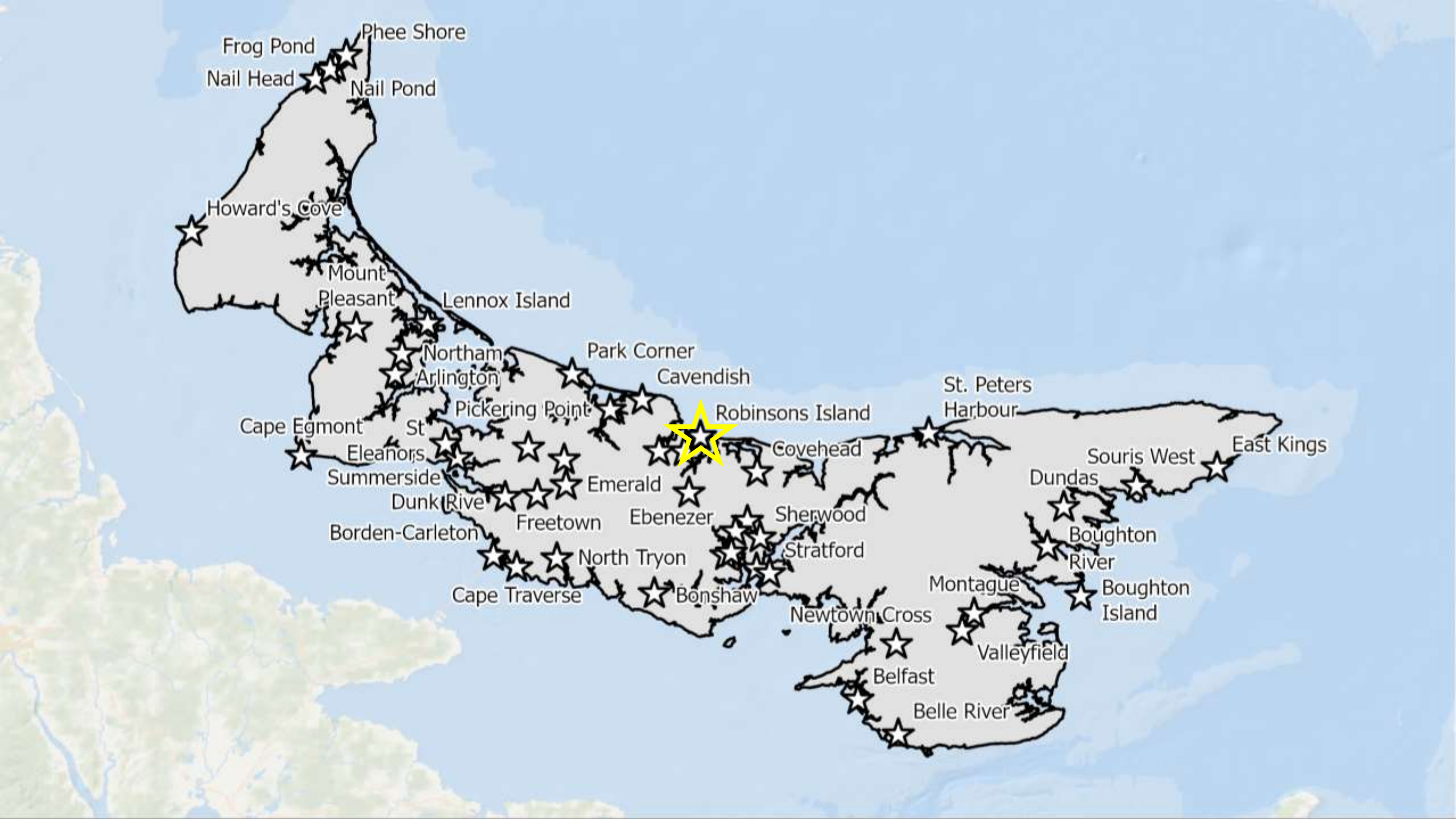


Government of Canada, IRCC


PEI, 1968
Orthographic Map
(aerial photos)
11
15
15
16
Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Northumberland

PEI, 2010
Orthographic Map

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Newtown Cross
Valleyfield
Belfast
Belle River

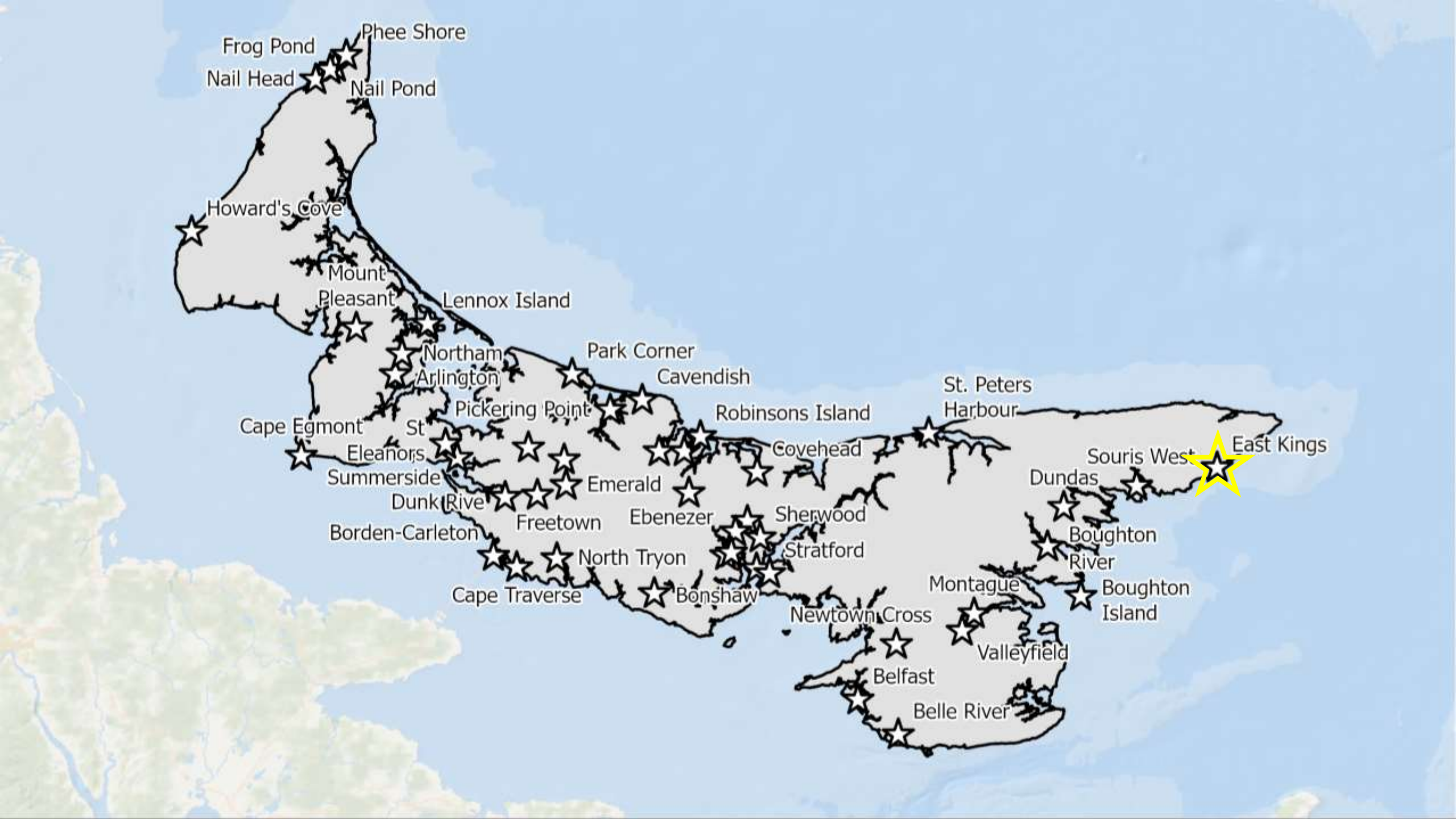
1935 Robinsons Island

island abandonment/development


B
1968 Robinsons Island
island abandonment/development
Gulf of St Lawrence
E
F
A


2020 Robinsons Island
island abandonment/development
B
Gulf of St
Lawrence
H
G
A

Contents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Newtown Cross
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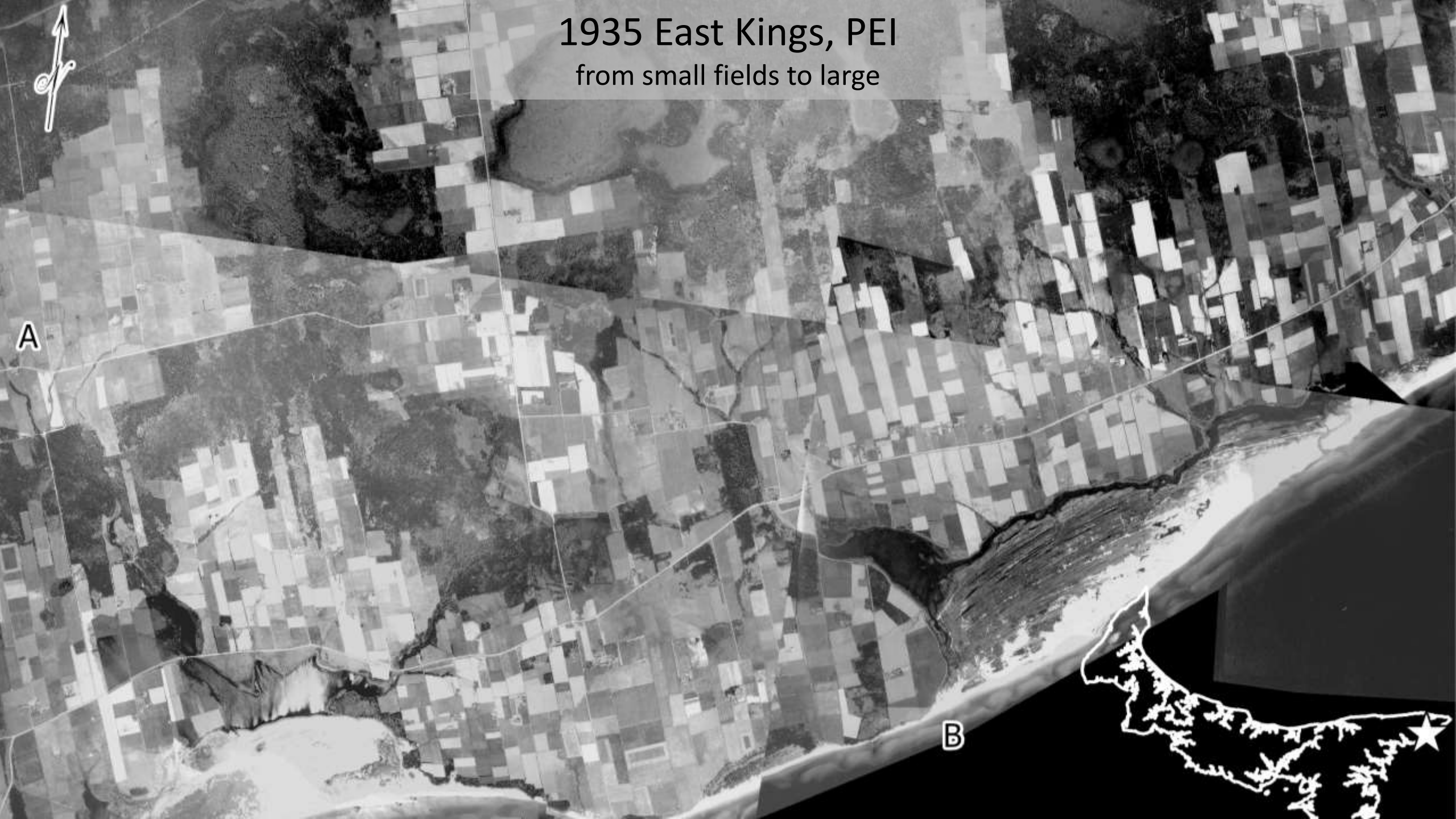
Belfast
Belle River

