# Dealing with Uncertainty: Developing a Knowledge System to Navigate Climate Driven Biodiversity Change in Canada's Arctic National Parks

## STATE OF THE ARCTIC

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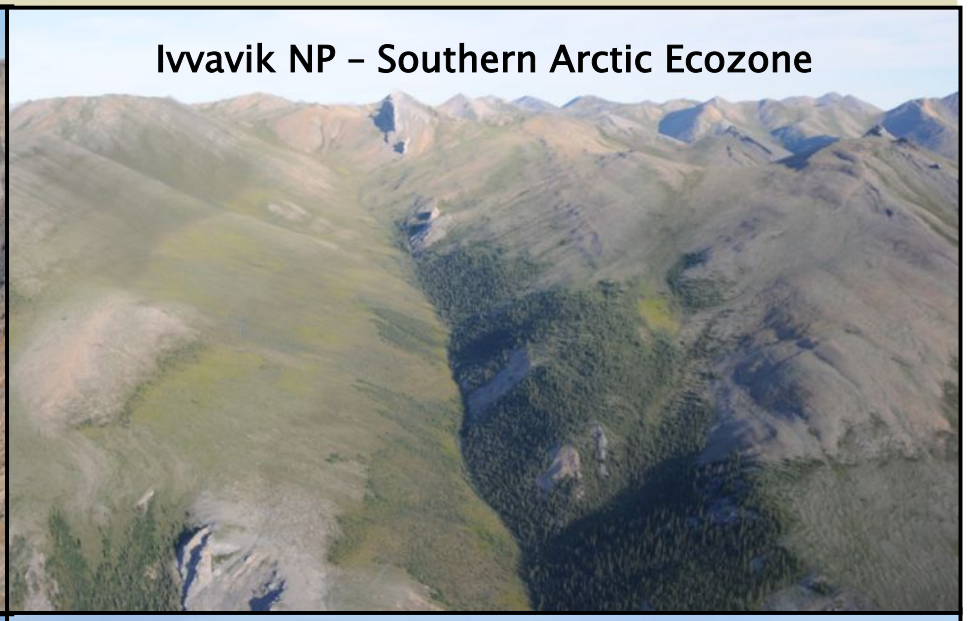
Torngat Mountains National Park, Labrador

# Outline

1. Parks Canada and ecological integrity
2. Implications of climate change
3. Reducing uncertainty around climate change effects
4. Working together to monitor and manage ecological change in the Arctic


Torngat Mountains NP
Arctic Cordilleran Ecozone


Ivvavik NP – Southern Arctic Ecozone


Sirmilik NP – Northern Arctic Ecozone


Wapusk NP – Hudson Plains Ecozone

# PCA Legislation

## Parks Canada Legislation

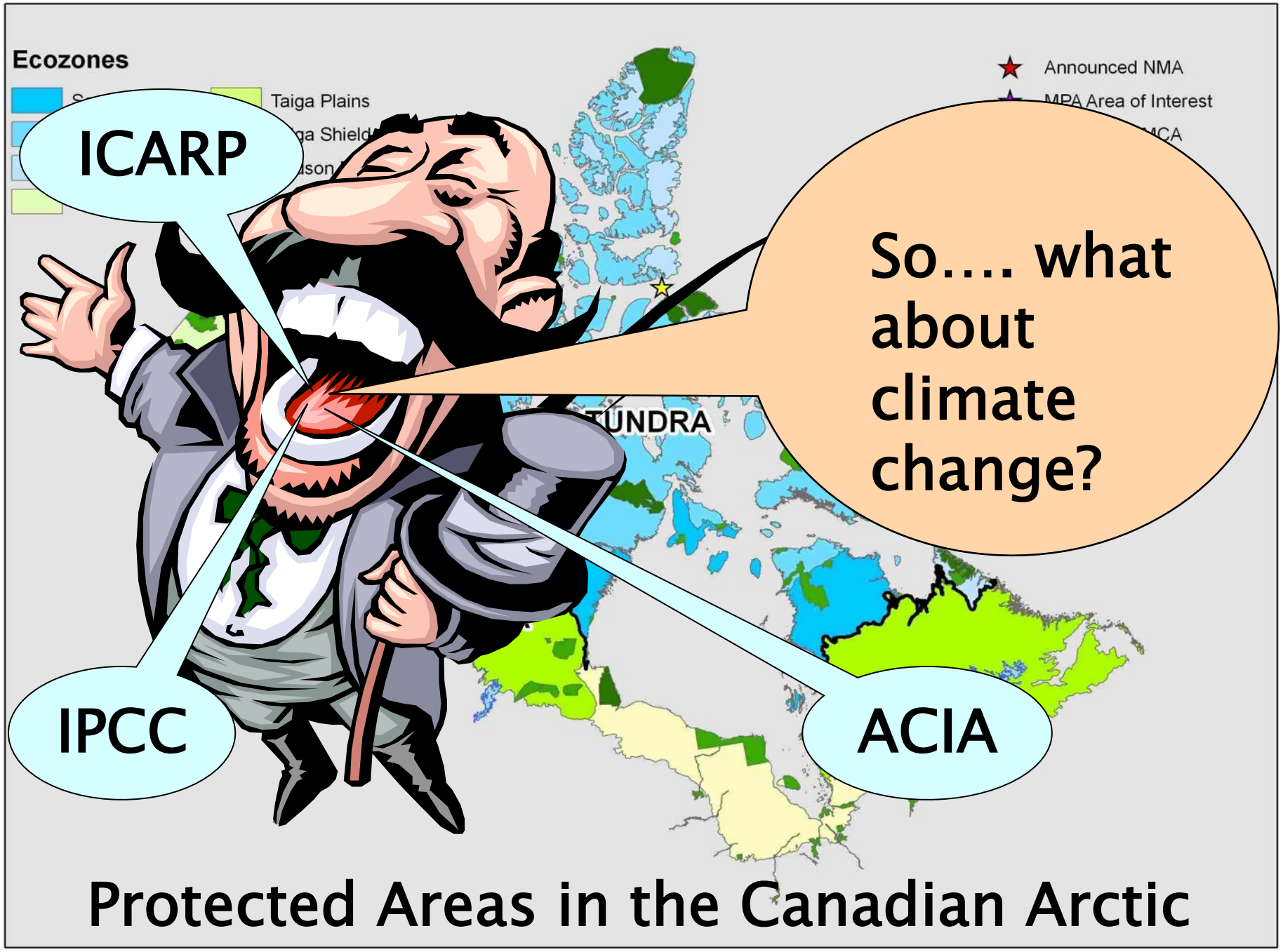
"Maintenance or restoration of *ecological integrity*, through the protection of natural resources and natural processes, shall be the **first priority** of the Minister when considering all aspects of the management of parks."

