

A social-ecological geography of southern Canadian lakes





My role: quantify lake ecosystem services and put their vulnerability to threats in a biophysical and geographic context

Importance of lakes (in Canada)

- Provide a wide variety of ecosystem services (ES) threatened by land use and climate change

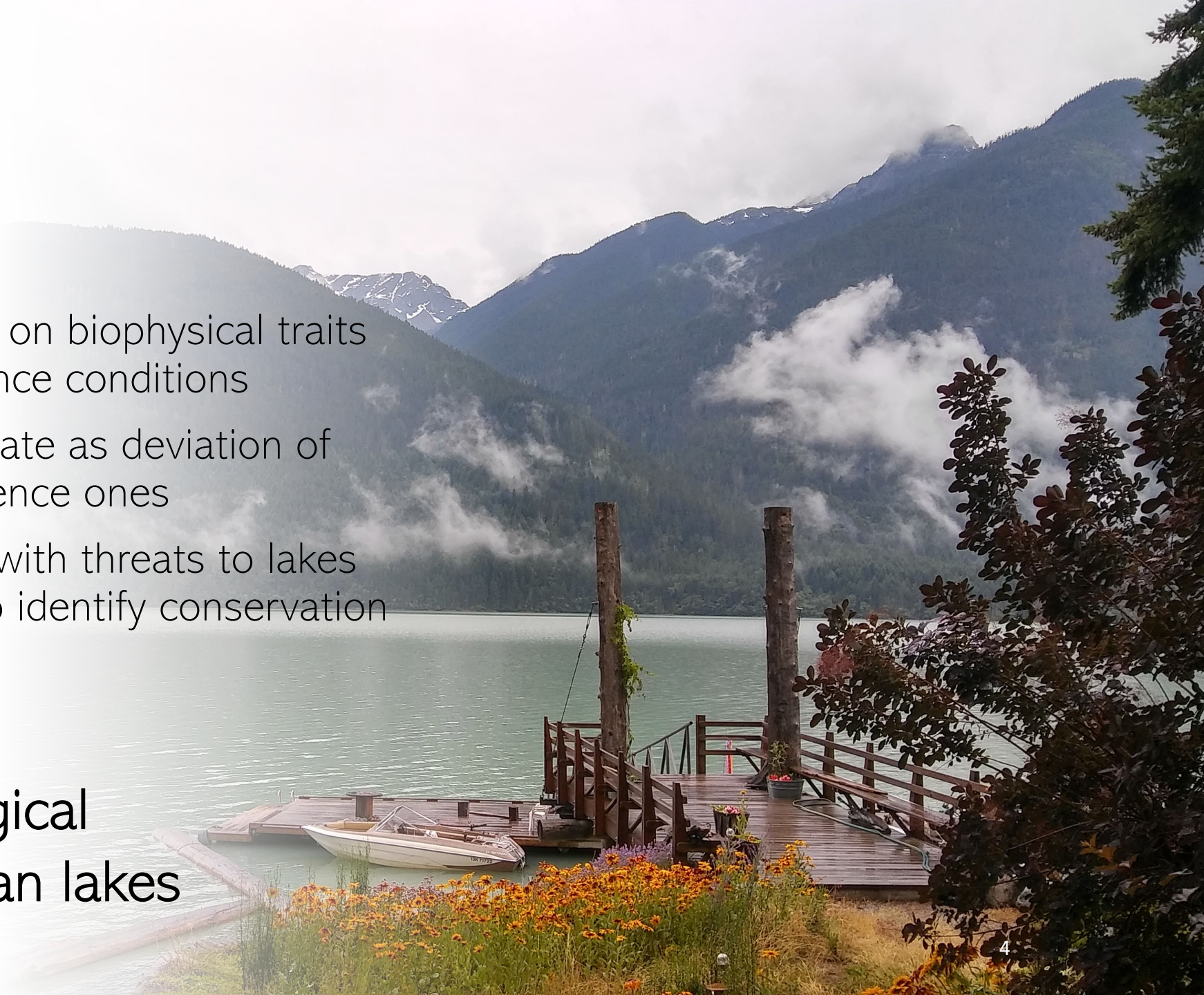


- Urgent need to protect lakes and the ES they provide
- The capacity to buffer human pressures is related to the biophysical features of a lake
- Ecological state must be considered within a regional context

Objectives

1. Create lake regions based on biophysical traits and determine lake reference conditions
2. Quantify ecological lake state as deviation of impacted lakes from reference ones
3. Combine ecological state with threats to lakes and recreational ES use to identify conservation priorities

First social-ecological
geography of Canadian lakes

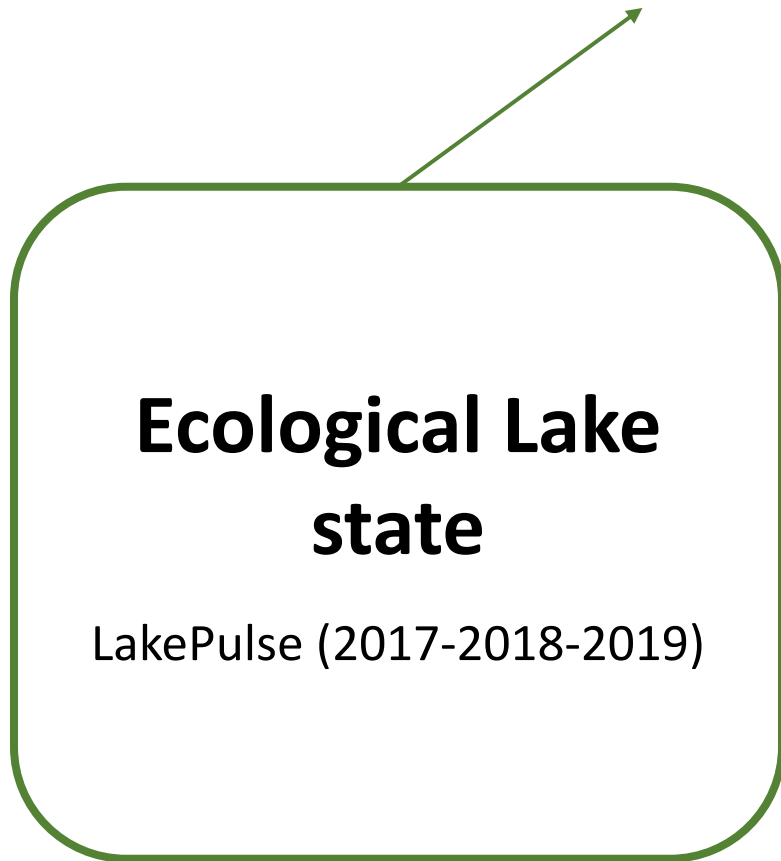


Methods

- 3 aspects = 3 datasets

Ecological

Social



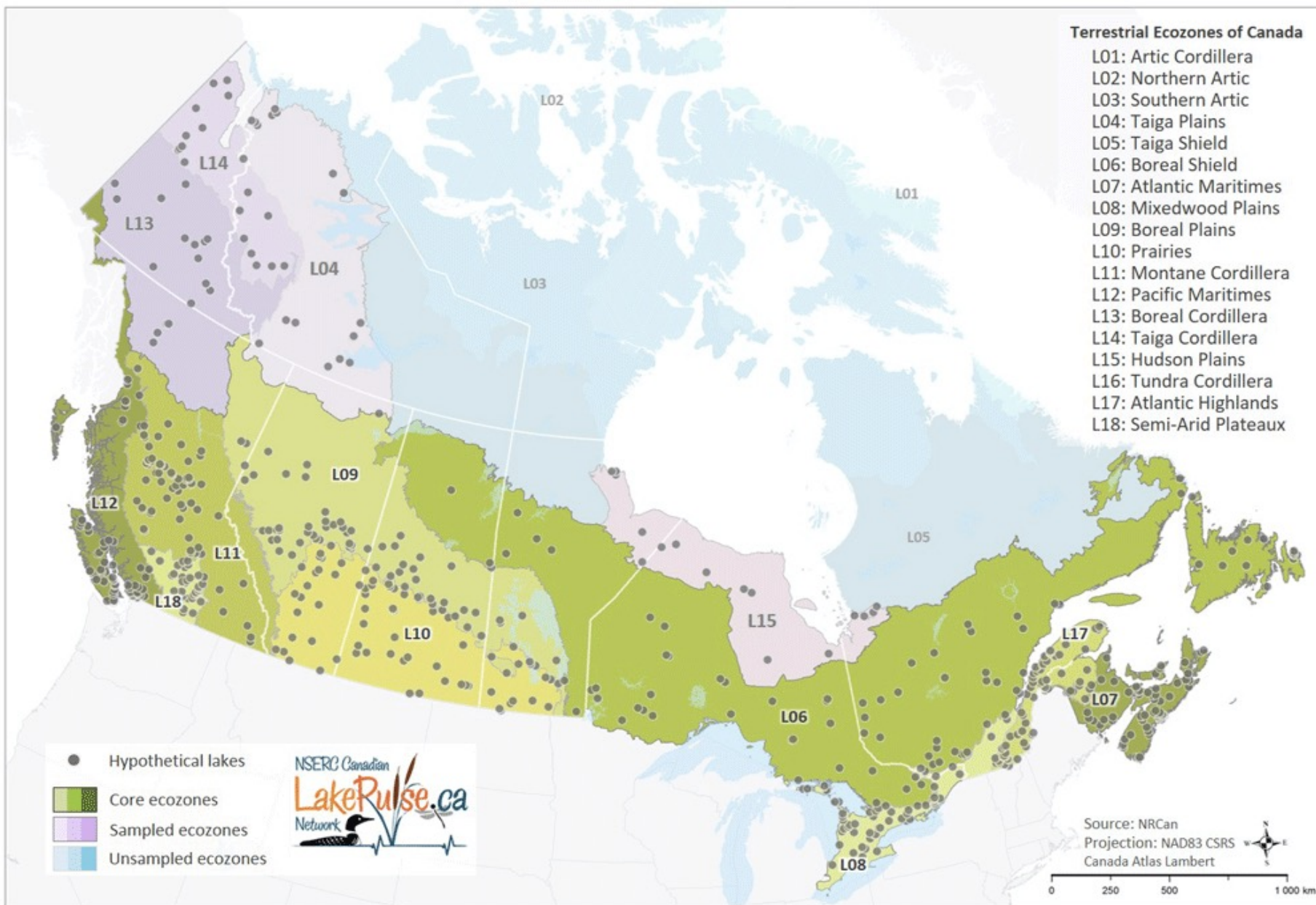
Ecological State of Canadian Lakes



Ecological State

- Lack of harmonized information on the status of lakes across Canada
- Lake Pulse Strategic Network intended to help fill that gap





Écozones échantillonnées par LakePulse (12/18)