1935 East Kings, PEI

from small fields to large

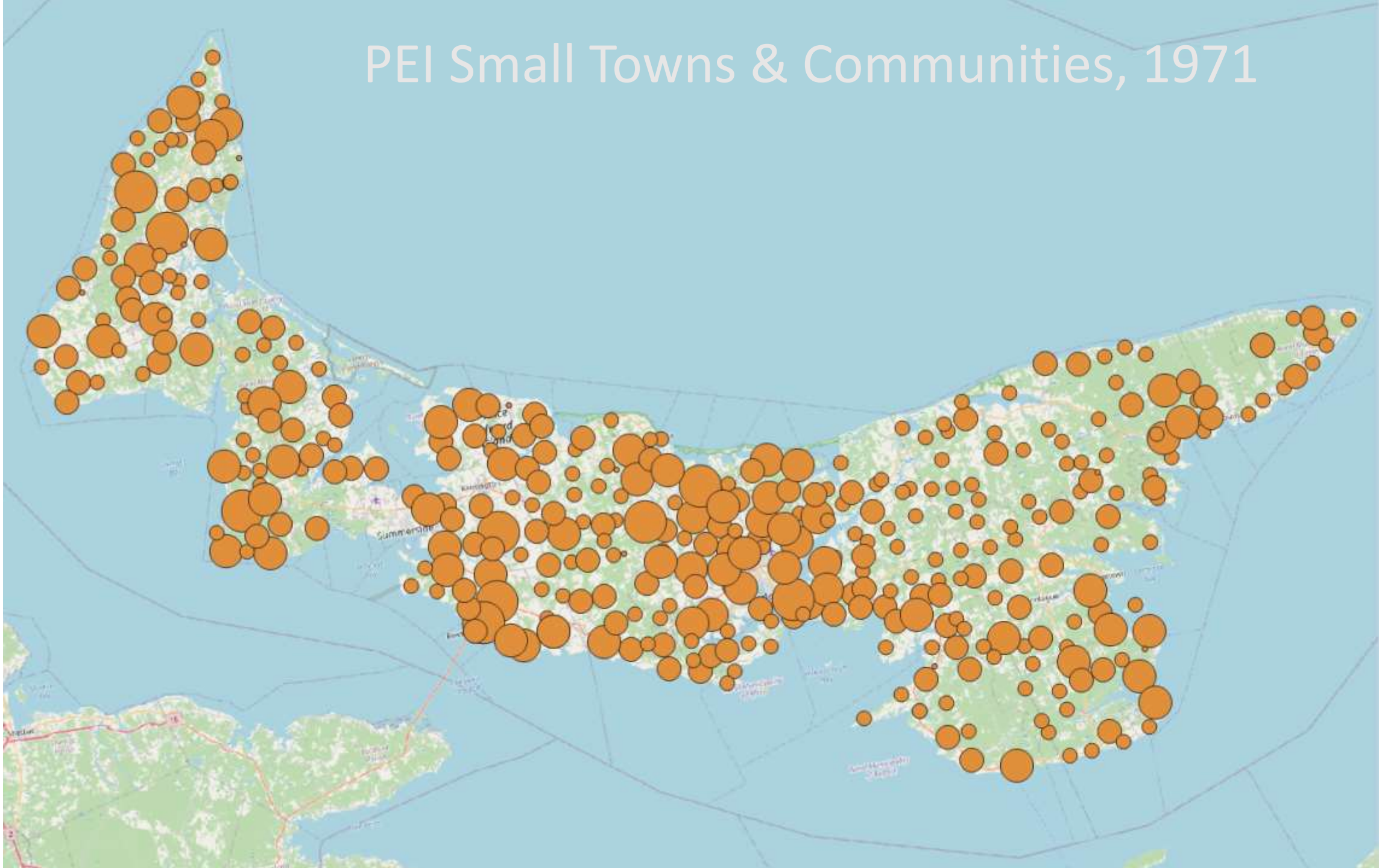



1968 East Kings, PEI
from small fields to large
A
B
C

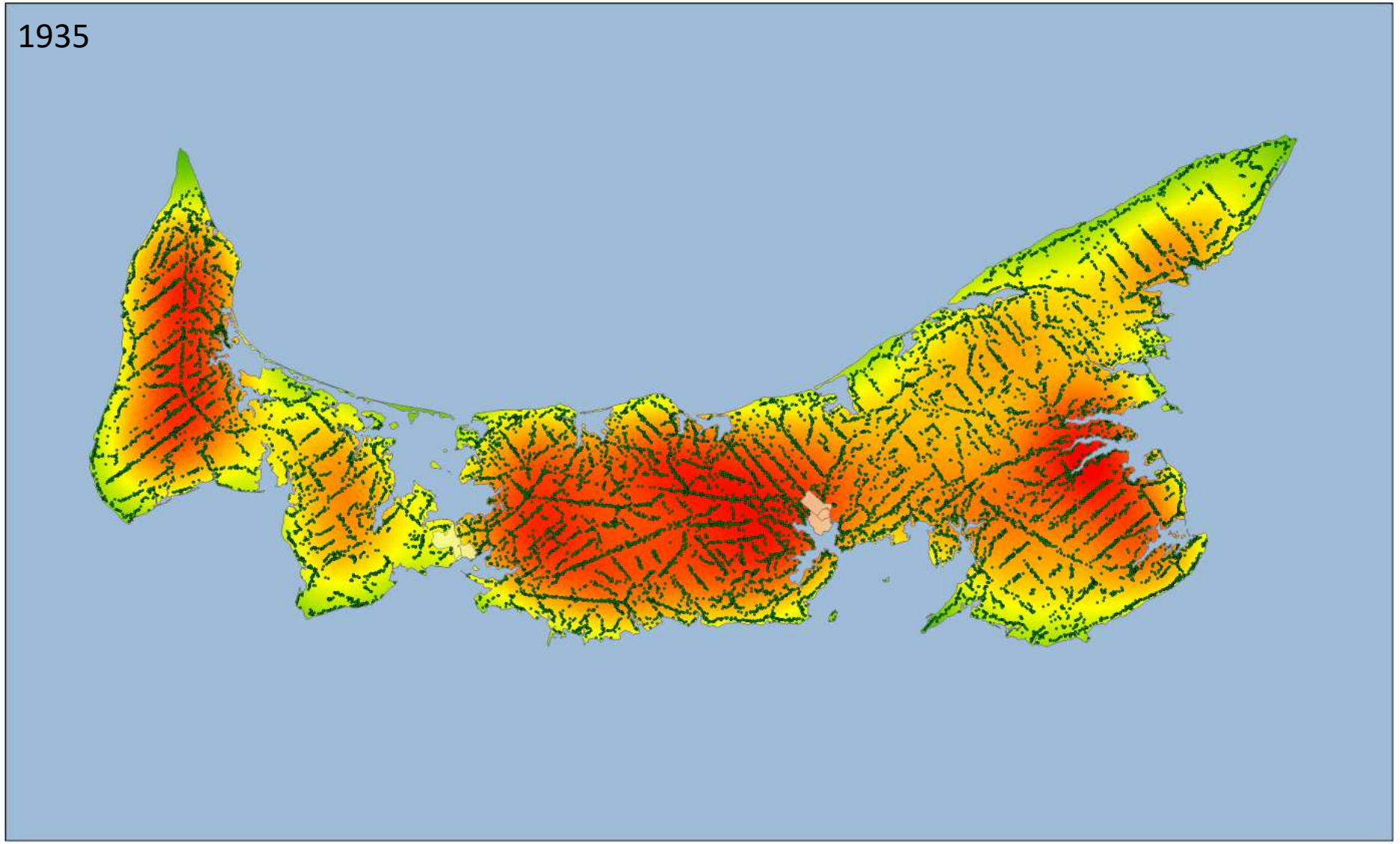
2020 East Kings, PEI

from small fields to large