Section 8. (2) Canada National Parks Act (2001)

## Definition: Ecological Integrity

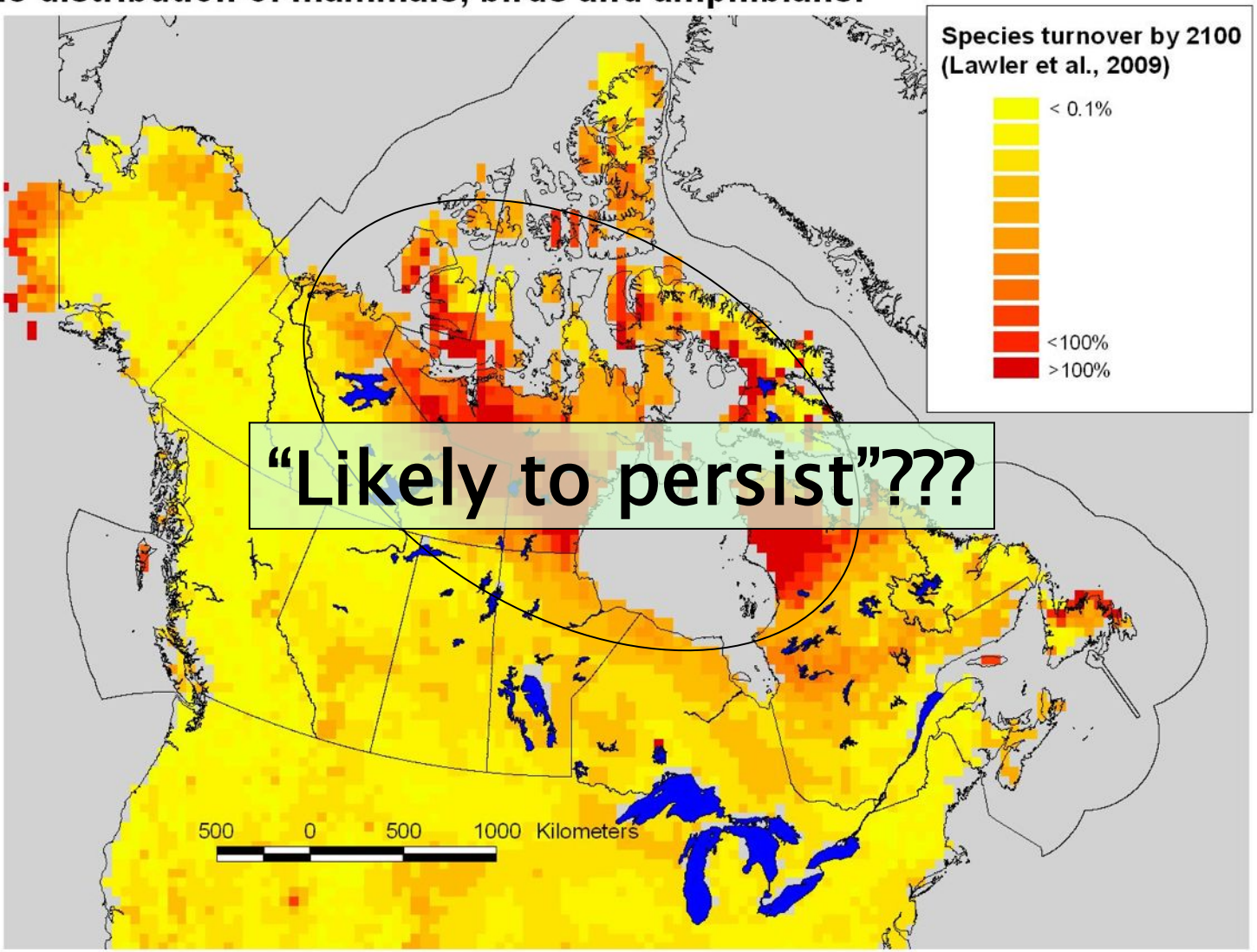
"….'ecosystem integrity' means, with respect to a park, a condition that is determined to be characteristic of its natural region and **likely to persist**, including abiotic components and the composition and abundance of native species and biological communities, rates of change, and supporting processes".

Section 2. (1) Canada National Parks Act (2001)




Protected Areas in the Canadian Arctic

## Predicted climate-induced changes in the distribution of mammals, birds and amphibians.




"Likely to persist"???

# Dealing with Uncertainty

1. How will climate change play out in weather at the scale of the park?

2. How will park biota respond to these changes?

# Proactive Adaptive Management for Protected Areas in a Changing World

Determine EI Measures and Indicator thresholds by looking back, assessing rate of change, and modelling forward

## EI Monitoring

- measure and assess present state and change of park ecosystems
- assess model predictions, based on change in EI condition measures
- assessment of success of active management in terms of EI measures in relation to targets

## Park Management Process

- decisions on what active management strategies to pursue
- public consultations
- design/propose active management
- set targets to measure success
- 5 yr window