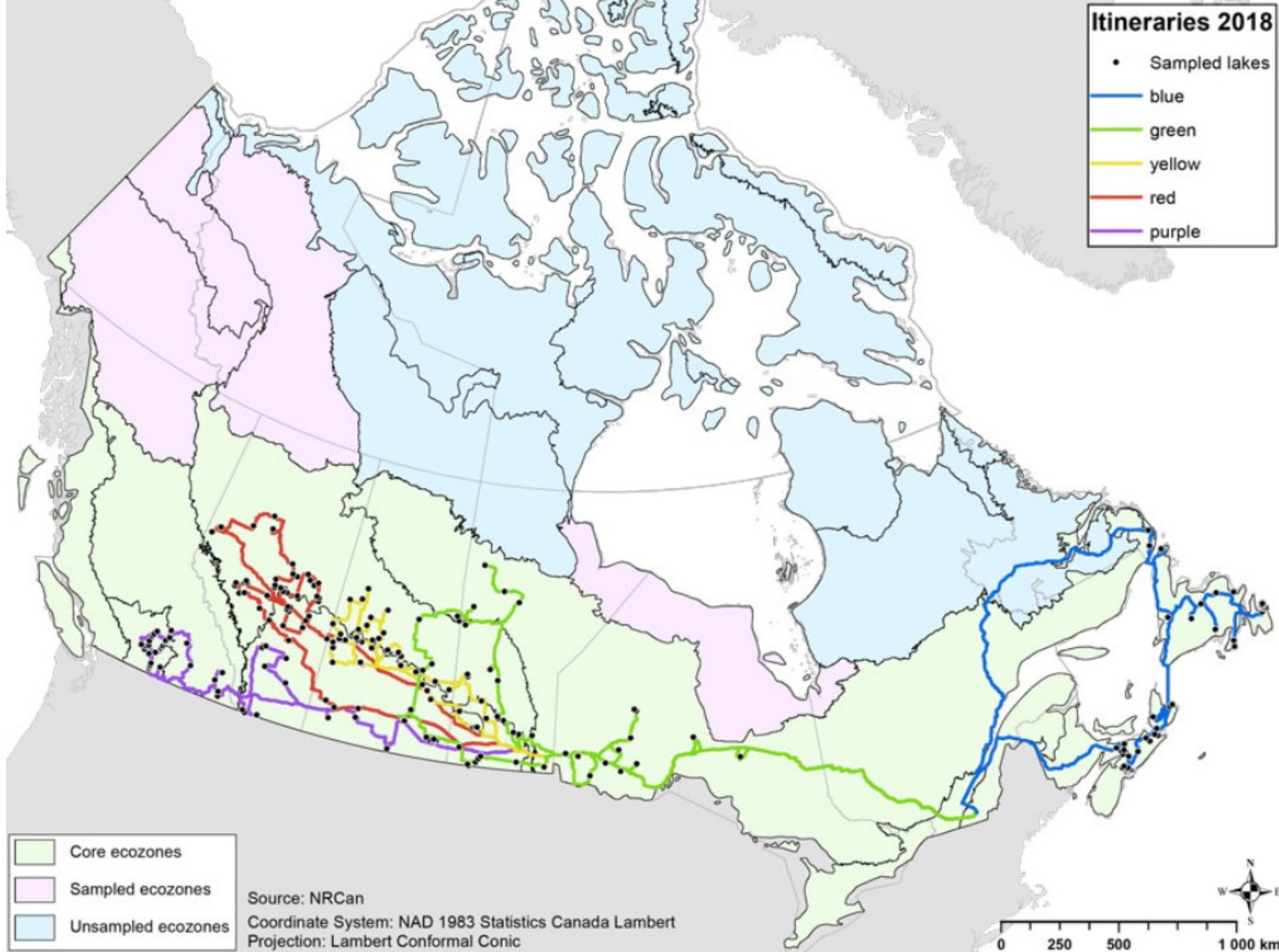
- 04 - Taïga des plaines
- 06 - Bouclier boréal
- 07 - Maritime de l'Atlantique
- 08 - Plaines à forêts mixtes
- 09 - Plaines boréales
- 10 - Prairies
- 11 - Cordillère montagnarde
- 12 - Maritime du Pacifique
- 13 - Cordillère boréale
- 14 - Taïga de la Cordillère
- 17 - Hautes-terres de l'Atlantique
- 18 - Plateaux semi-arides

15 – Plaines de Hudson

Représentation cartographique des écozones où des lacs ont été échantillonnés par le réseau LakePulse. Les 9 écozones en vert représentent les écozones principales, les 4 écozones en violet sont les écozones nordiques où certains lacs ont été échantillonnés. La région en bleu regroupe les 5 écozones qui n'ont pas été visitées (LakePulse, 2017).

Complicated logistics...





Variables used here

Chimiques

Productivité : TN, TP, chl *a*, secchi

Géologie et ions : Chlorure, pH, conductance

Apport de carbone : DOC, CDOM-Abs

Morphométriques

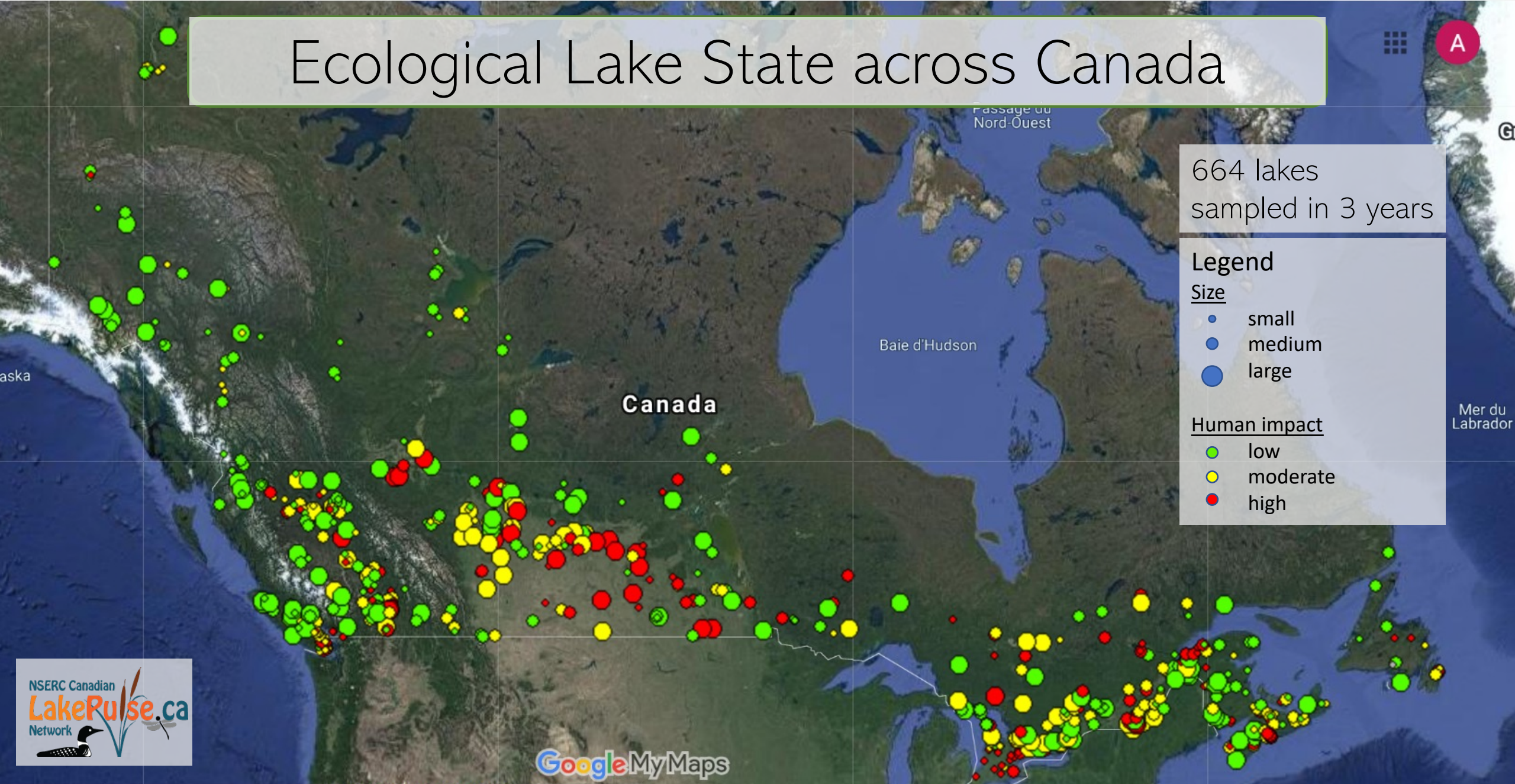
Forme du lac : Superficie du lac, profondeur moyenne, volume d'eau, ratio dynamique

Bassin versant et topographie : Pente moyenne, altitude, ratio de drainage

Indice d'impact humain

- Faible
- Modéré
- Élevé

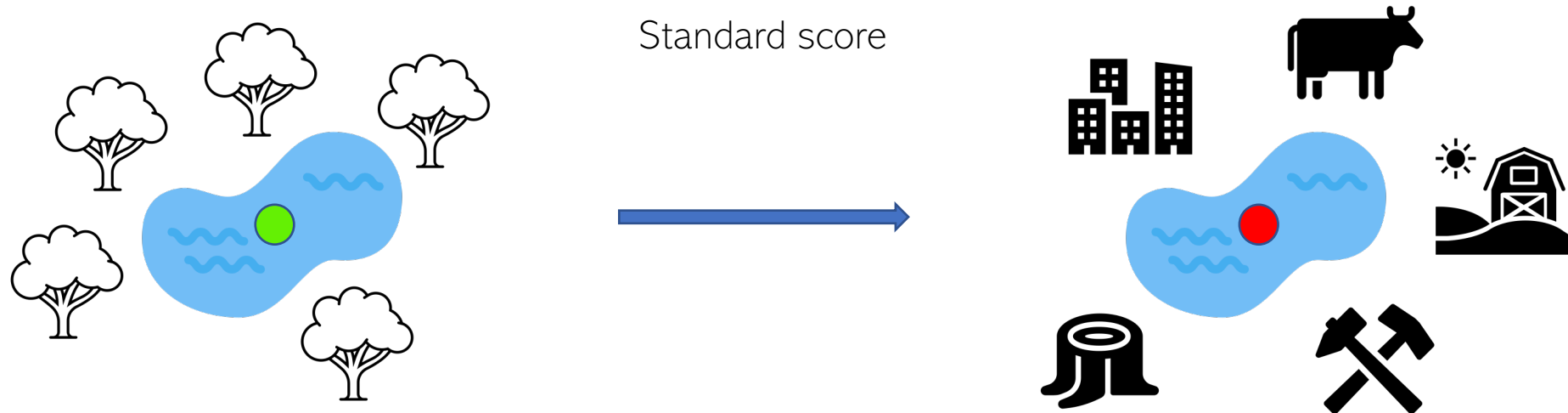
Ecological Lake State across Canada



Distribution of the lakes sampled by the LakePulse network. The size of the dots represents the size class to which the lake belongs (small, medium or large). The color of the dot indicates the human impact index (green=low, yellow=moderate, red=high) (LakePulse, 2019).