PEI Small Towns & Communities, 1971



Population growth & urbanization



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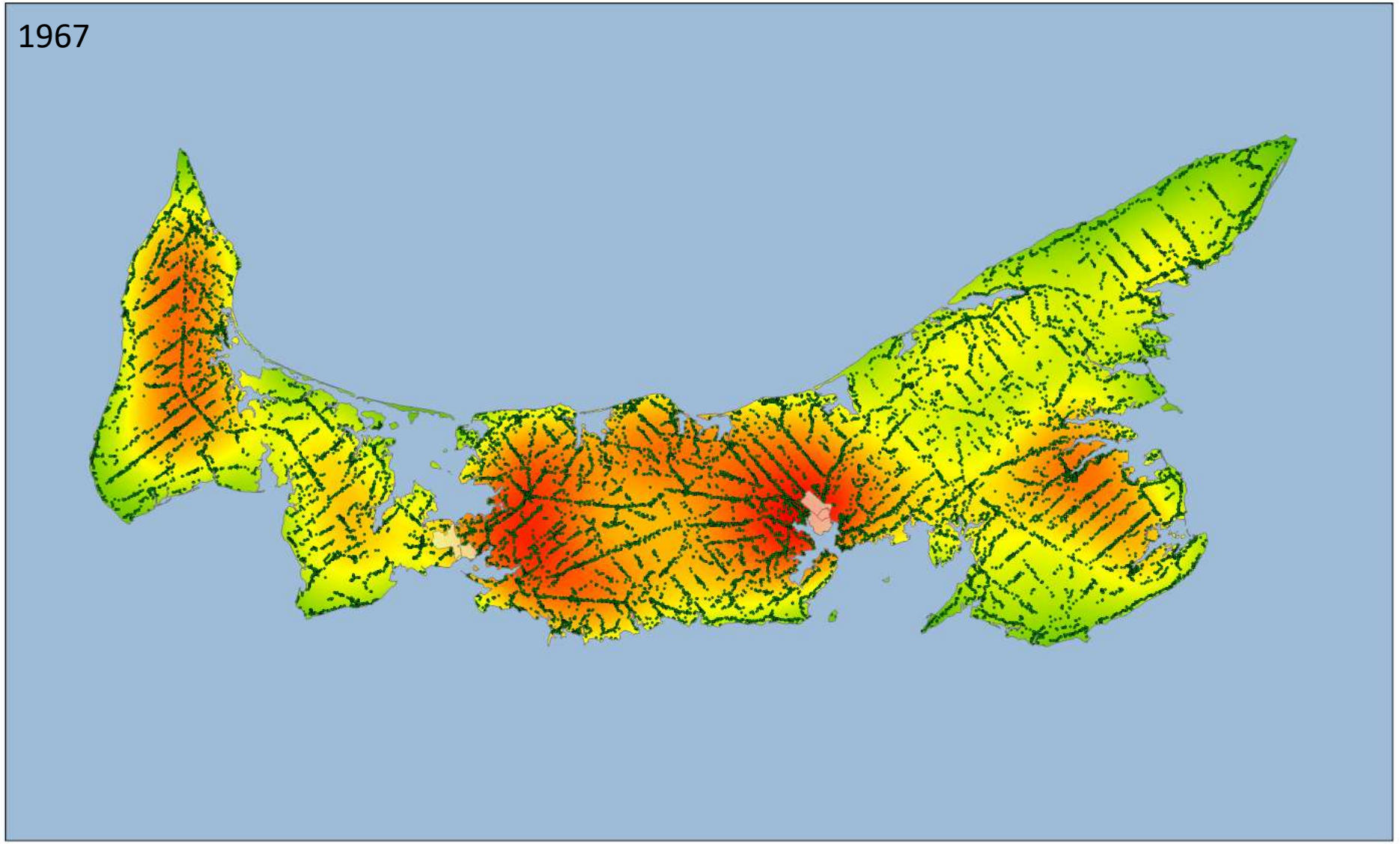
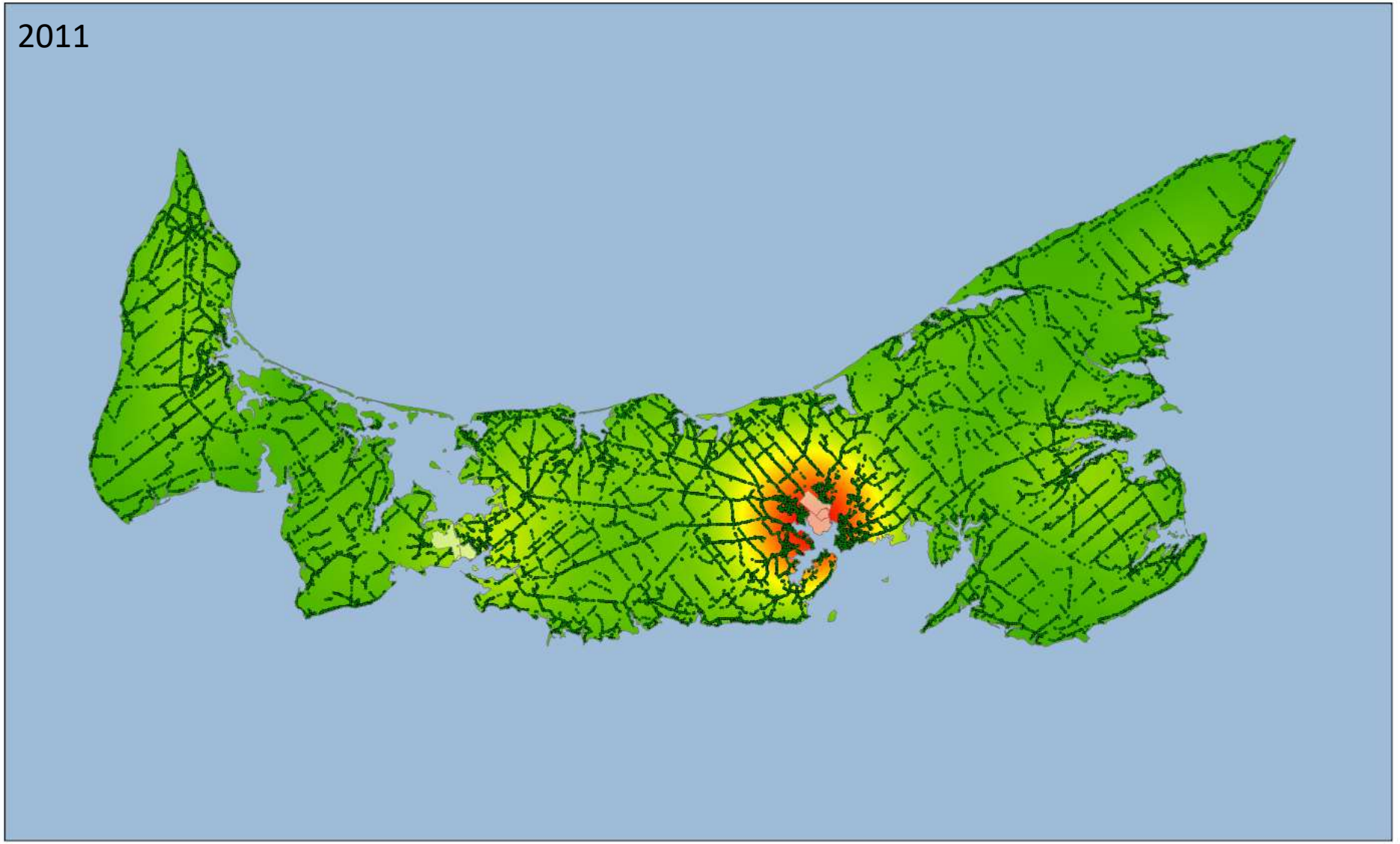
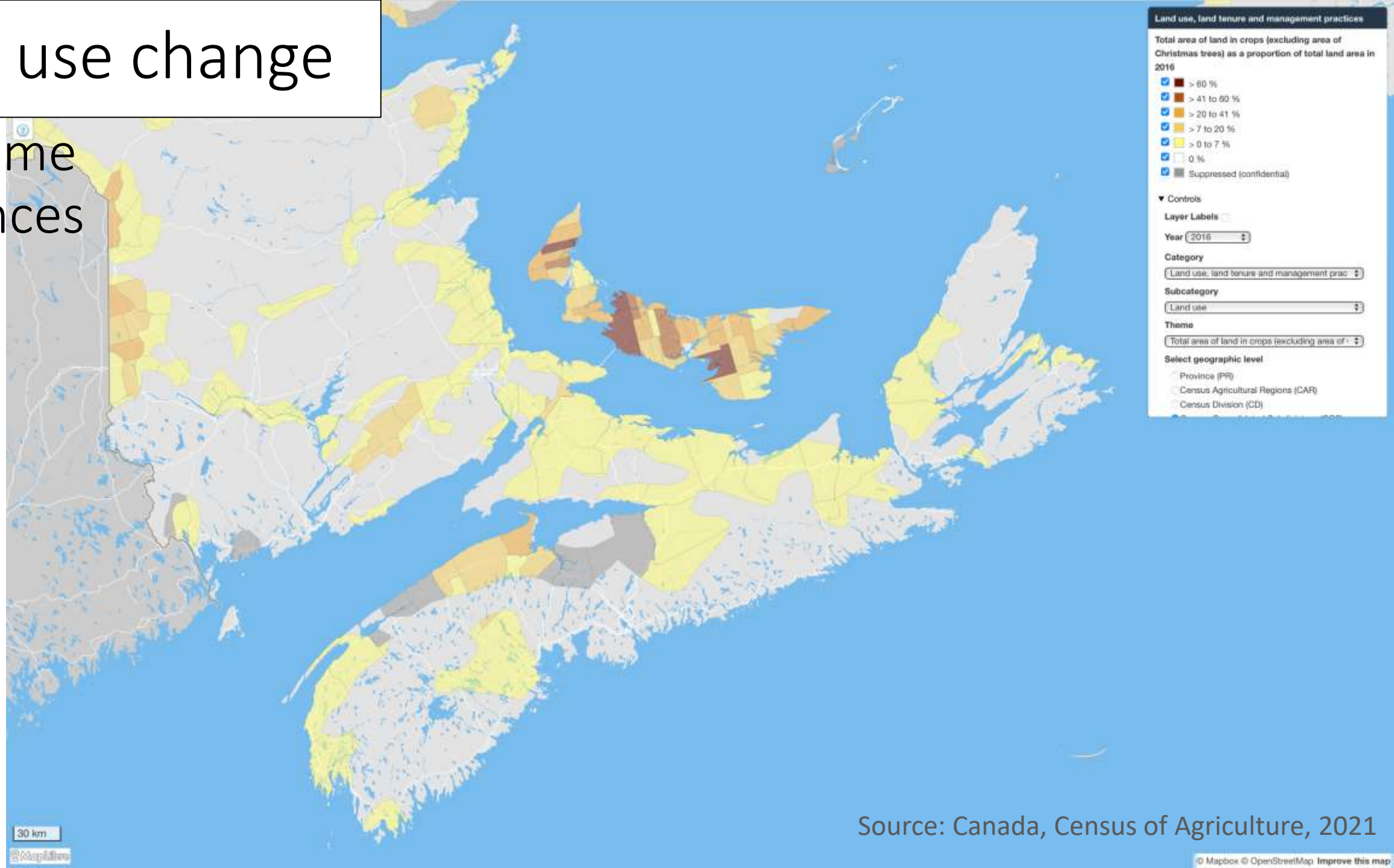