## Focussed Research

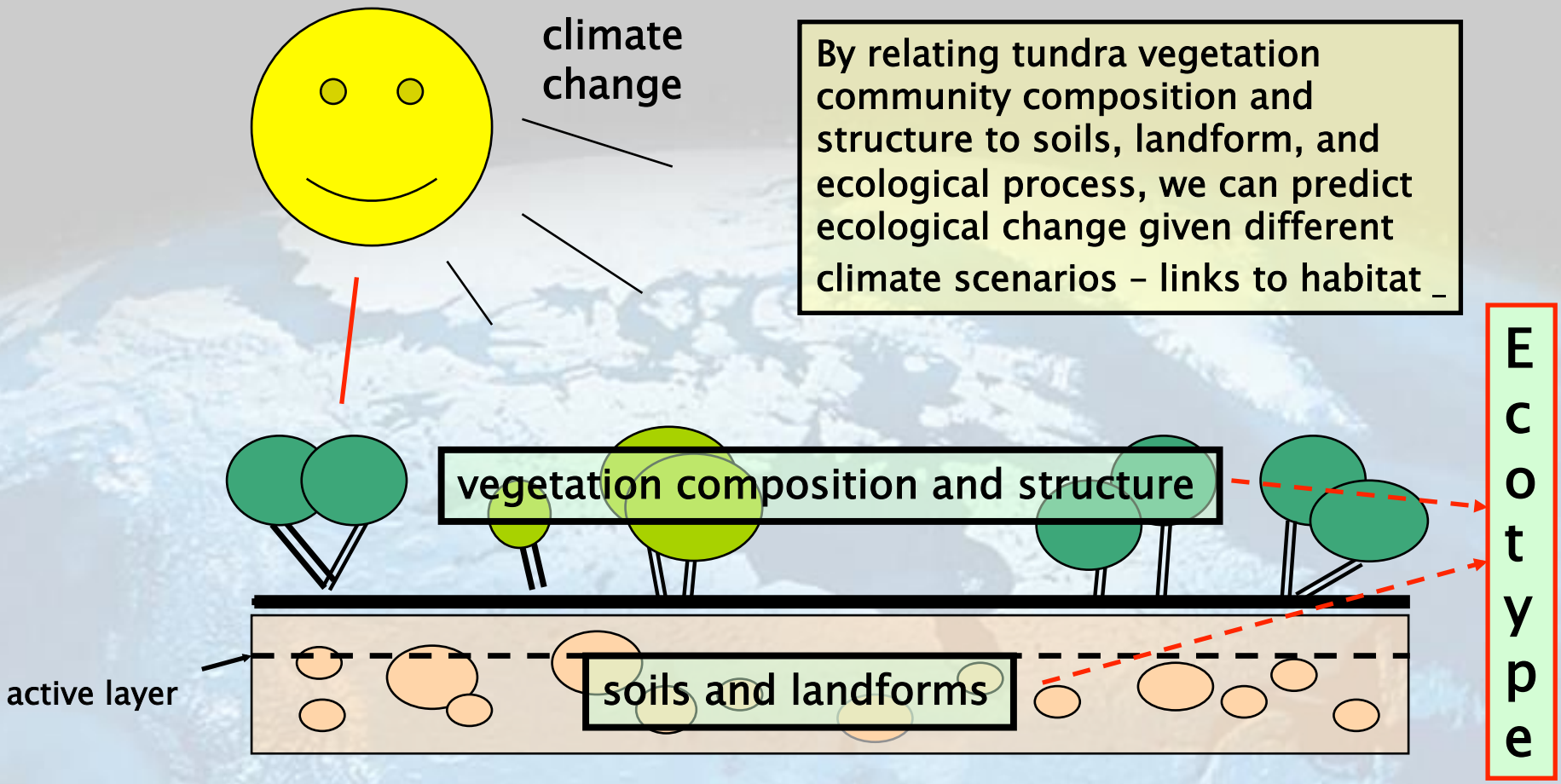
- examine and assess ecological change – biological mechanisms, ecosystem regulation, and rates and directions of change
- identify/improve active management approaches and develop management options

Conduct/upgrade process-based inventories of park ecological communities to establish 'baselines'

## Management Decision Modelling

- predict 5 yr change of local climates and park ecological communities/refine models
- sensitivity analysis/risk assessment of active management options for key management questions

# Terrestrial Ecosystem Mapping – Delineating Ecotypes




By relating tundra vegetation community composition and structure to soils, landform, and ecological process, we can predict ecological change given different climate scenarios – links to habitat _

Similar ecological conditions affecting ecotypes results in similar plant communities that can be classified into vegetation associations

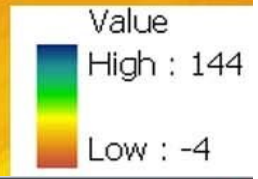
# INTEGRATED PREDICTIVE ECOSYSTEM MAPPING (IPEM)

## SPOT5

- radiance (red, green, NIR, SWIR)
- VIs (NIR/red, NIR/SWIR – Fernandez et al 2003)
- image texture (5m Pan)