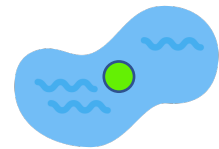
Ecological state

- Lake ecological state : Level of deviation from reference conditions specific to its region
 1. Define **regional** reference condition (natural)
 2. Calculate the deviation of impacted lakes from their **regional** reference condition



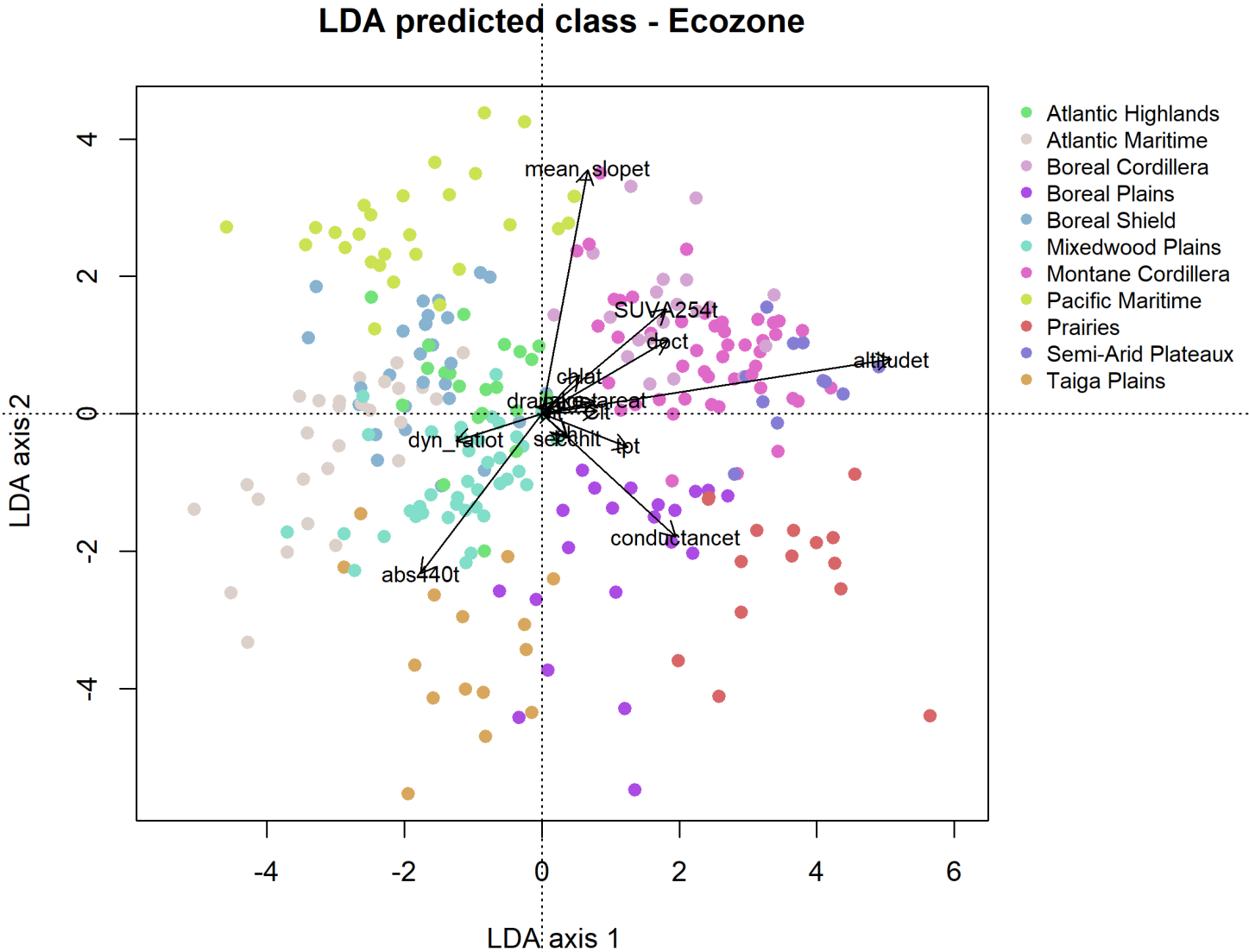
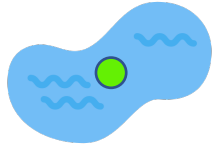
Analyse linéaire discriminante

Si on classifie les lacs selon leur écozone, à quel point les variables chimiques et morphométriques expliquent-elles bien ces groupements?

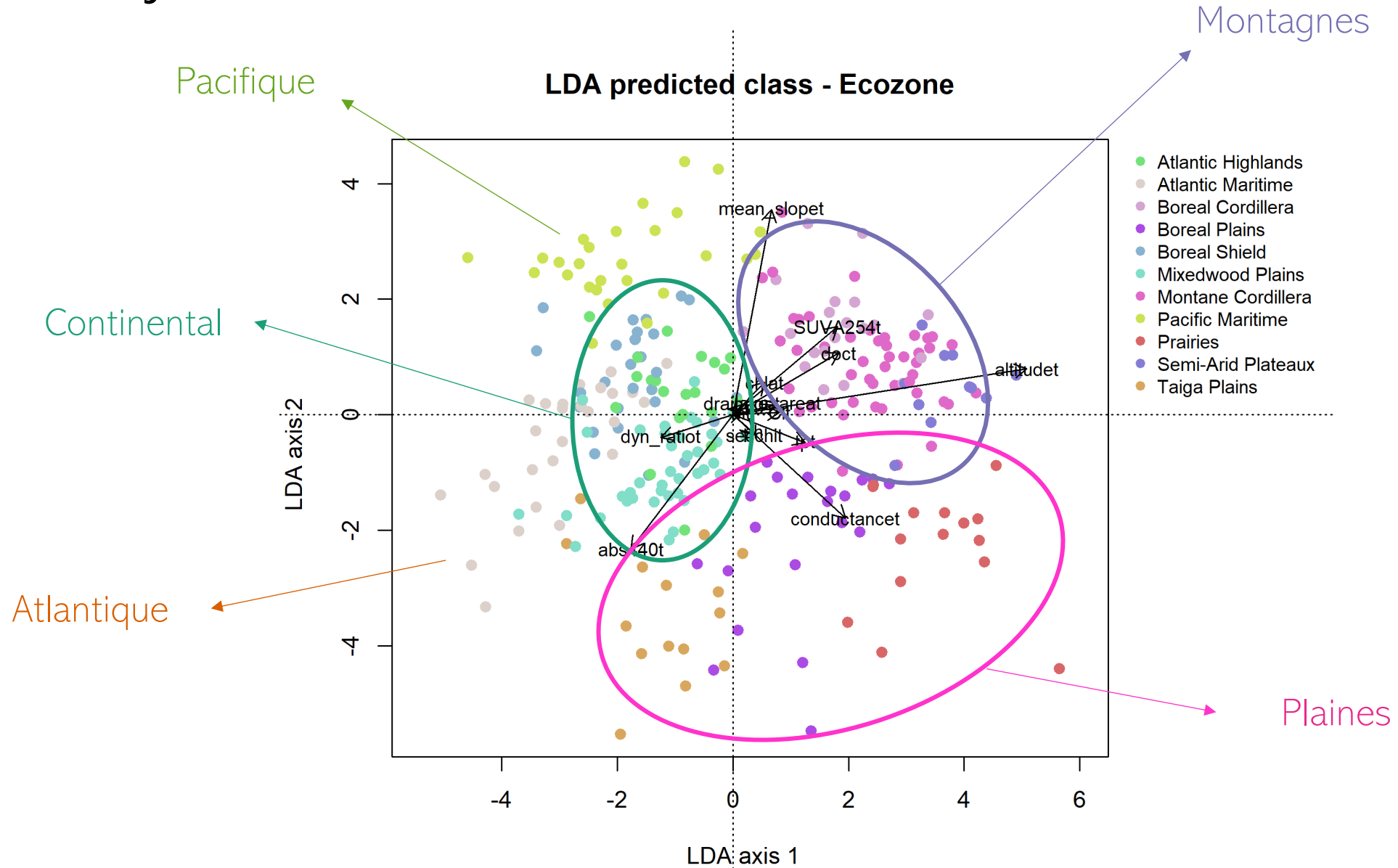
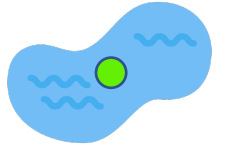