Population growth & urbanization



Land use change

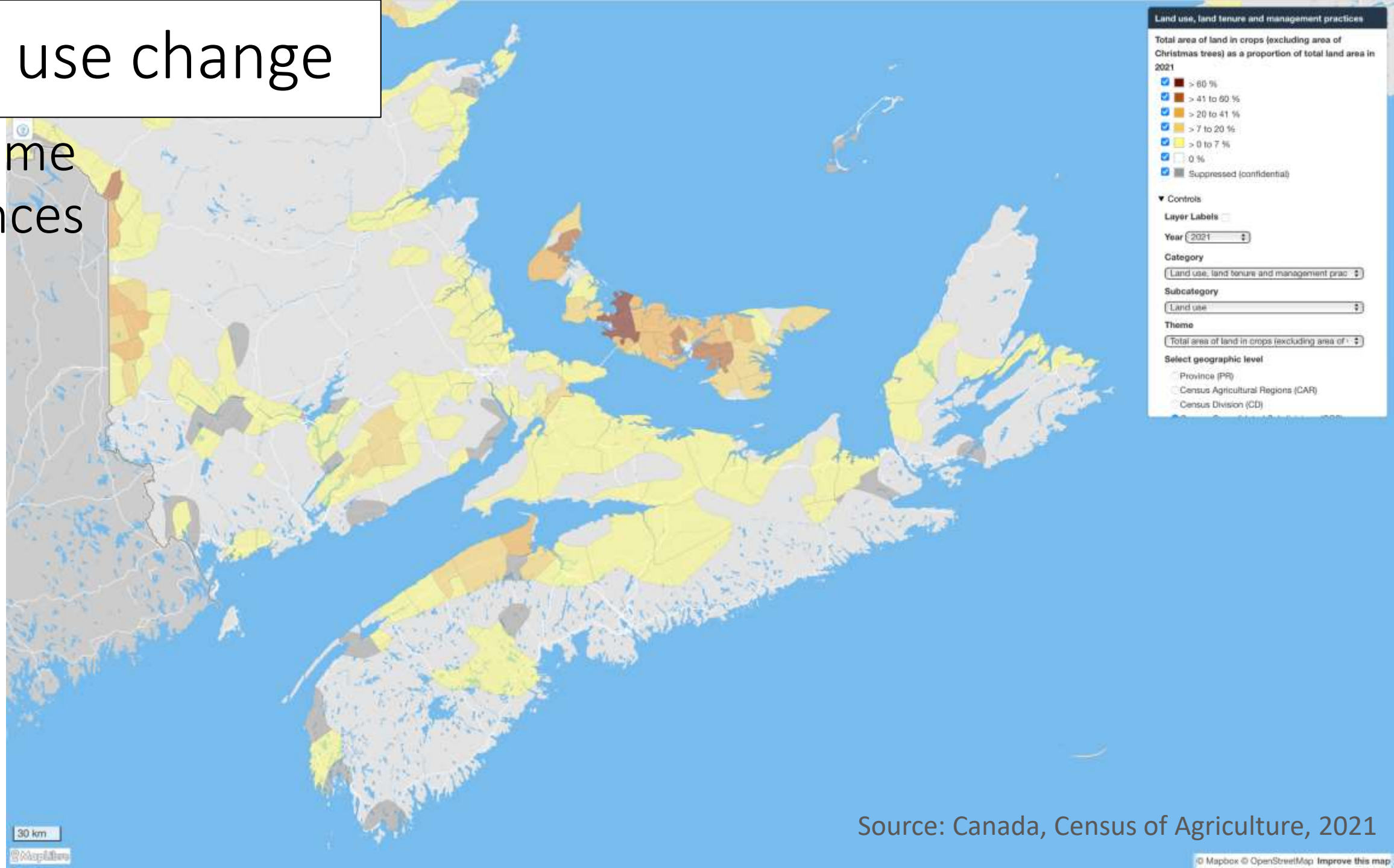
Maritime provinces **2016-** 2021



Source: Canada, Census of Agriculture, 2021

Land use change

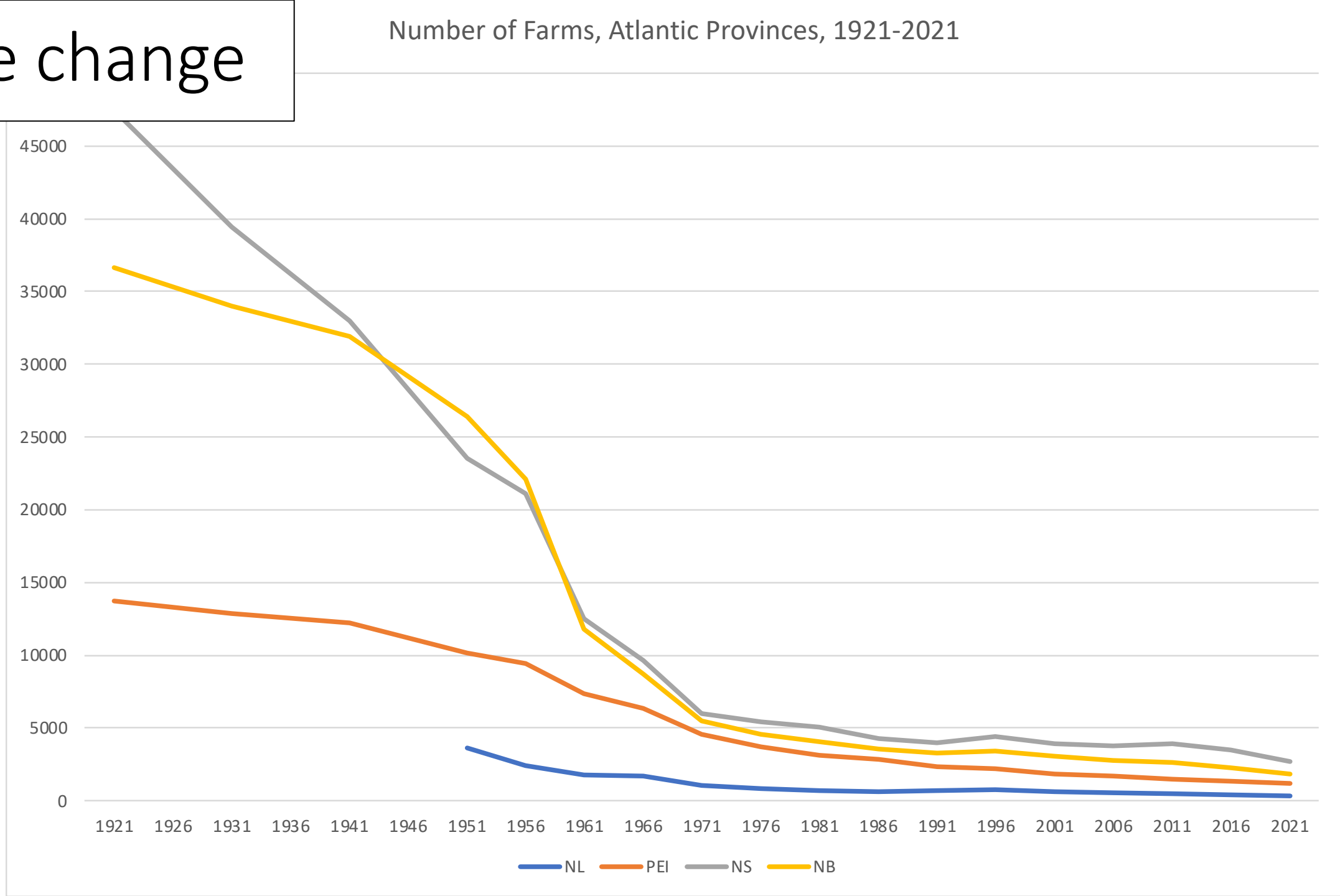
Maritime provinces 2016-**2021**



Source: Canada, Census of Agriculture, 2021

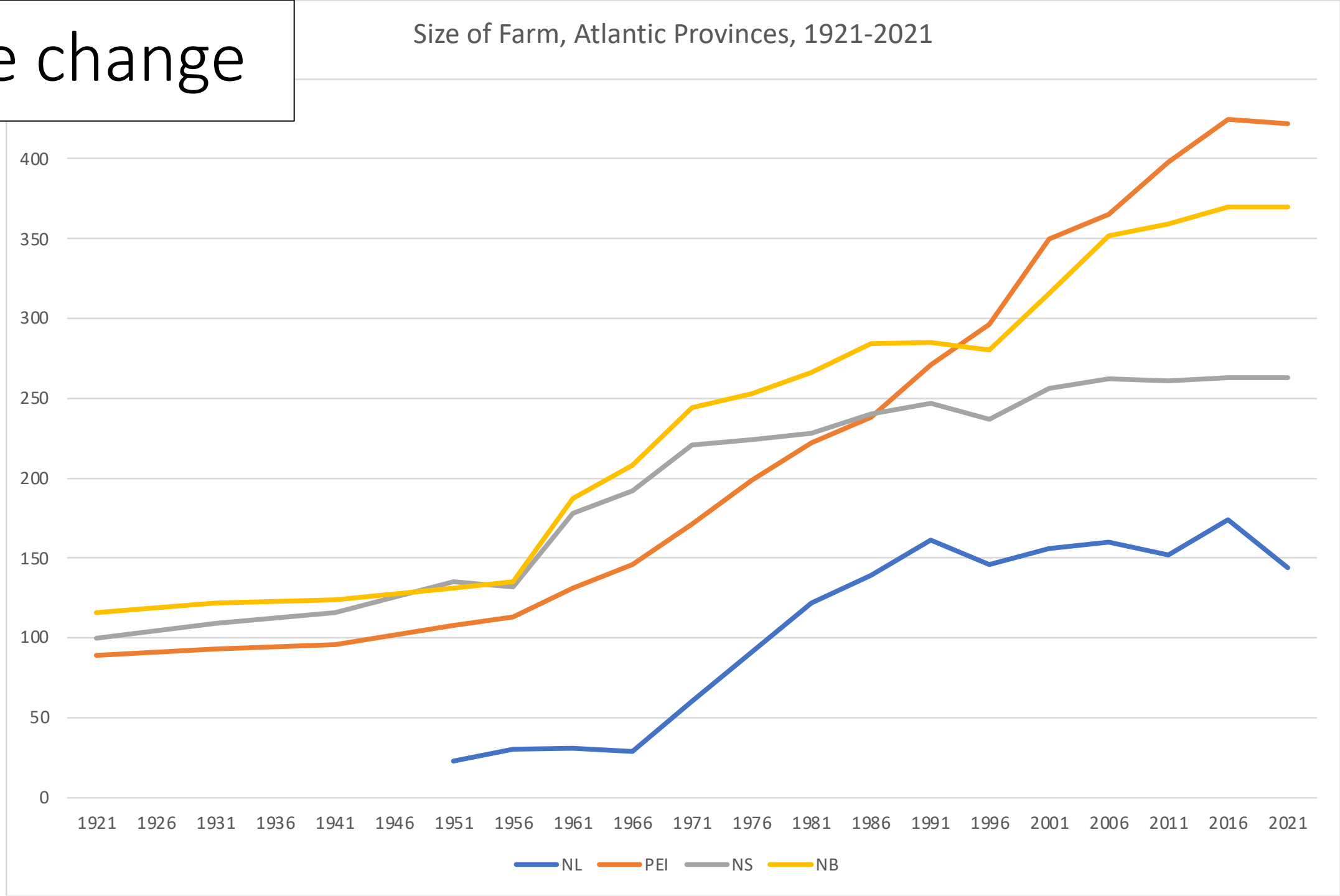
Land use change

Atlantic provinces 1921-2021



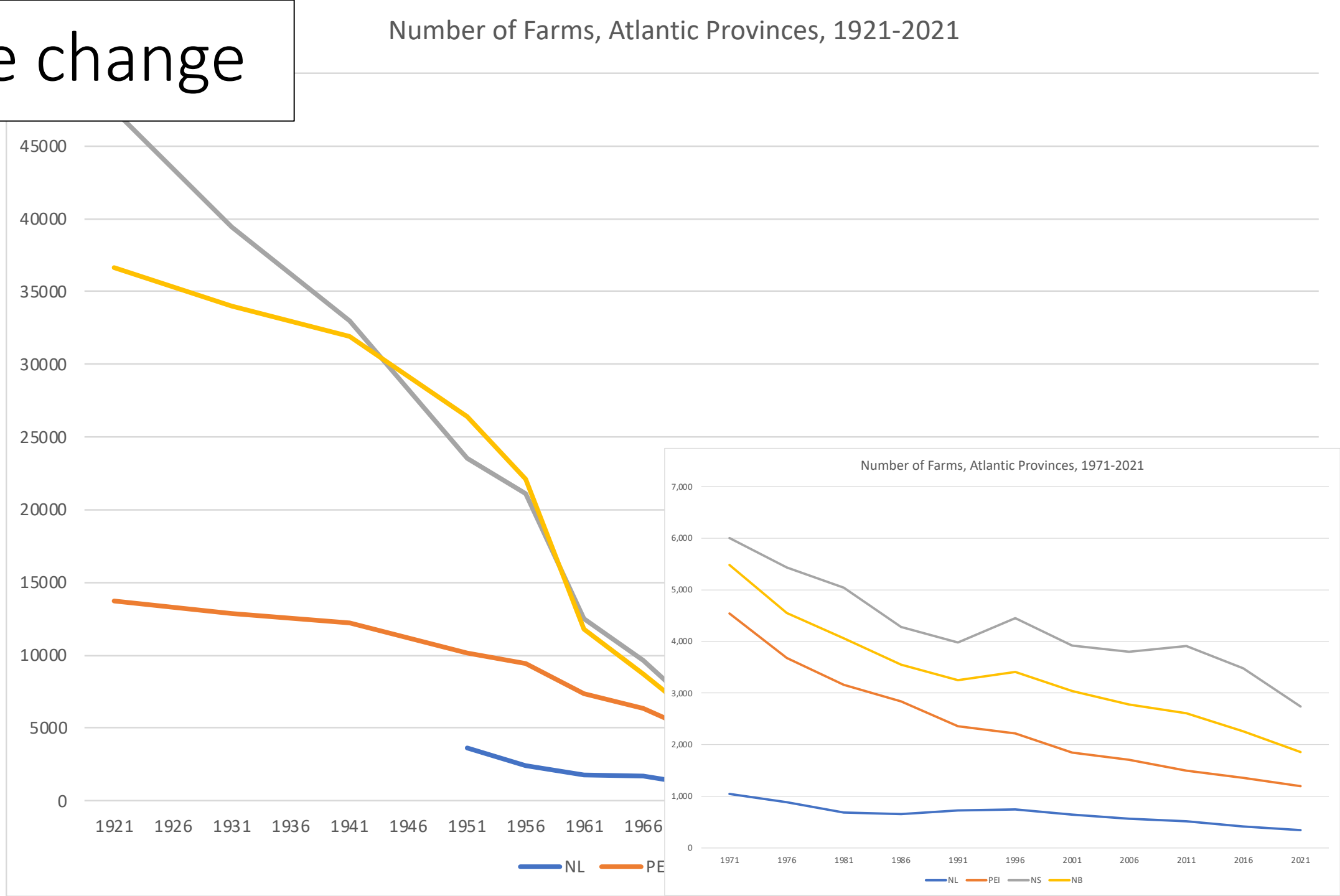