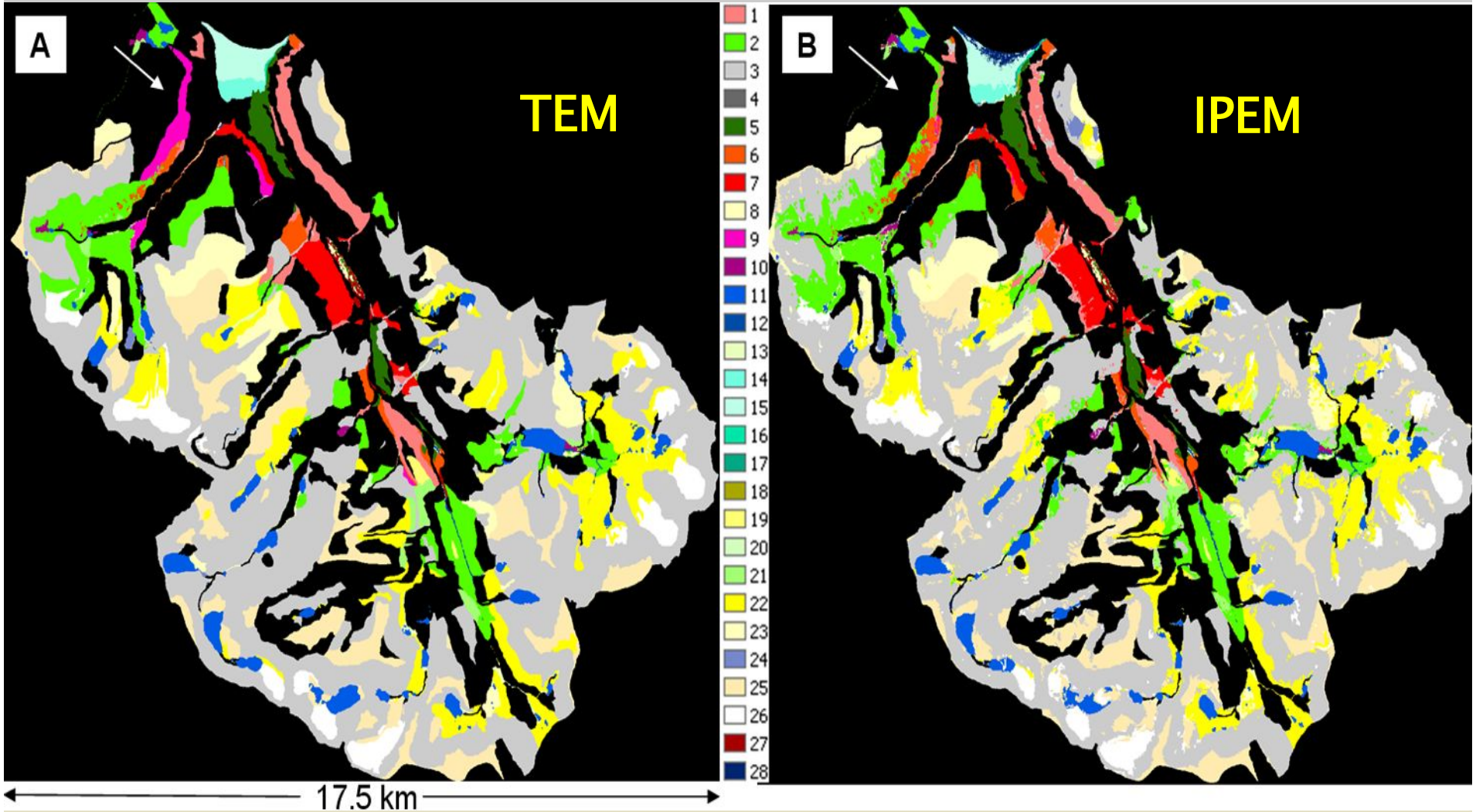
## DEM

- elevation, slope, aspect
- radiation (Rich et al 1995)
- slope curvature (concavity/convexity – McNab1989)
- moisture index (Beven et al 1979)



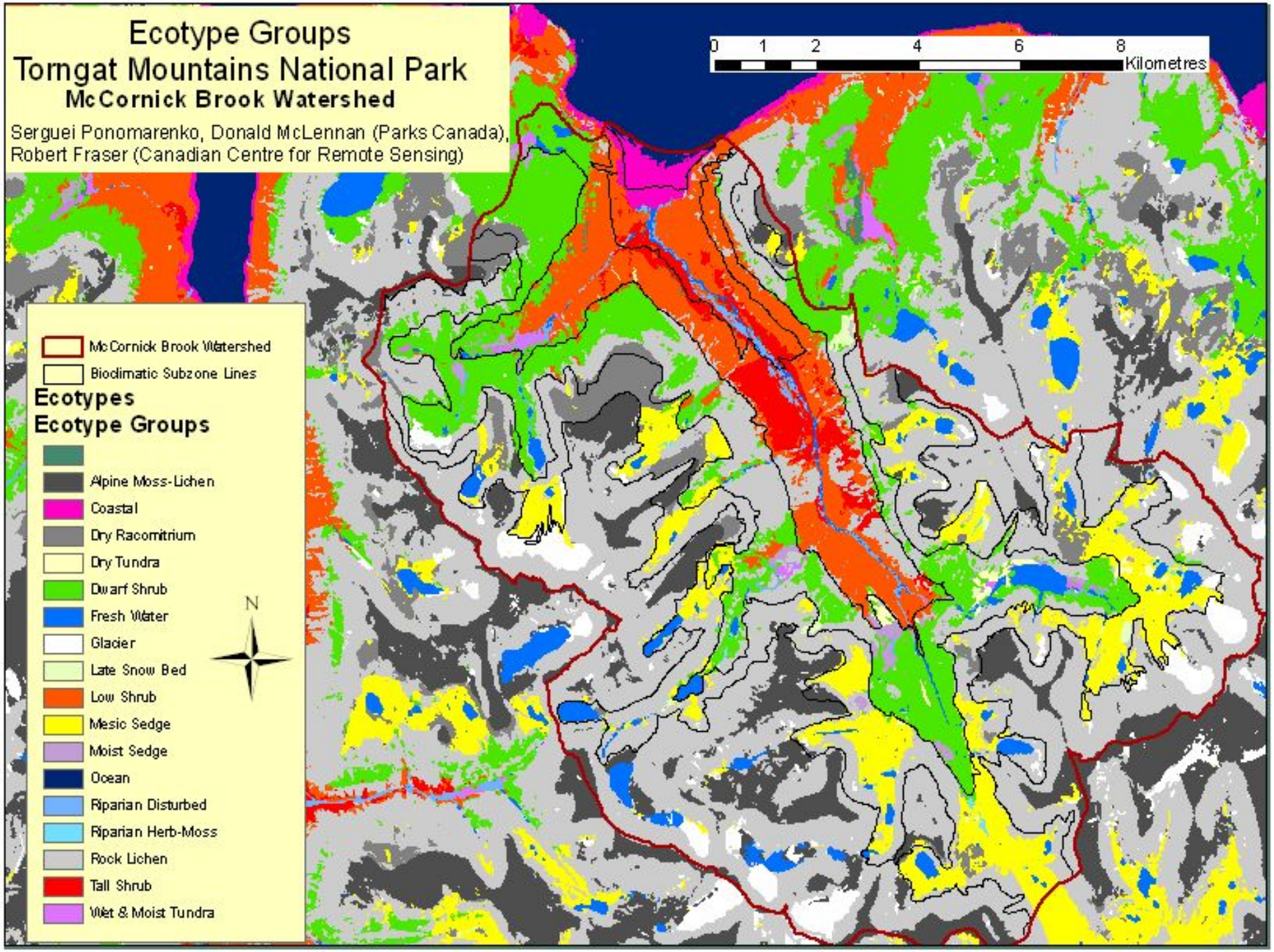

- distance to waterbodies

# TEM and IPEM – McCornick






Fraser et al (in prep)