= caractéristiques de référence

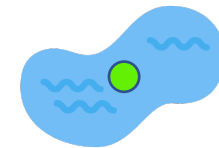
Analyse linéaire discriminante



Analyse linéaire discriminante



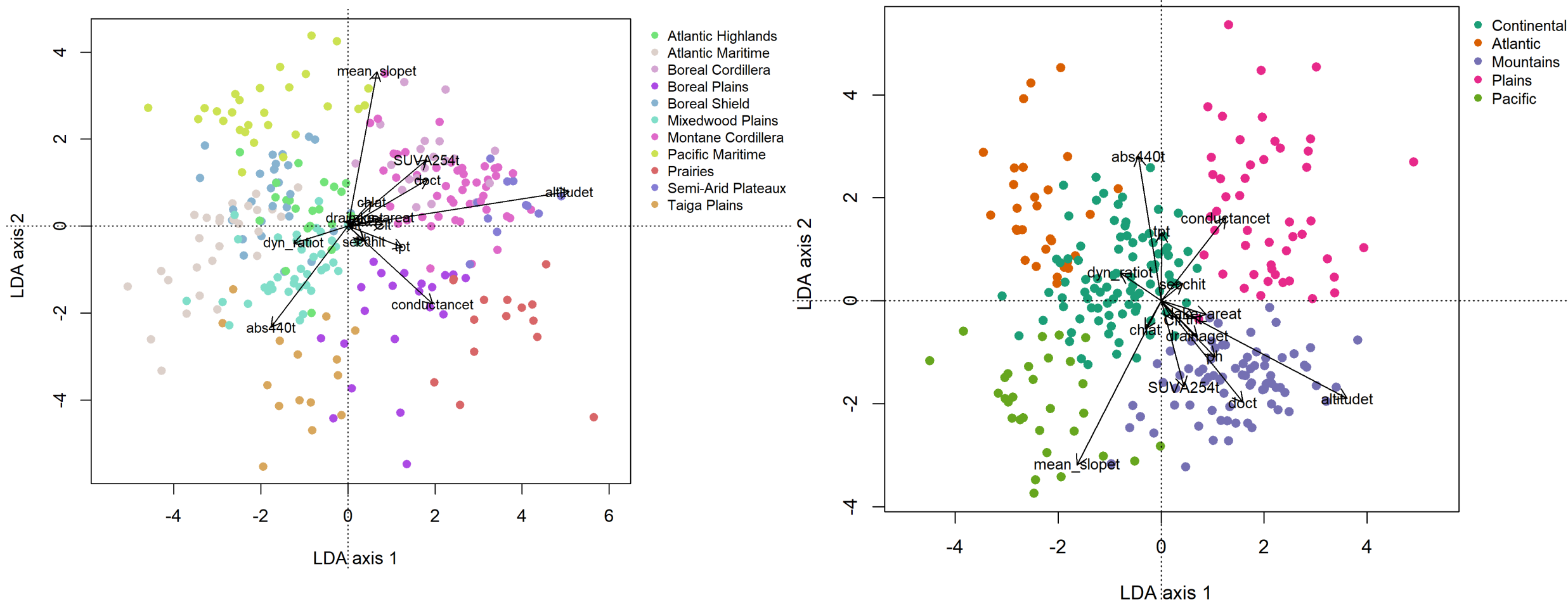
LDA = Linear discriminant analysis



Define appropriate lake divisions for Canada

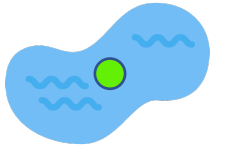
ECOZONE

LAKE REGION

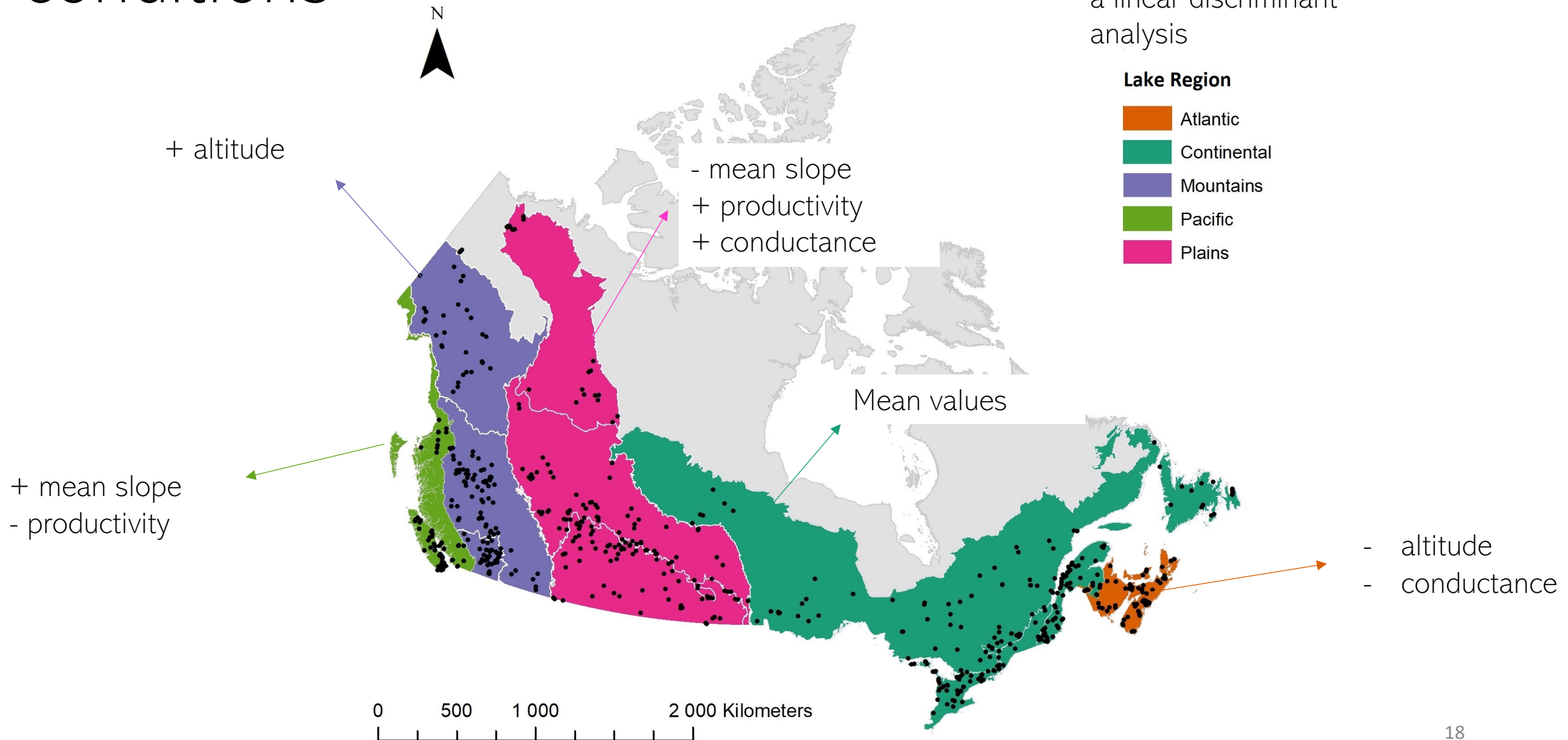


Proportion of correct classification on average : 73% (ecozone) vs 85% (lake region)

1. Regional reference conditions

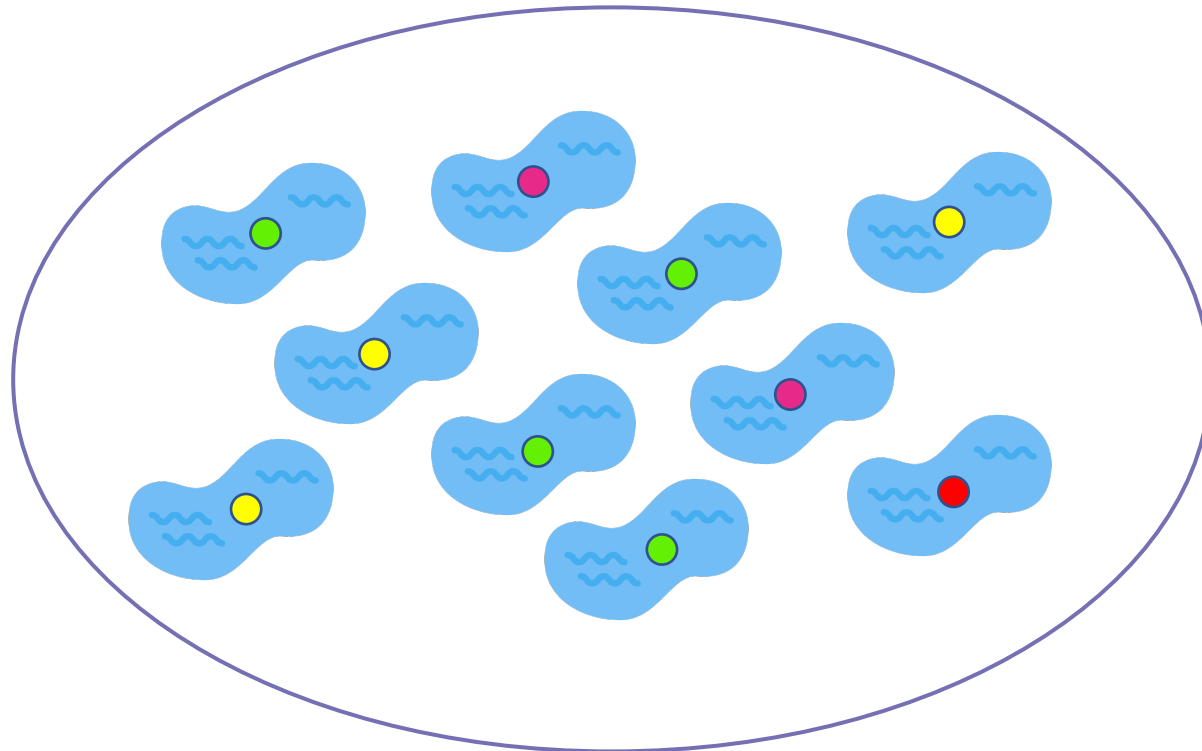


New divisions based on a linear discriminant analysis



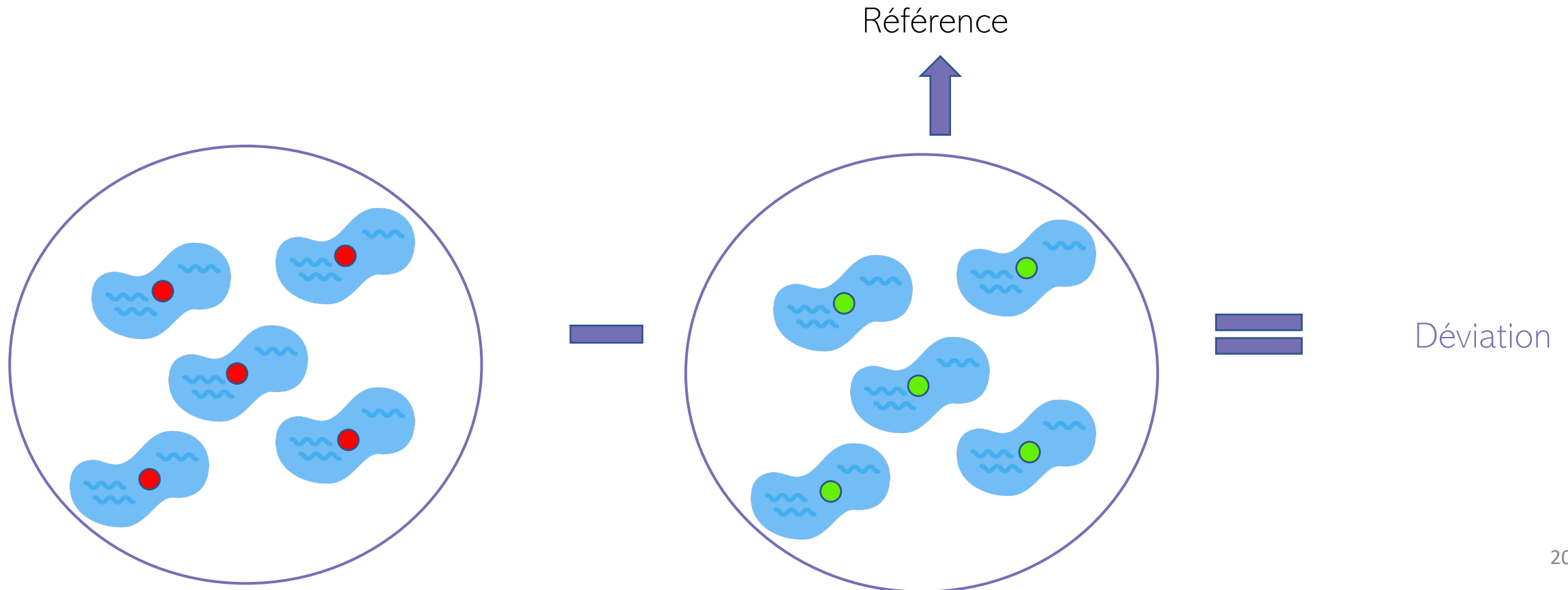
Détermination de l'état écologique des lacs