Land use change

Atlantic provinces 1921-2021



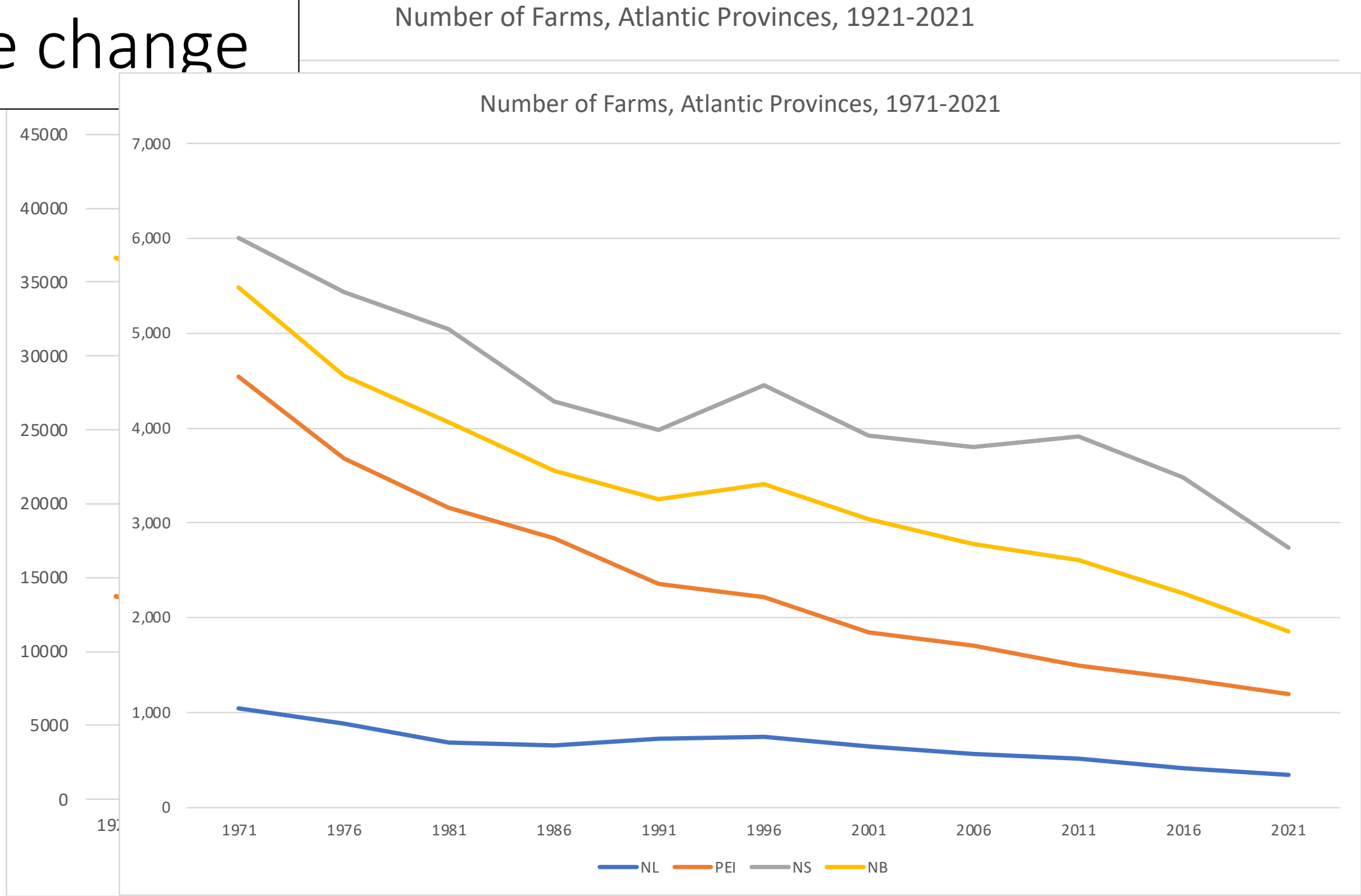
Land use change

Atlantic provinces 1921-2021



Land use change

Atlantic provinces 1971-2021



Sustainable Agriculture and Water Use for Prince Edward Island

NSERC Alliance Grant 2021-2026

PI: Michael Van den Heuvel

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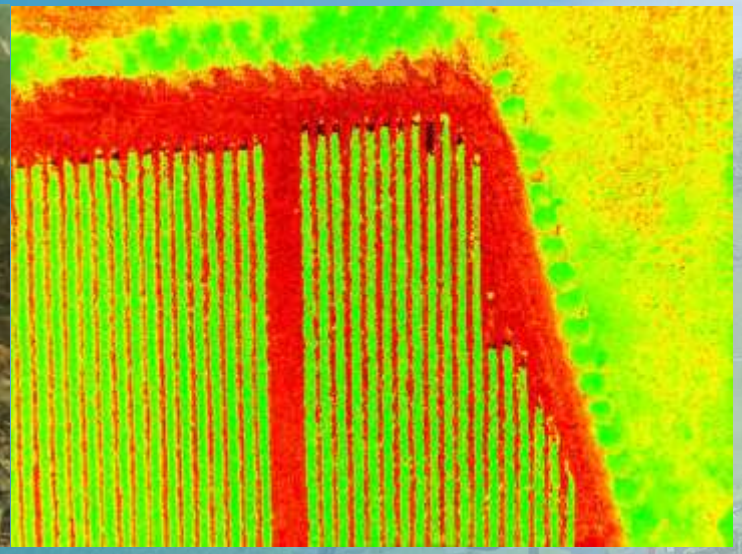
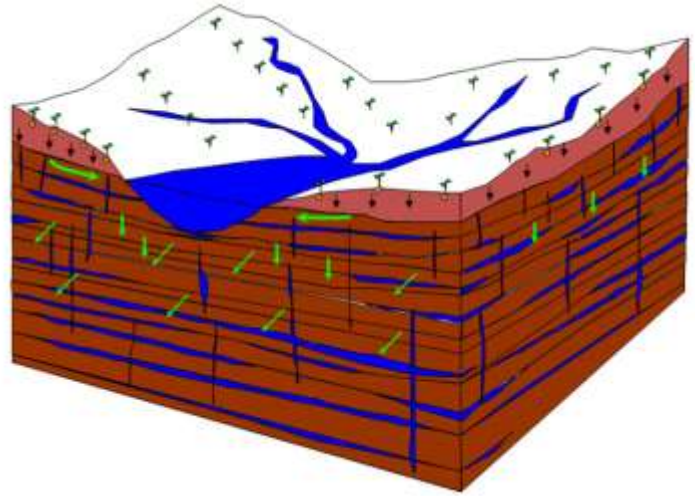