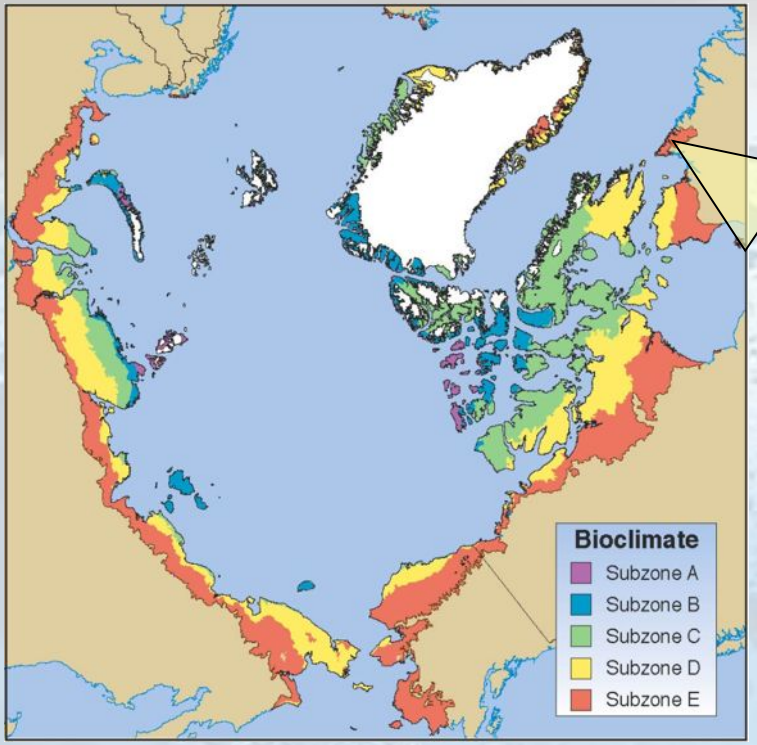

Ecotype Groups
Torngat Mountains National Park
McCornick Brook Watershed
Serguei Ponomarenko, Donald McLennan (Parks Canada),
Robert Fraser (Canadian Centre for Remote Sensing)
0 1 2 4 6 8
Kilometres
McCornick Brook Watershed
Bioclimatic Subzone Lines
Ecotypes
Ecotype Groups
Alpine Moss-Lichen
Coastal
Dry Racomitrium
Dry Tundra
Dwarf Shrub
Fresh Water
Glacier
Late Snow Bed
Low Shrub
Mesic Sedge
Moist Sedge
Ocean
Riparian Disturbed
Riparian Herb-Moss
Rock Lichen
Tall Shrub
Wet & Moist Tundra
N

# Zonal Ecotypes

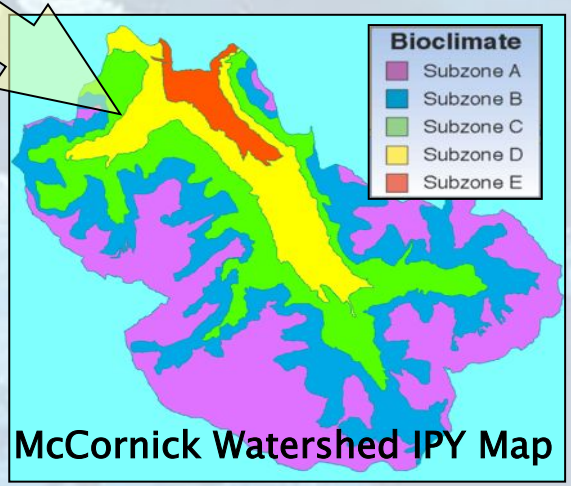
## Developing a Bioclimate Classification

| Code | CAVM name | TMNPR Project Name | Elevation Distribution In TMNPR[1] |
|---|---|---|---|
| A | Polar Desert | Lichen-Herb Tundra | > 900 m |
| B | High Arctic Tundra | Herb-Lichen - Cushion Tundra | 600 - 900 m |
| C | Low Arctic Tundra | Dwarf Shrub Tundra | 300 - 600 m |
| D | High Hypoarctic Tundra | Low Erect Shrub - Dwarf Shrub Tundra | 50 - 300 m |
| E | Low Hypoarctic Tundra | Low Erect Shrub Tundra | 0 - 50 m |