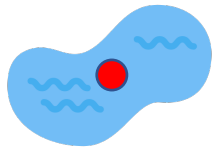
Étape 2 : Déviation des lacs impactés par rapport à l'état de référence de leur région



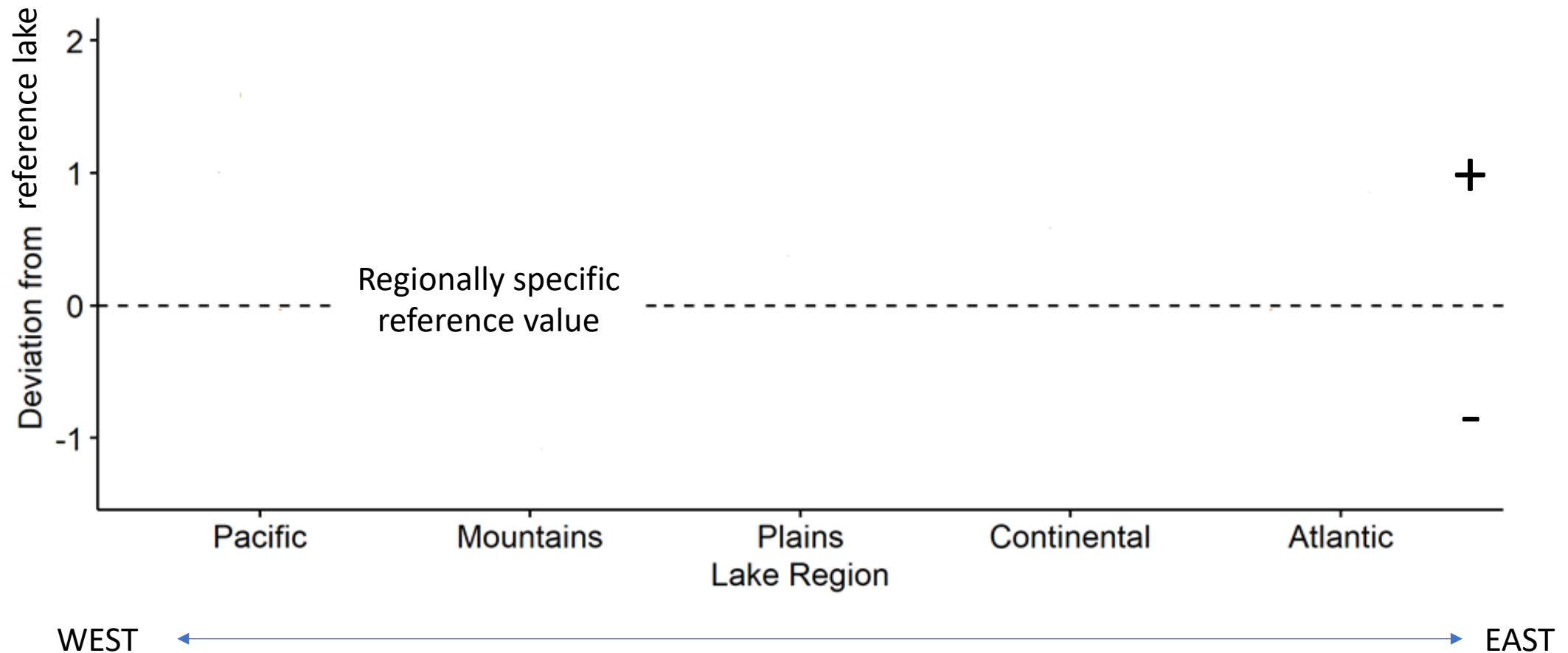
Détermination de l'état écologique des lacs

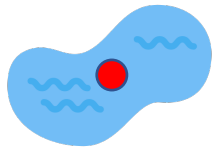
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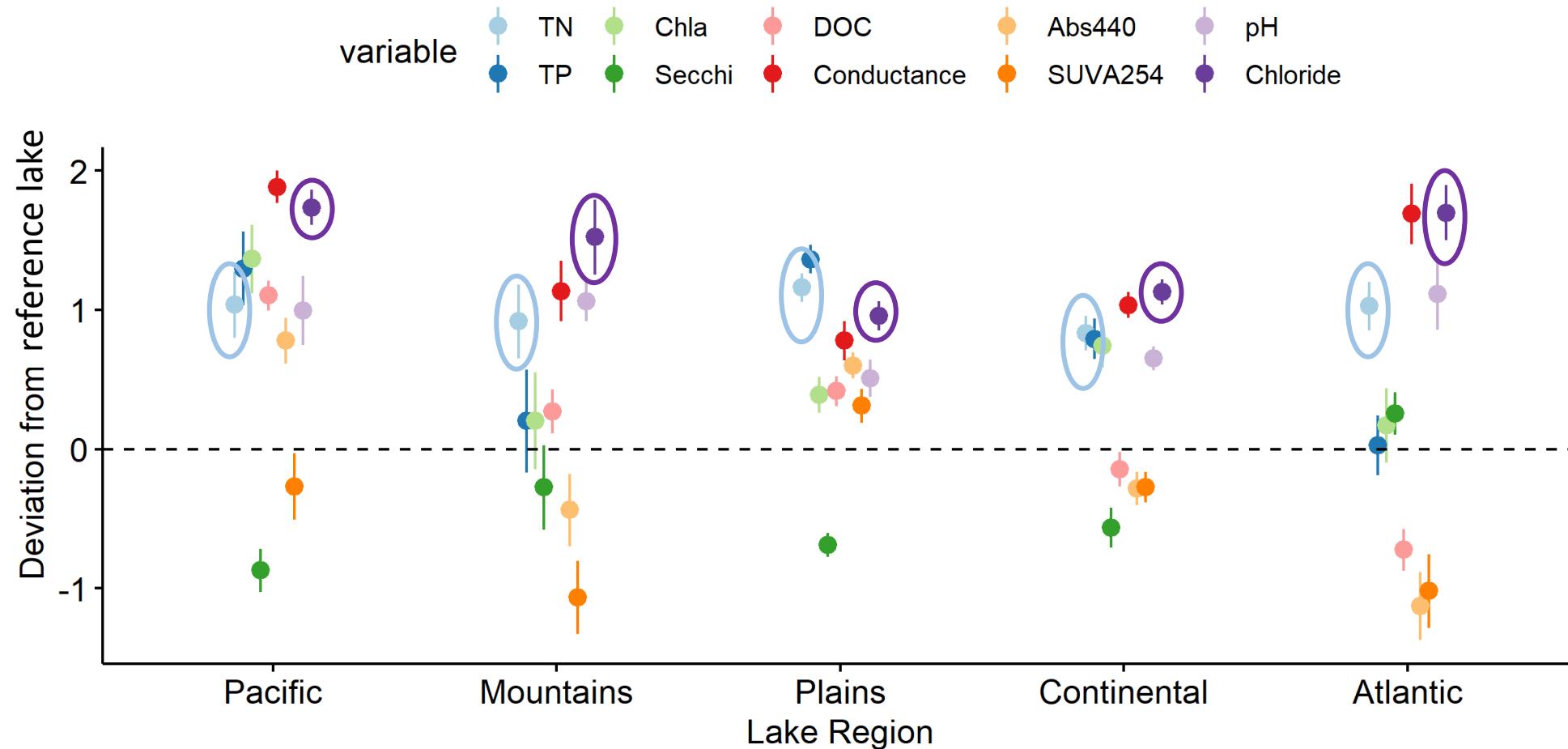


Selection of ecological state indicators





Selection of ecological state indicators



Nitrogen & chloride

- Total nitrogen (TN)
 - Fertilizer use
 - More constant than TP
 - Agricultural and urban indicator
 - Promotes toxic algal blooms



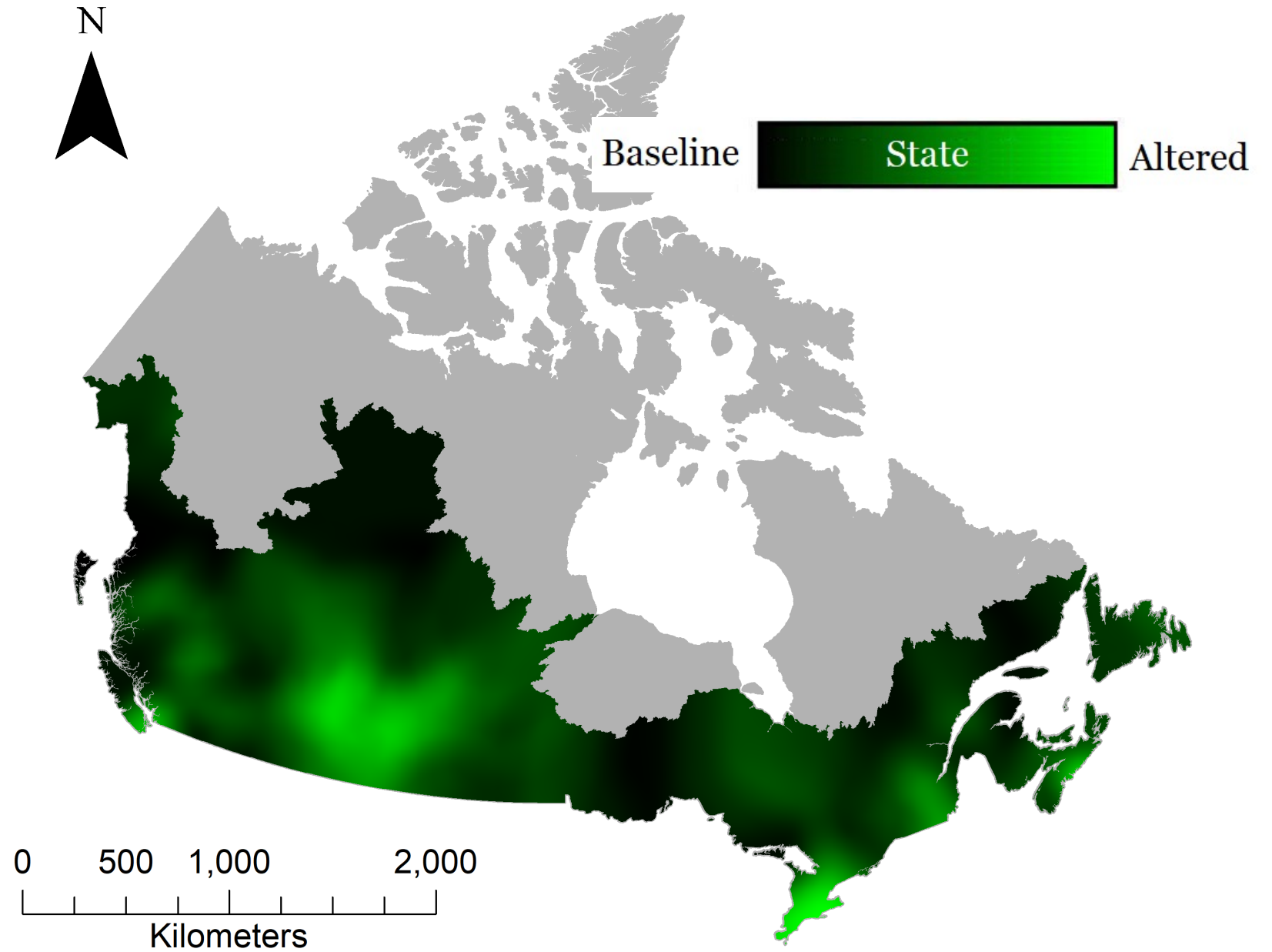
- Chloride (Cl)
 - Salt application on roads
 - Urban indicator
 - Adverse effects on aquatic life