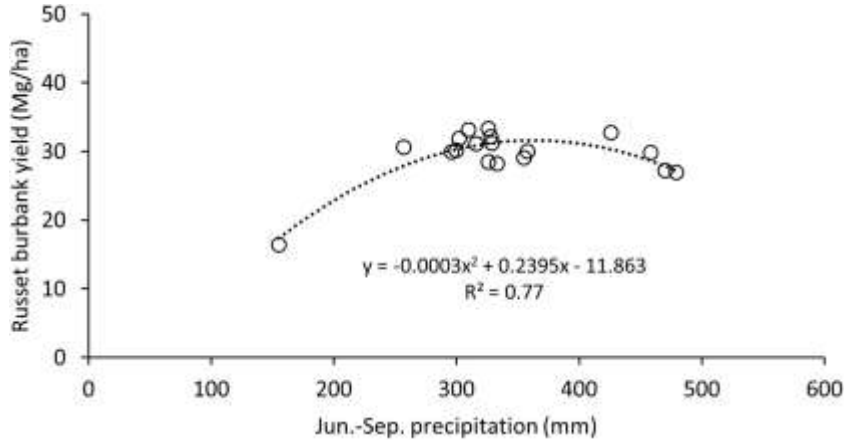
Sustainable Agriculture and Water Use for Prince Edward Island

NSERC Alliance Grant 2021-2026

The goal of the partnership is to quantify and optimize sustainability trade-offs associated with both agriculture and water use to improve environmental, economic, and social outcomes.

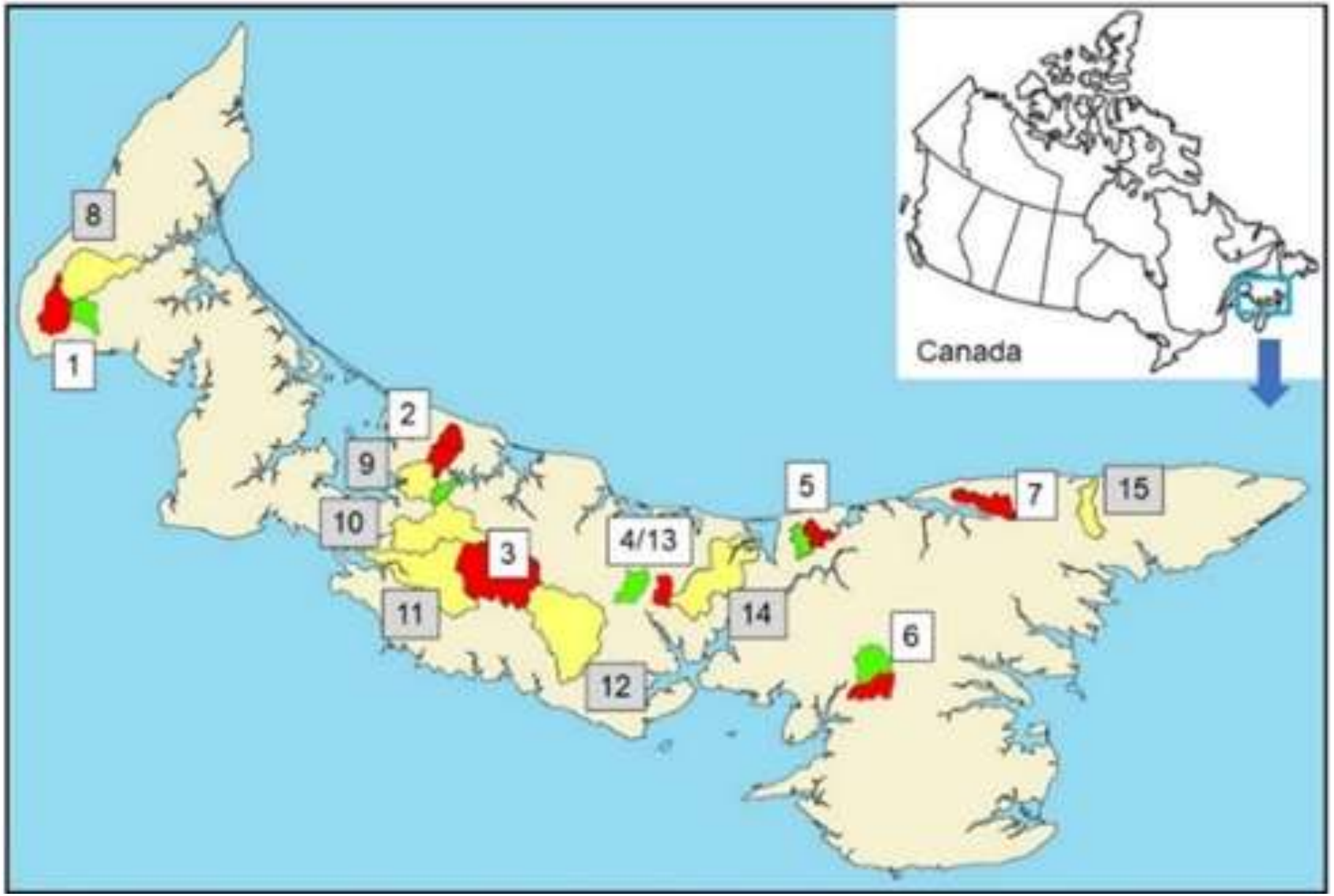
Location/Farm	Primary Water Use	Watershed	Reference Watershed	Irrigated Area (ha)	Extraction (m^3/min)
1. MacLennan Farm	Potatoes	Big Pierre Jacques	Little Pierre Jacques	40	2
2. Arthur Cousins & Sons Inc.	Potatoes	Southwest and Cousins Pond	Tuplin Creek	44	2
3. Country View Farms and Smith Farms	Potatoes	Dunk River subwatershed	Dunk River subwatershed	220	7.3
4. Miltonvale wellfield	Charlottetown water supply	Coles Creek	North River	N/A	3.6–4.8
5. Lawton Produce	Wild blueberries	Desroches Pond E, Savage Harbour	Desroches Pond W	650	5.4
6. Rollo Bay Holdings	Potatoes	Schooner Creek	Schooner Creek	32	2
7. Middelkamp Organic Produce	Beets	Vernon River S	Vernon River N	58	2

Optimal (4 mm/day)
Jiang et al. 2021



Site Selection

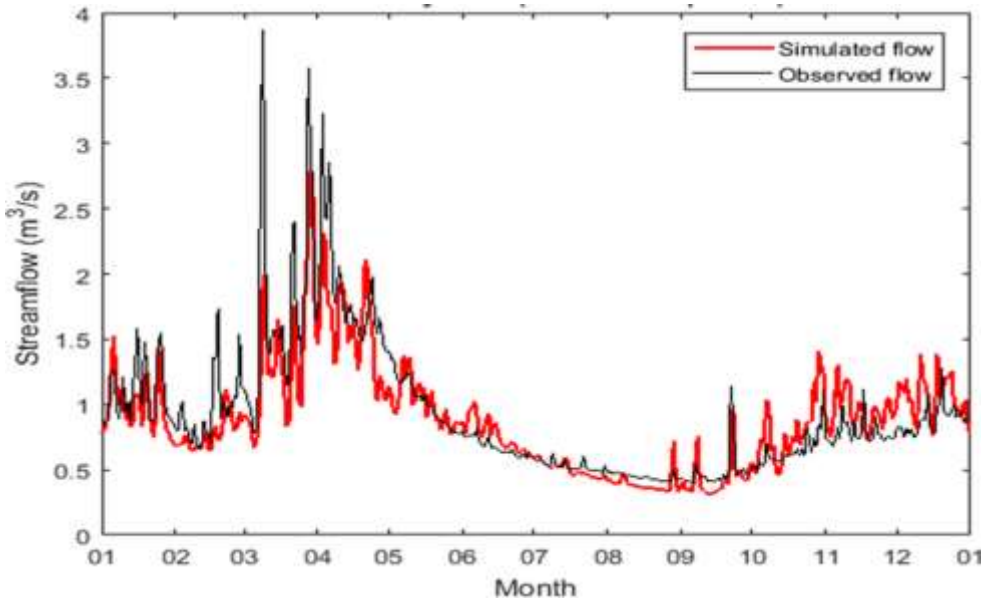
Seven experimental watersheds
Five paired reference (sub)watersheds
ECCC hydrometric station watersheds
Over 25 flow monitoring stations



Objective 1. Environmental Flows and Water Abstraction in a Changing Climate

Overarching Question: What methods should be used to define e-flows in the context of increased water abstraction and climate change?

- Will water extraction cause a decrease in the frequency of flows below the 70Q50?
- Will climate change influence on flow and temperature be consistent across PEI?
- Is the 70Q50 protective of stream biodiversity?
- How will habitat change with flow reduction?