[1] for TMNPR south of Nachvak Fiord

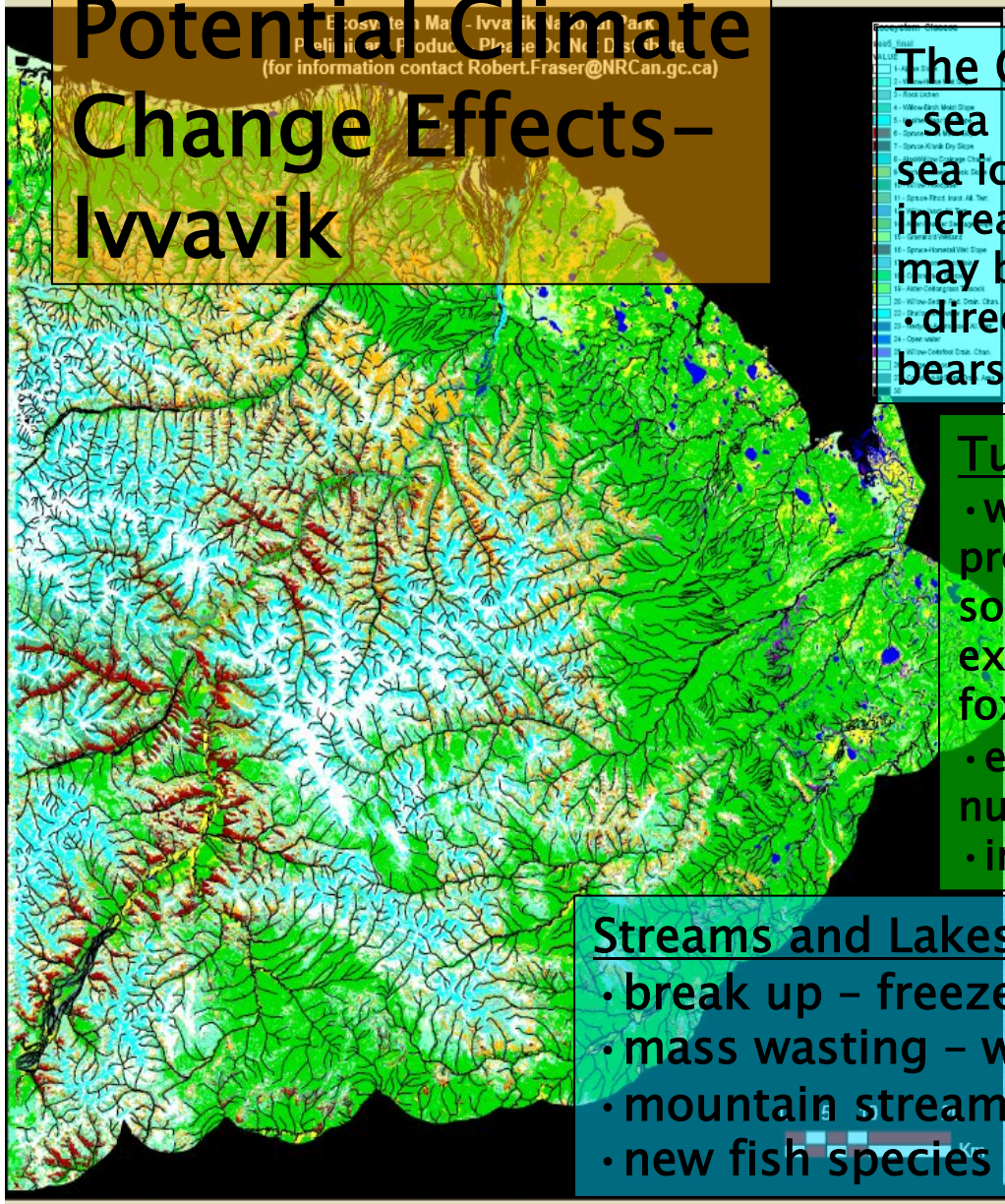



Circum-Arctic Vegetation Map (CAVM)




McCornick Watershed IPY Map

# Potential Climate Change Effects– Ivvavik




## The Coast

- sea level rise, permafrost melting, sea ice reduction and increased storminess will increase coastal erosion, flood estuaries and may block stream access
- direct effects on ice dependent species (polar bears, walrus)

## Tundra and Wetlands

- warmer temperatures and increased precipitation (snow?) will mean influx of southern species (moose, red fox,voles) at expense of arctic species (muskox, arctic fox, lemmings)
- effects on caribou uncertain (post calving nutrition, icing events, fly harassment)
- increased shrubs and trees – >tundra fire?

## Streams and Lakes

- break up – freeze up and increased ?discharge
- mass wasting – water quality – damming?
- mountain stream winter freezing?
- new fish species (salmon?)

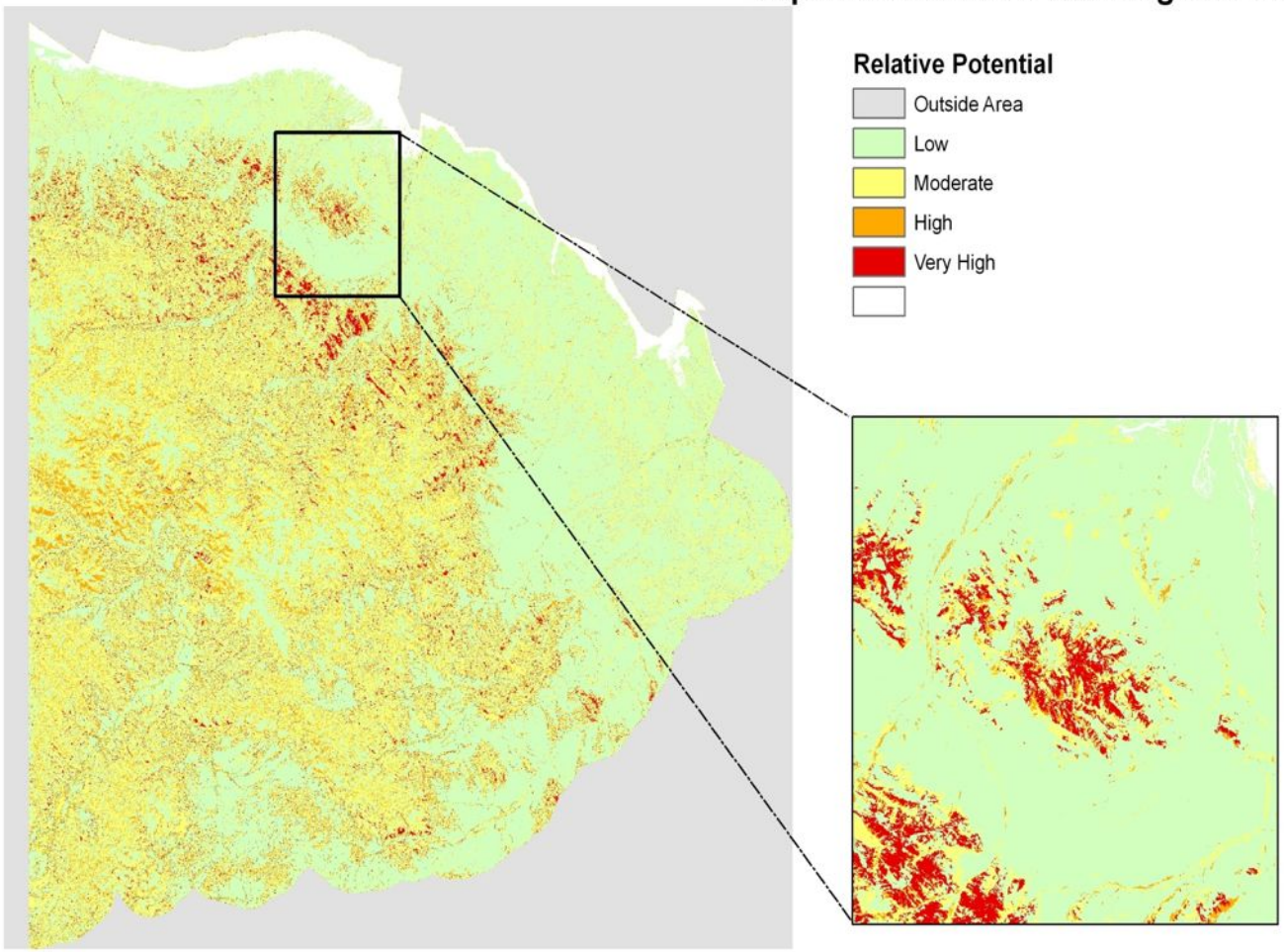
# Shrubs are getting more abundant

From Sturm et al 2001

# Ranking Relative Response of Shrub Ecotypes to Warming

| Shrub Ecotype | Predicted Response |
|---|---|
| Willow Horsetail Wet Slope | |
| Willow Birch Moist Slope | |
| Alaska Willow Drainage Channel | |
| Birch Crowberry Mesic Slope | |
| Willow Floodplain | |
| Willow Floodplain Inactive Terrace | |
| Alder Heather Seepage Slope | |
| Alder Cottongrass Tussock | |
| Willow Sedge | |
| Willow Coltsfoot | |