Ecological state

Addition of the deviations from reference values

TN + CI





Threats

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Lake ecological state

LakePulse (2017-2018-2019)

Threats to Lakes

WWF (2017)

Recreational ecosystem service use

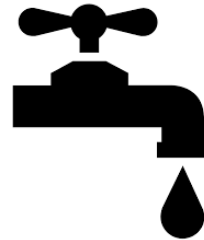
Statistics Canada (1996)



Threats to Lakes

- Dataset : WWF's 2017 Watershed Report
- Sub-watershed (168) score for 7 indicators of threats to water quality
- Selection of the 5 most important threats to lakes

1. Pollution
2. Climate change
3. Invasive species
4. Overuse of water
5. Habitat loss





Aires de drainage principales

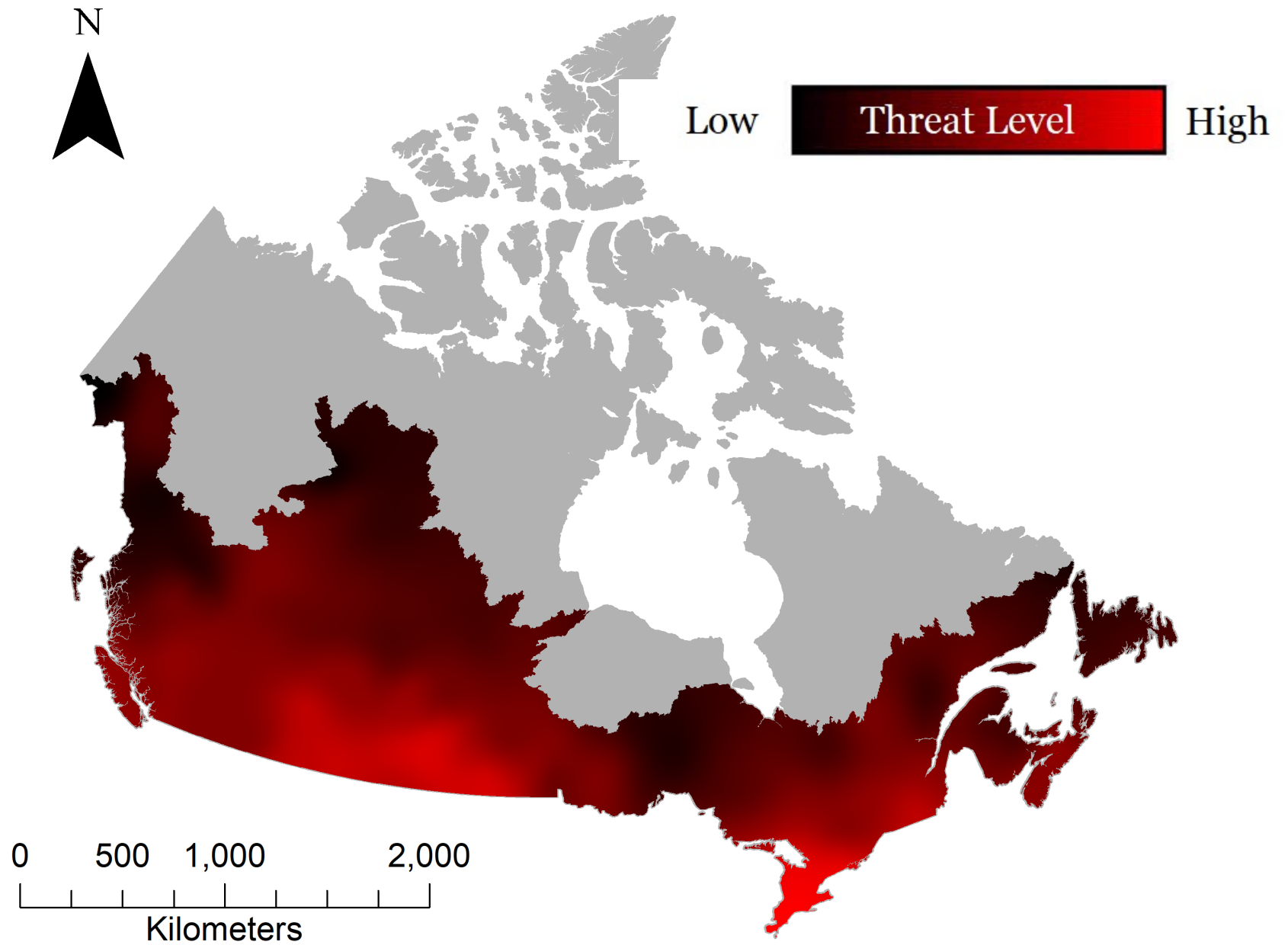
- Provinces Maritimes
- Saint-Laurent
- Nord du Québec et Labrador
- Sud-Ouest de la baie d'Hudson
- Fleuve Nelson
- Ouest et Nord de la baie d'Hudson
- Grand lac des Esclaves
- Pacifique
- Fleuve Yukon
- Arctique
- Fleuve Mississippi

168 sous-bassins-versants
du Canada

Threats

Pollution +
Climate change +
Invasive species + Overuse of
water + Habitat loss

5





Ecosystem Services

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Lake ecological state

LakePulse (2017-2018-2019)

Threats to Lakes

WWF (2017)

Recreational ecosystem service use

Statistics Canada (1996)

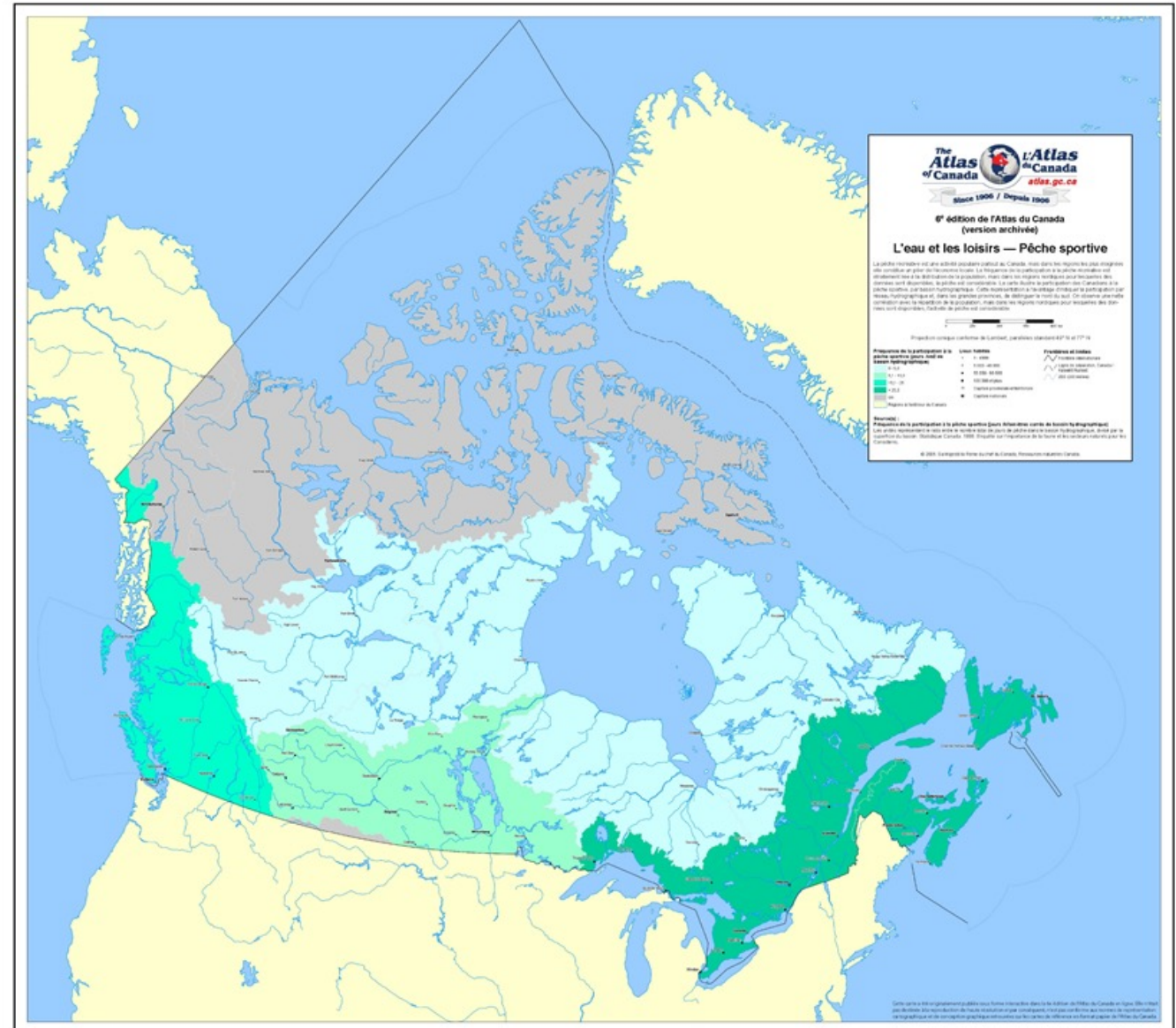
Ecosystem services (Recreational)

- Aquatic ecosystem use for 4 recreational activities across major watersheds (11) :
 1. Sport fishing
 2. Swimming and beach activities
 3. Canoeing, kayaking and sailing
 4. Power boating
- Dataset : Statistics Canada Survey on the Importance of Nature to Canadians (1996); 87,000 respondents; adjusted for 2016 population