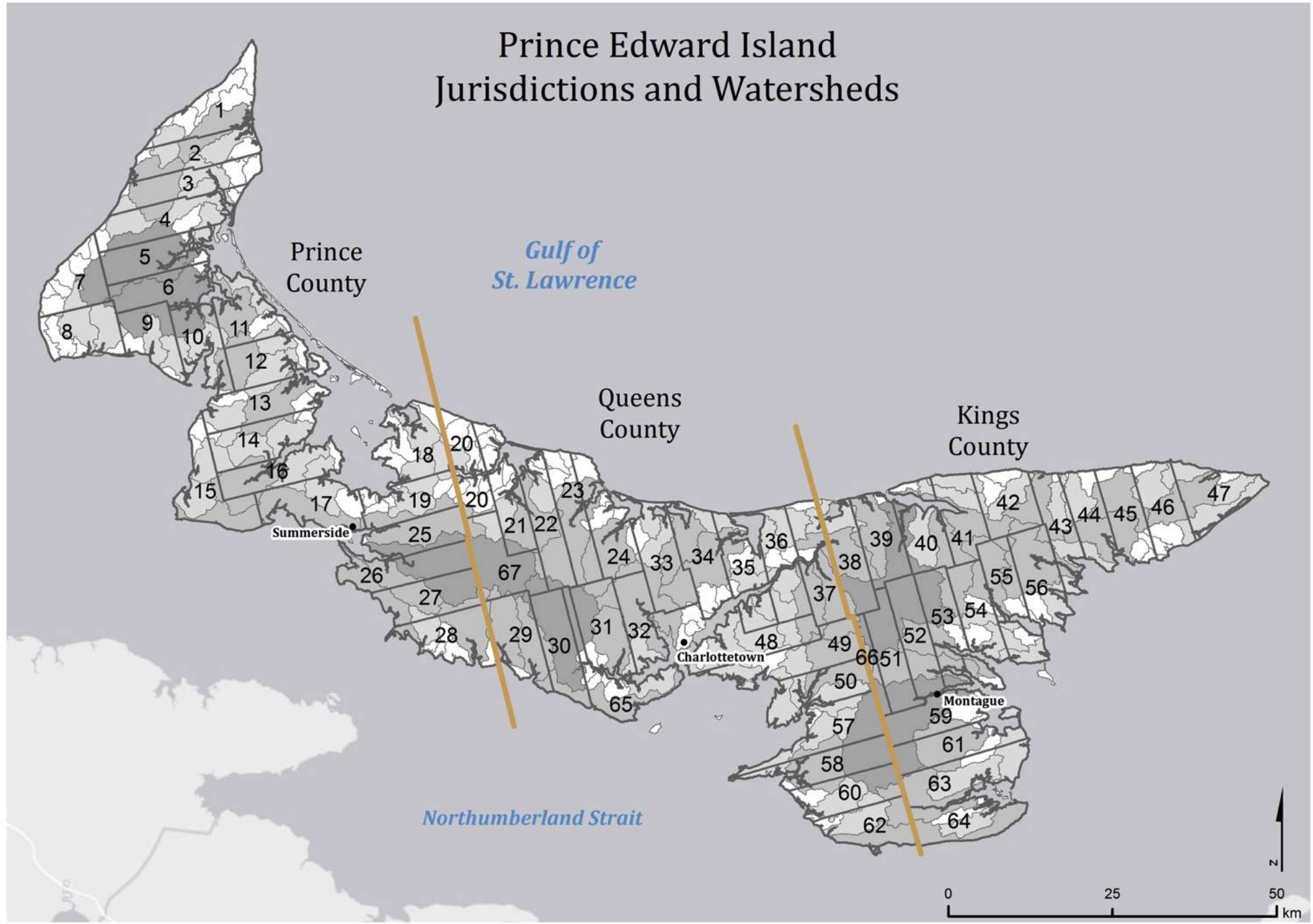
Objective 5. Evaluating Sustainability Decision Making and Trade-offs

Overarching Question: How do we best quantify the sustainability trade-offs given the range of economic, social, and environmental variables examined in decisions about water use?

- Has a consistent approach been adopted in e-flows decision making across Canada?
- Does supplemental irrigation provide additional financial benefits?
- Does the PEI Water Act facilitate an approach to sustainability incorporating trade-offs and offsets?
- Do the conditions for cooperation exist among PEI water users that will reduce the need to enforcement of trade-offs and offsets?
- Will sustainability trade-offs either due to cooperation or regulatory instruments improve ecosystem services and economic viability?
- Will the quantity and quality of stakeholder engagement be improved through participatory research in the use of groundwater?

"Ruin is the destination towards all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons"

"People can govern themselves through common pool resources regimes"


Prince Edward Island
Jurisdictions and Watersheds
Prince County
Queens County
Kings County
Gulf of St. Lawrence
Northumberland Strait
Summerside
Charlottetown
Montague
1
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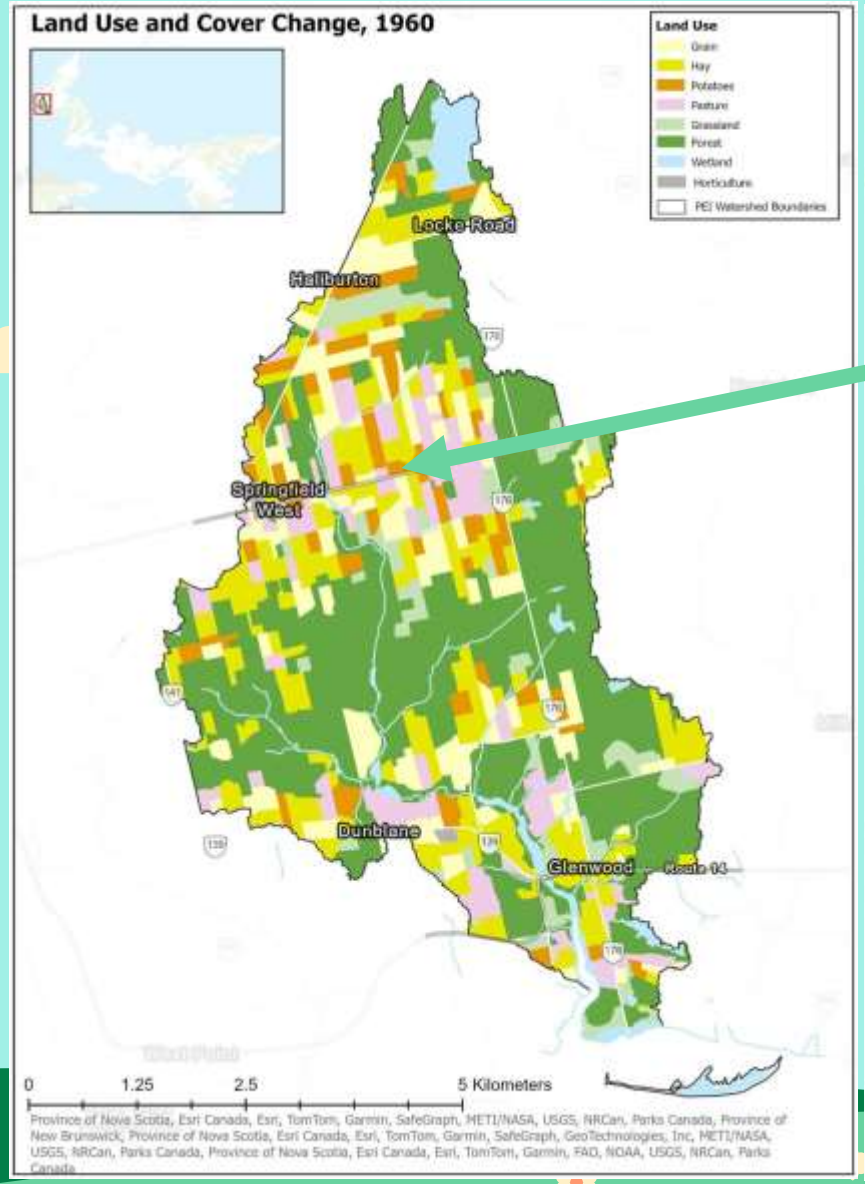
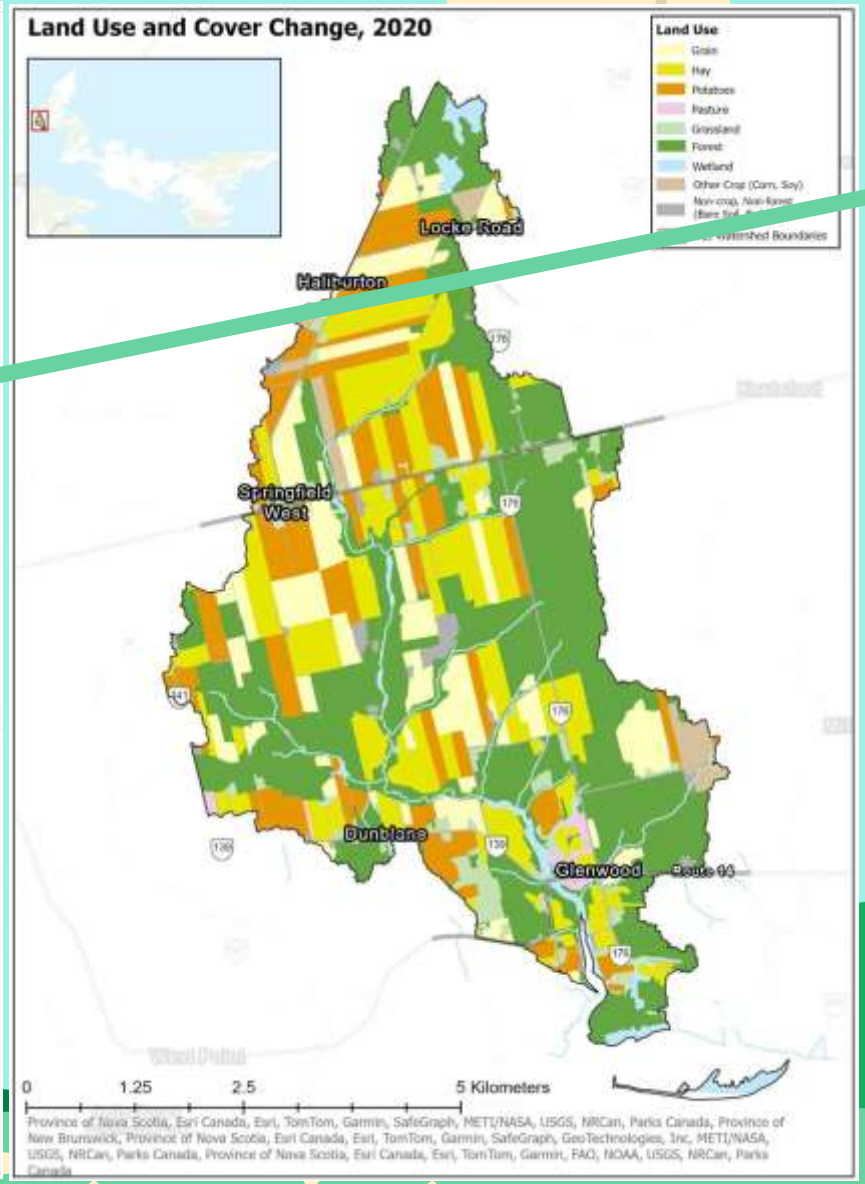
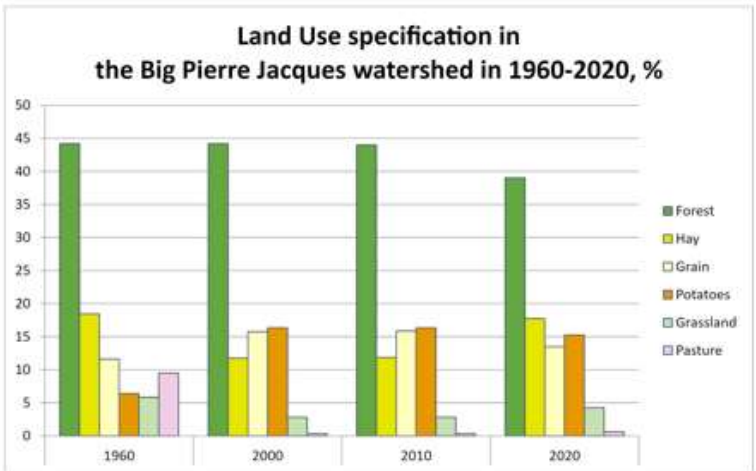
Field of Change