## Relative Potential For Shrub Expansion Under A Warming Climate

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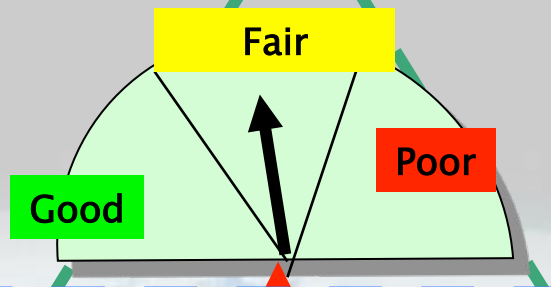
# PCA EI Monitoring and Reporting Program

1. Monitoring Question: What is the state of park EI and how is it changing?
2. Organized through reporting on 4-6 EI Indicators (=major park ecosystems – Tundra, Wetlands, Freshwater, Coastal, Glaciers) represented by a suite of EI Measures (='biological indicators')
3. EI Measures: track biodiversity, ecological processes and stressors/drivers for an EI Indicator
4. Program Design:
    1. long term monitoring sites, other ground measures, remote sensing measures
    2. multi-stage sample design: sites-focal watershed-park
5. Assessments: based on biological thresholds for each measure
6. Communicated: in 5 year State of the Park Reports – 42 SOPRs tabled in Parliament

# Final Results
# SOPR Information

## Tundra EI Indicator




**Local Level Tundra EI**

ASSESSMENT

**Landscape Level Tundra EI**

Models

↑

Measures

↑

Data

species (α) diversity, species relative abundance, alien invasive species, soil decomposition, active layer depth, soil temperature, soil arthropods, small mammals

community change, tree line/ shrub change, tundra productivity (NDVI/biomass), grizzly bear, caribou, vegetation phenology

# LONG TERM SITES

<u>Tundra/Wetland/Forest</u>

- vegetation change (ITEX, surveys, structure, biomass)
- active layer (CALM)
- soil temperature
- (water table)
- snow
- small mammals
- songbirds
- (arthropods)

<u>Streams</u>

- benthic inverts
- discharge
- water quality
- char/fish community

# OTHER GROUND MEASURES

<u>Tundra/Wetland</u>

grizzly, fox, caribou, muskox, raptors, BBS, lemmings, plant phenology

<u>Lakes and Streams</u>

char/fish community, Harlequin ducks

<u>Coastal</u>

polar bears, coastal fish, shorebirds/waterfowl, raptors

# REMOTE SENSING

<u>ParkSPACE Measures</u>

- land cover (ecotype/community)
- productivity (biomass and VIs)
- permafrost (NEST)
- lake and river ice
- coastal change
- glaciers (area, retreat, mass balance)

# Success Through Cooperation

## Coordinated Monitoring/Research

i. **build on ongoing cooperation** (other govs, academics, museums) to optimize science for climate adaptation in protected areas and other long term research sites

ii. **coordinate monitoring, research and modeling** to understand and adapt to evolving climate change effects

iii. **link to other initiatives** nationally and internationally – CBMP, SAON, CIMP, NGMP – standardize core variables and protocols

iv. **focus on social-ecological resilience**; promote community monitoring and citizen science

# Arctic National Parks As Anchors of Arctic Monitoring – INORMs

1. PCA committed to long term monitoring
2. baseline ecosystem data ongoing – ecological inventories, stream discharge, weather stations
3. very large (166,000 km$^2$) areas
4. 'baselines' of ecological change
5. good terrestrial ecological representation
6. cooperative management with Indigenous partners
7. professional staff present in the North and operational in the field
8. more science monitoring staff than any other Agency

Canadian Arctic and Sub-Arctic Protected Areas

# Success Through Cooperation (2)

## Working Together for Healthy Matrix Lands

i. Protected areas alone will not be enough to ensure long term ecological integrity of the North – **must have healthy matrix lands to ensure connectivity**

ii. Matrix presently in excellent condition – but due to low pressure not to land use policy

iii. need to **ensure effective land use planning and enforcement to ensure an ecologically functional matrix**

iv. All parties (government(s), communities/Indigenous People, industry) will **need to work together to develop effective land use plans and ensure their implementation**

v. **monitoring/research/modeling PAD is the key to reducing uncertainty across the Arctic**


working together for a common future

# An Evolving Monitoring Program

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Coastal
polar bears, coastal fish, shorebirds/waterfowl, raptors, polar bears,