Importance of Nature to Canadians

Statistics Canada 1996

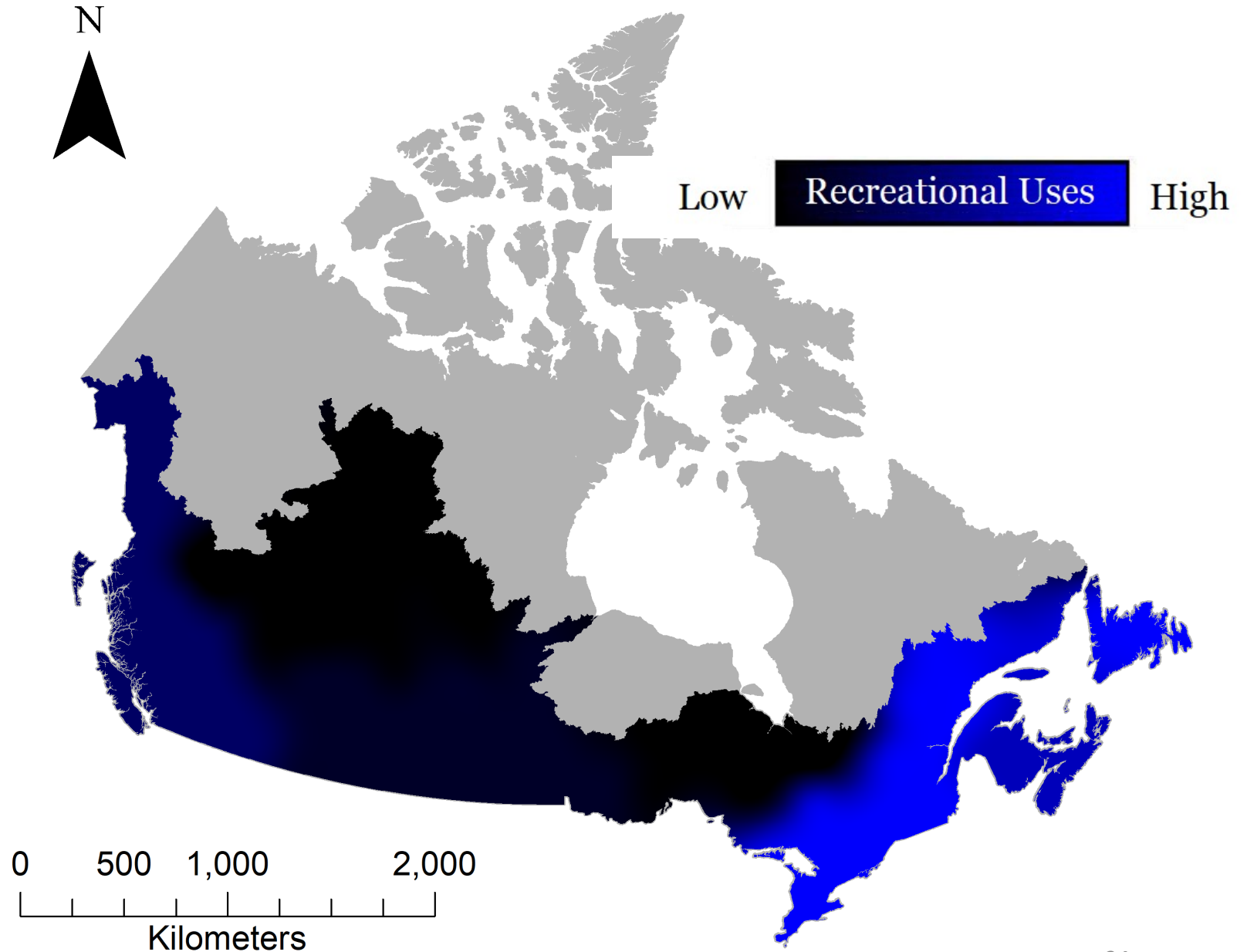
Données quantitatives d'utilisation des plans d'eau au Canada (jours/km² de bassin hydrographique)



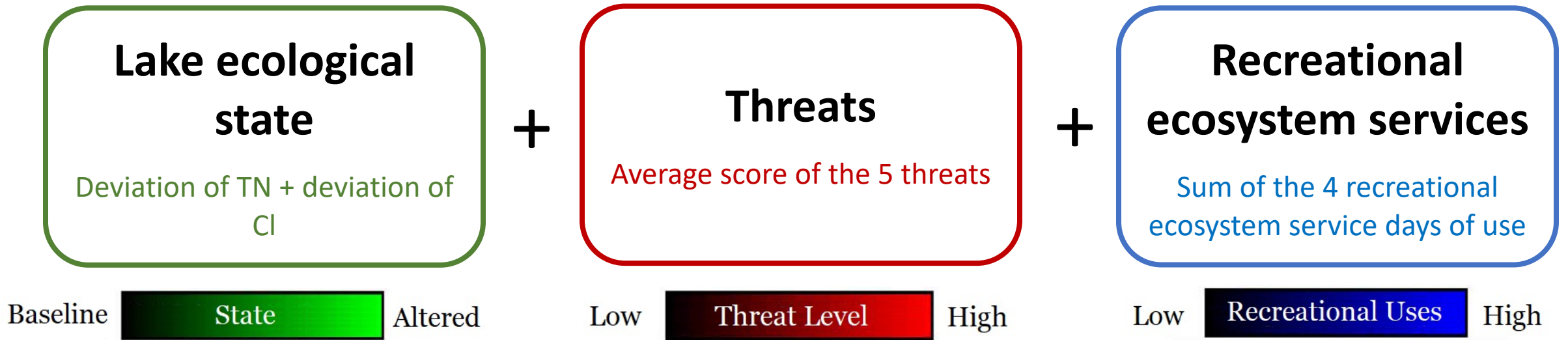
Ecosystem services

Recreational uses:

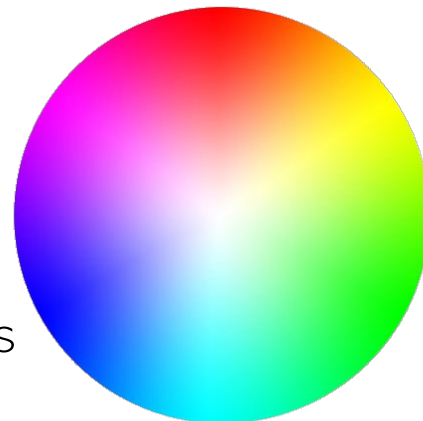
Sport fishing +
Swimming +
Canoeing, kayaking and
sailing +
Power boating



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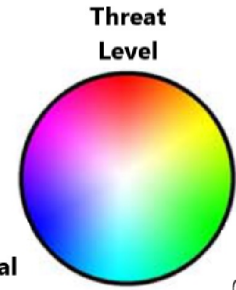


Threat level



Recreational uses

State (deviation from reference)