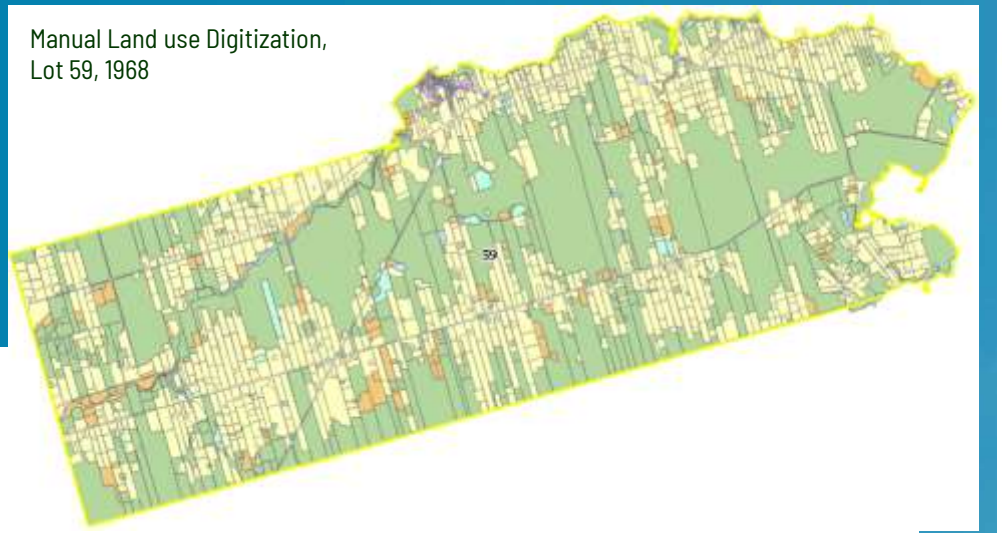
Example farm

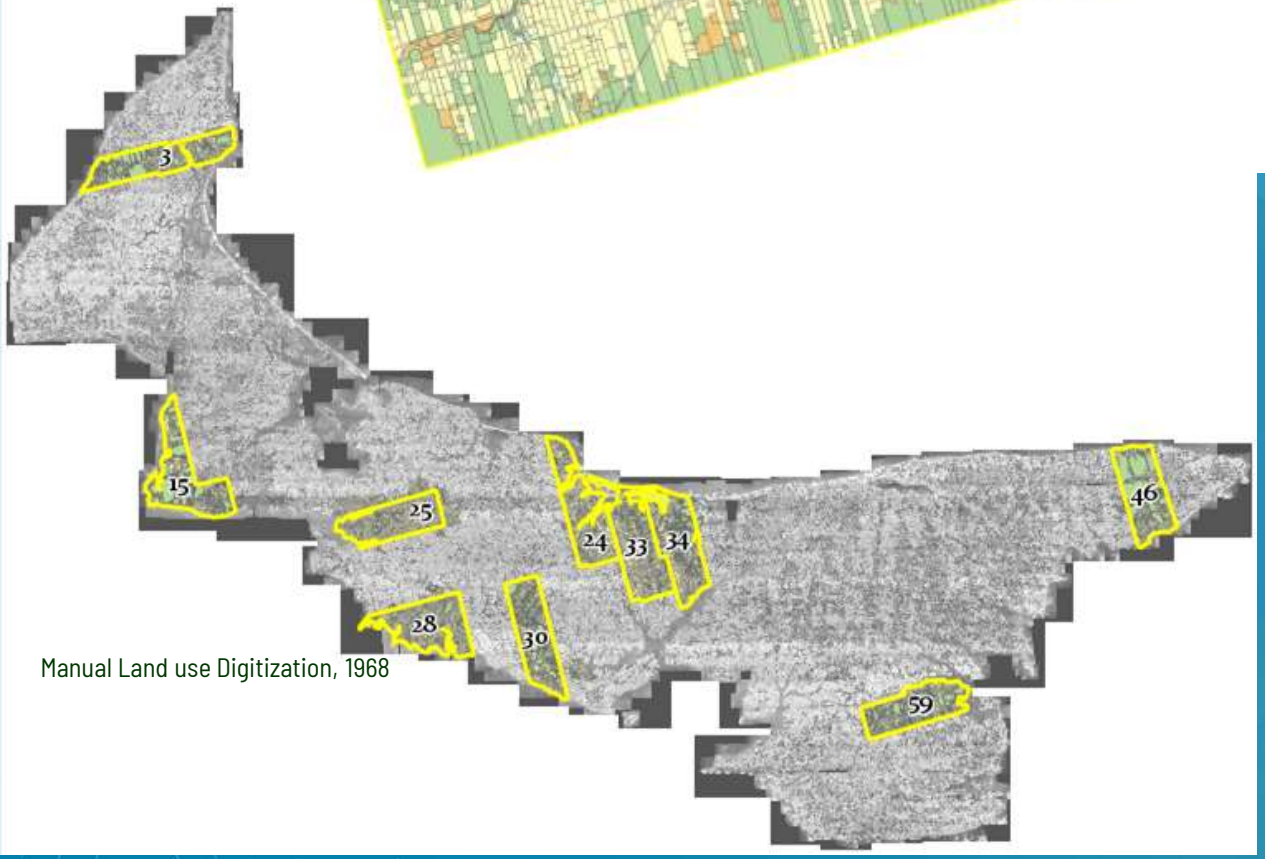


	1960		2000		2010		2020	
	Hectars	%	Hectars	%	Hectars	%	Hectars	%
Forest	1455.8	43.1	1534.6	44.2	1526.9	44.0	1355.9	39.0
Hay	627.0	18.5	408.5	11.8	412.4	11.9	616.1	17.7
Grain	425.3	12.6	546.7	15.7	550.5	15.9	468.6	13.5
Potatoes	246.0	7.3	567.4	16.3	567.5	16.3	529.8	15.3
Pasture	311.6	9.2	11.6	0.3	11.6	0.3	21.5	0.6
Grassland	202.2	5.9	98.4	2.8	98.4	2.8	148.4	4.3

Digitizing Landscapes

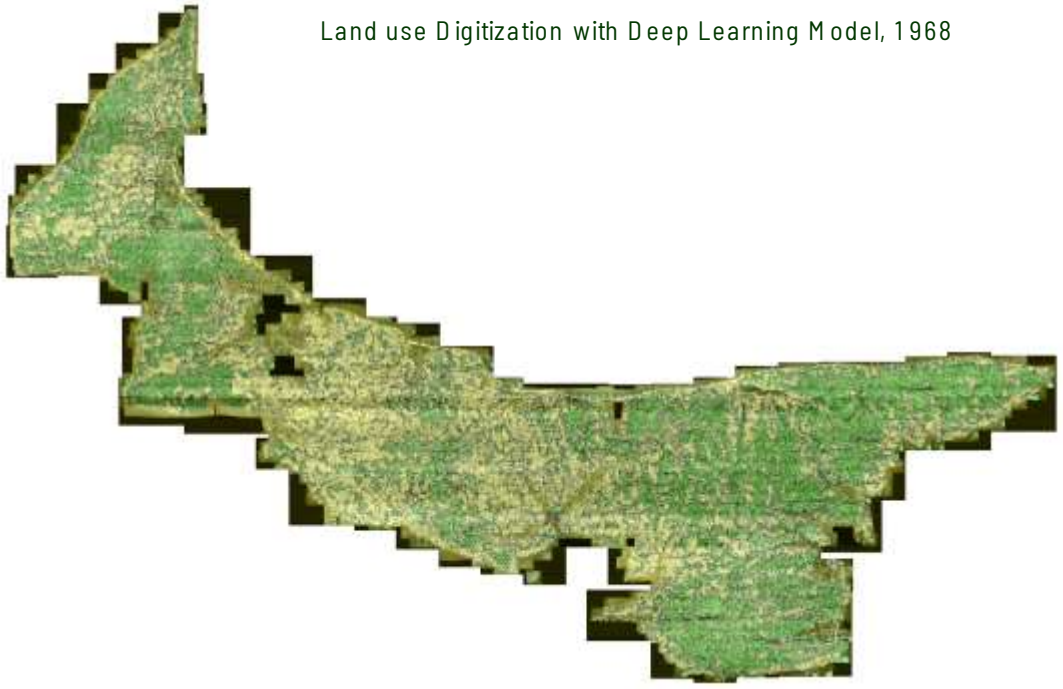
Manual Land use Digitization,
Lot 59, 1968



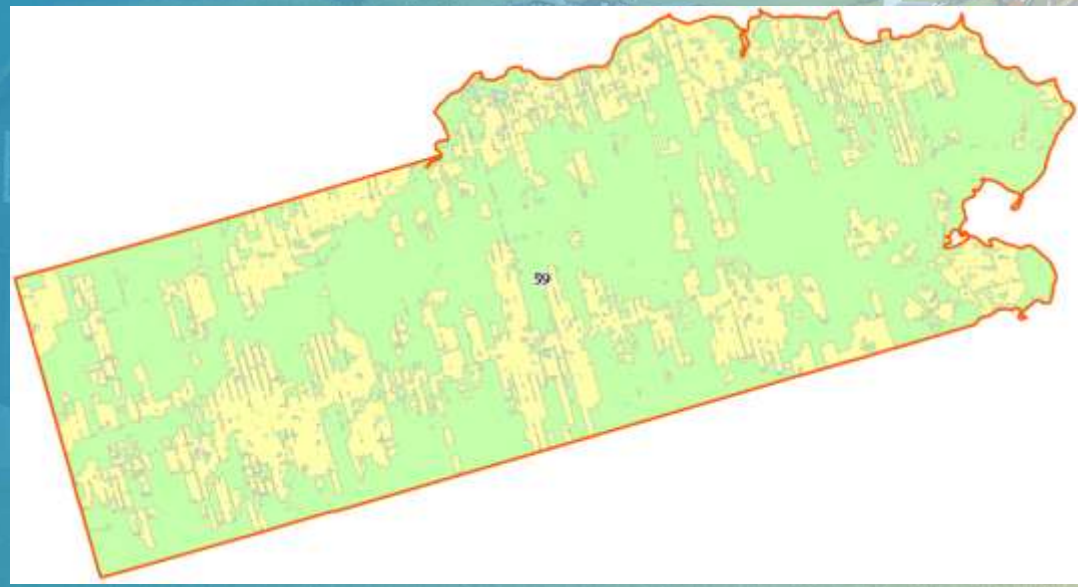


Manual Land use Digitization, 1968

Land use Digitization with Deep Learning Model, 1968



Land use Digitization with Deep Learning Model,
Lot 59, 1968



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