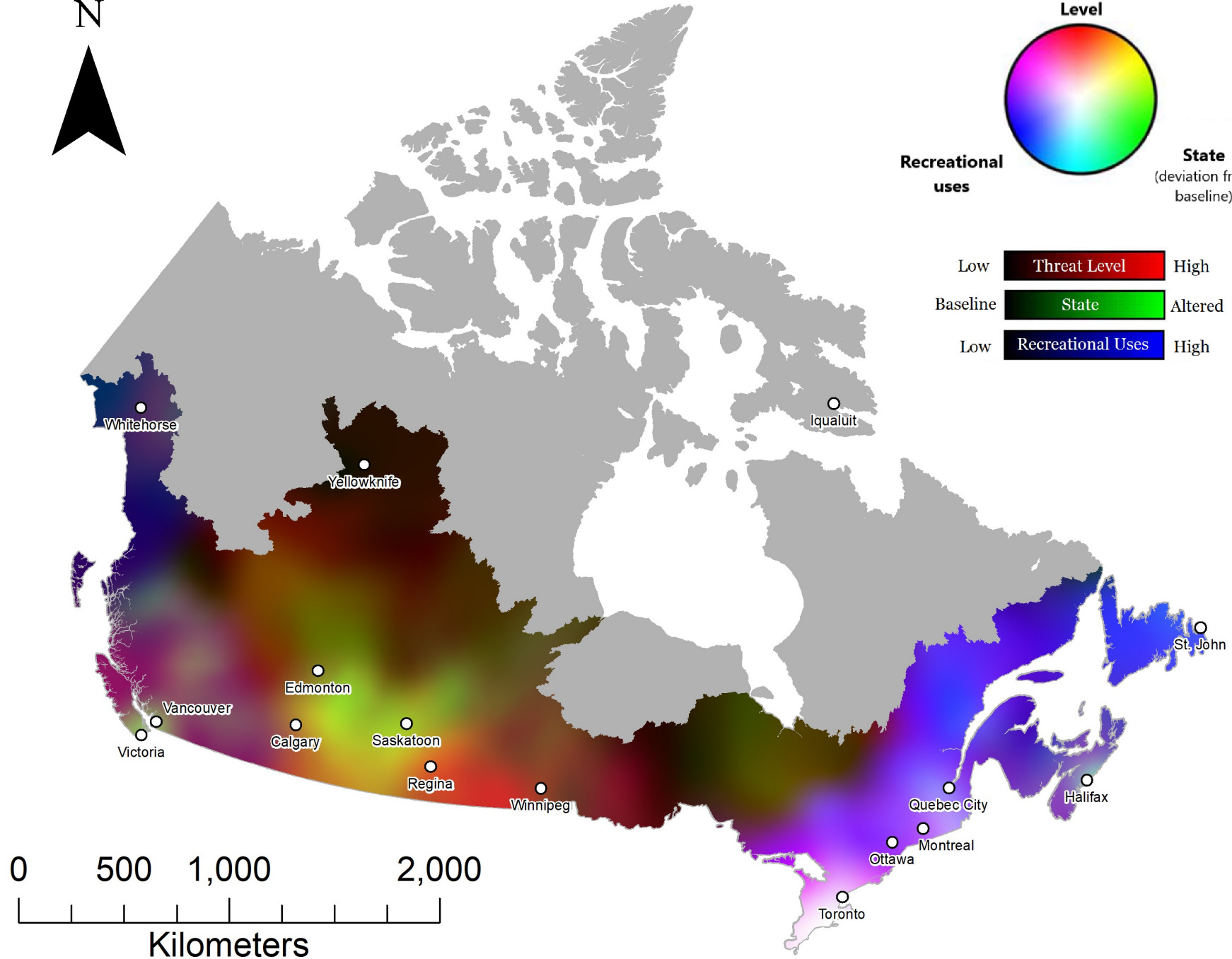
**Recreational
uses**

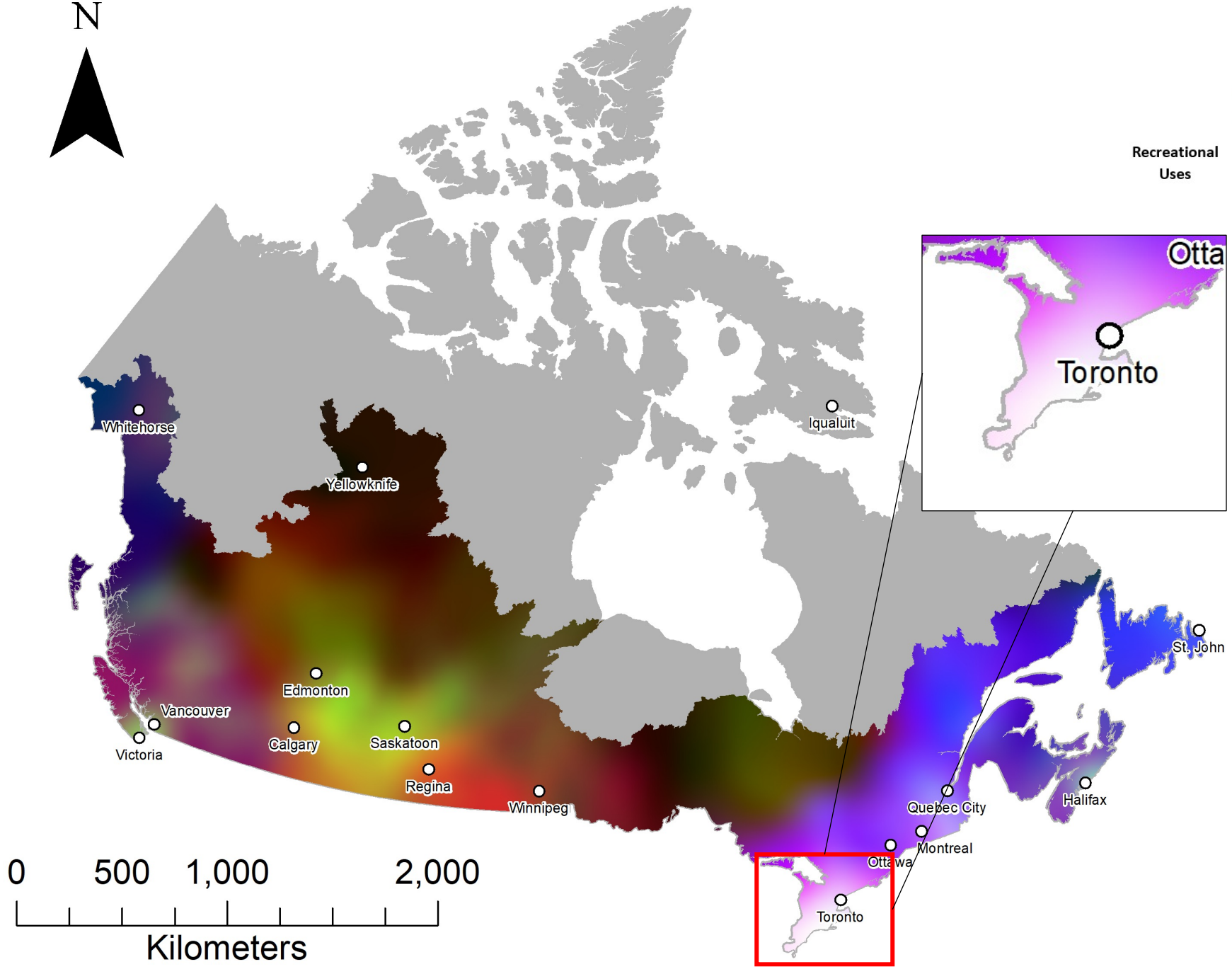
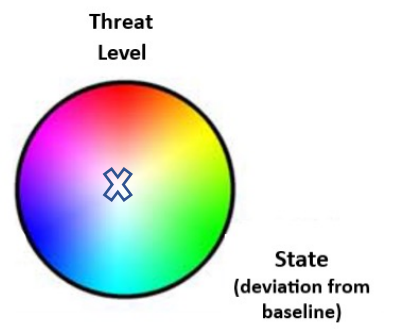
State
(deviation from
baseline)

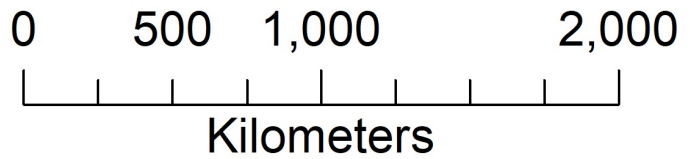
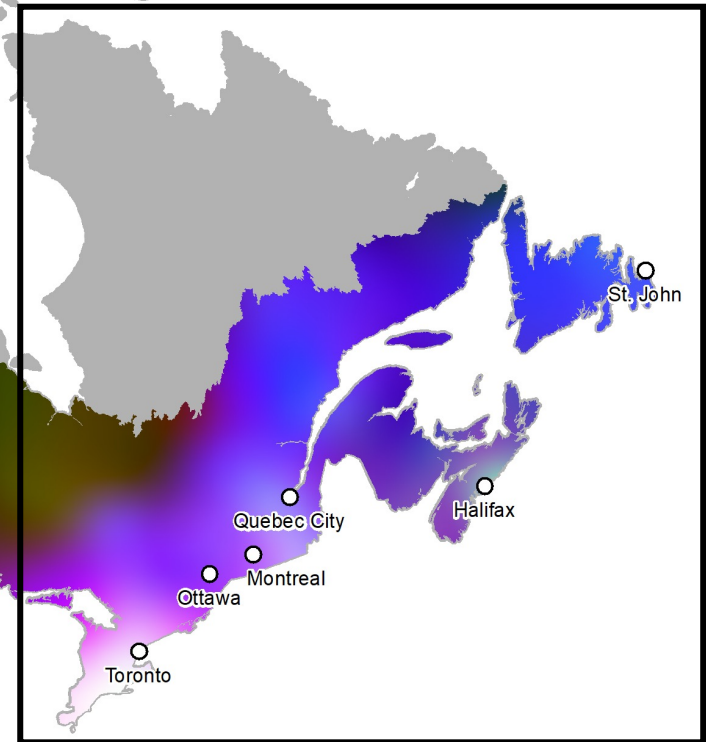
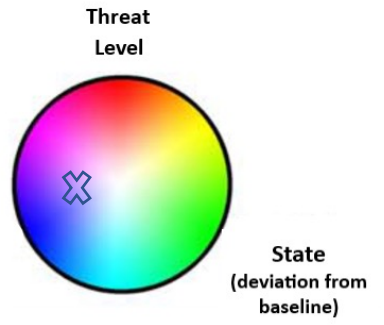
Low **Threat Level** High

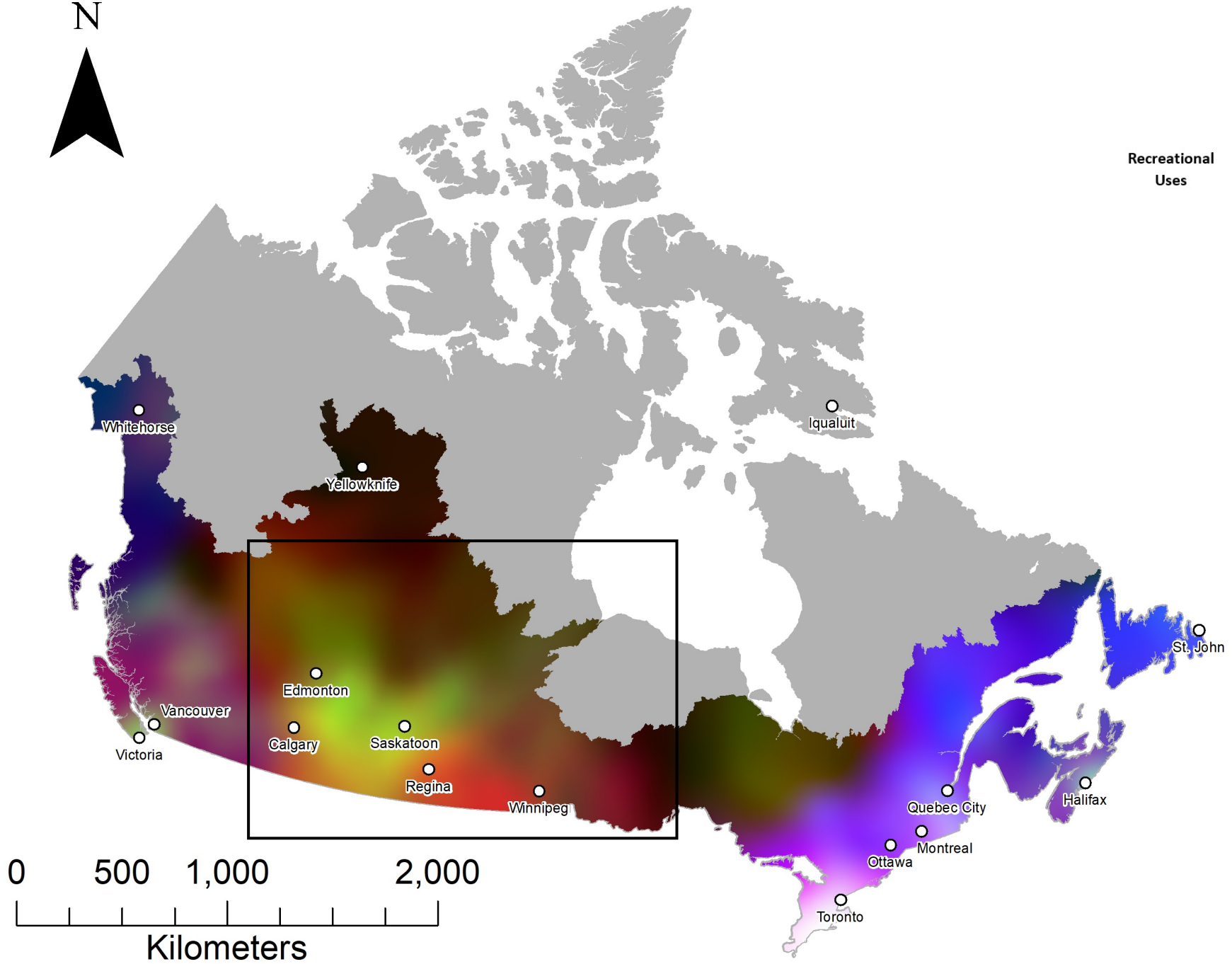
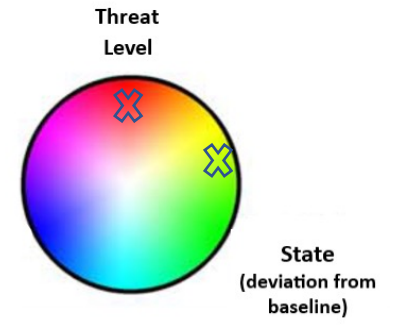
Baseline **State** Altered

Low **Recreational Uses** High









Conclusion

Novel approach to assess the social-ecological geography of lakes

- Delineation of distinctive lake regions
- TN and CI as indicators of the lake ecological state across Canada
- Ability to synthesizing a large amount of information and message clearly
- Identifying priority areas for conservation and potential adaptation to a finer scale

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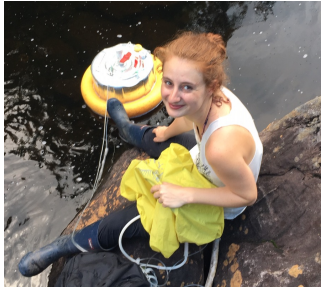
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For more details....

Acknowledgements



Questions ?