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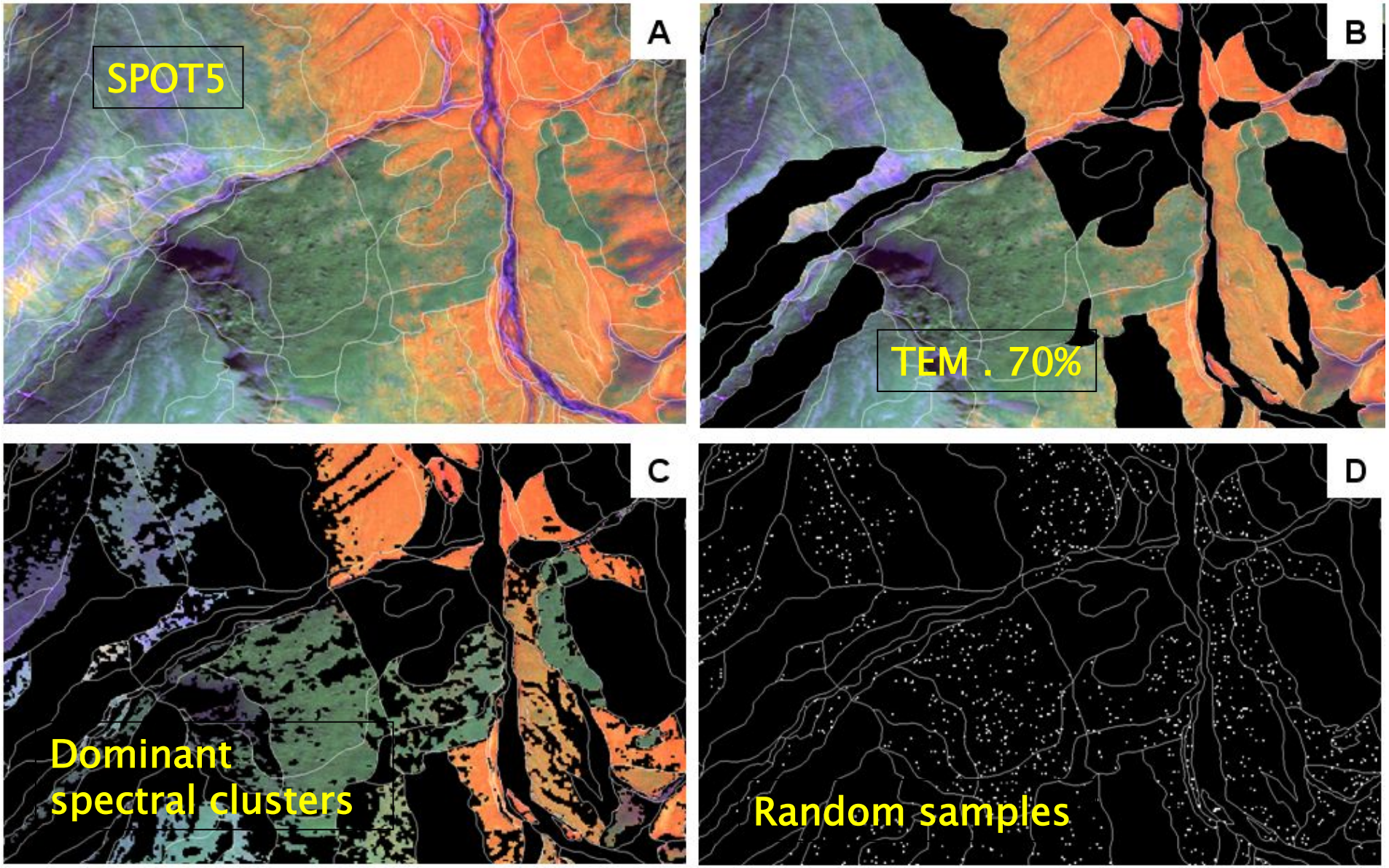




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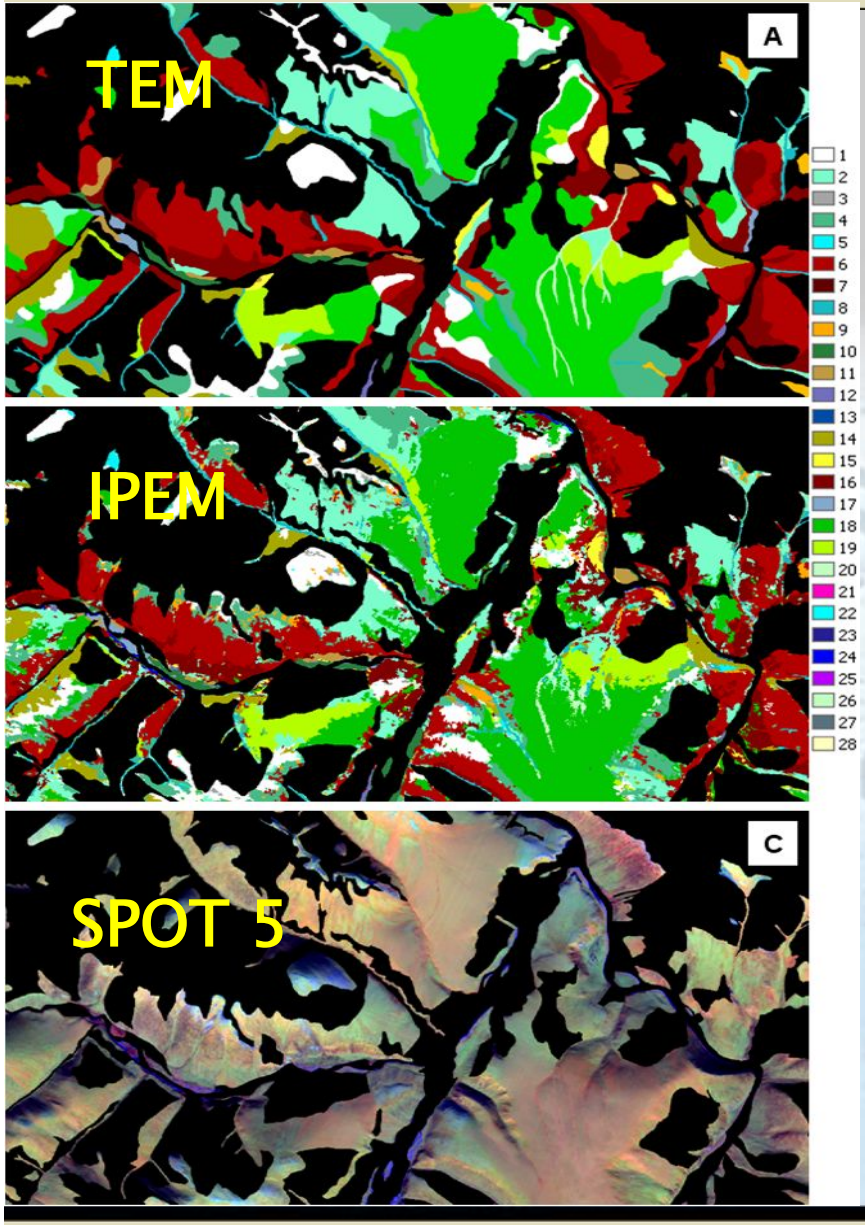



# TEM – IPEM Ivvavik

1. sample TEM (>70% pure)
2. develop IPEM model from predictor variables
3. recreate TEM units using IPEM model
4. Apply IPEM model to wider area



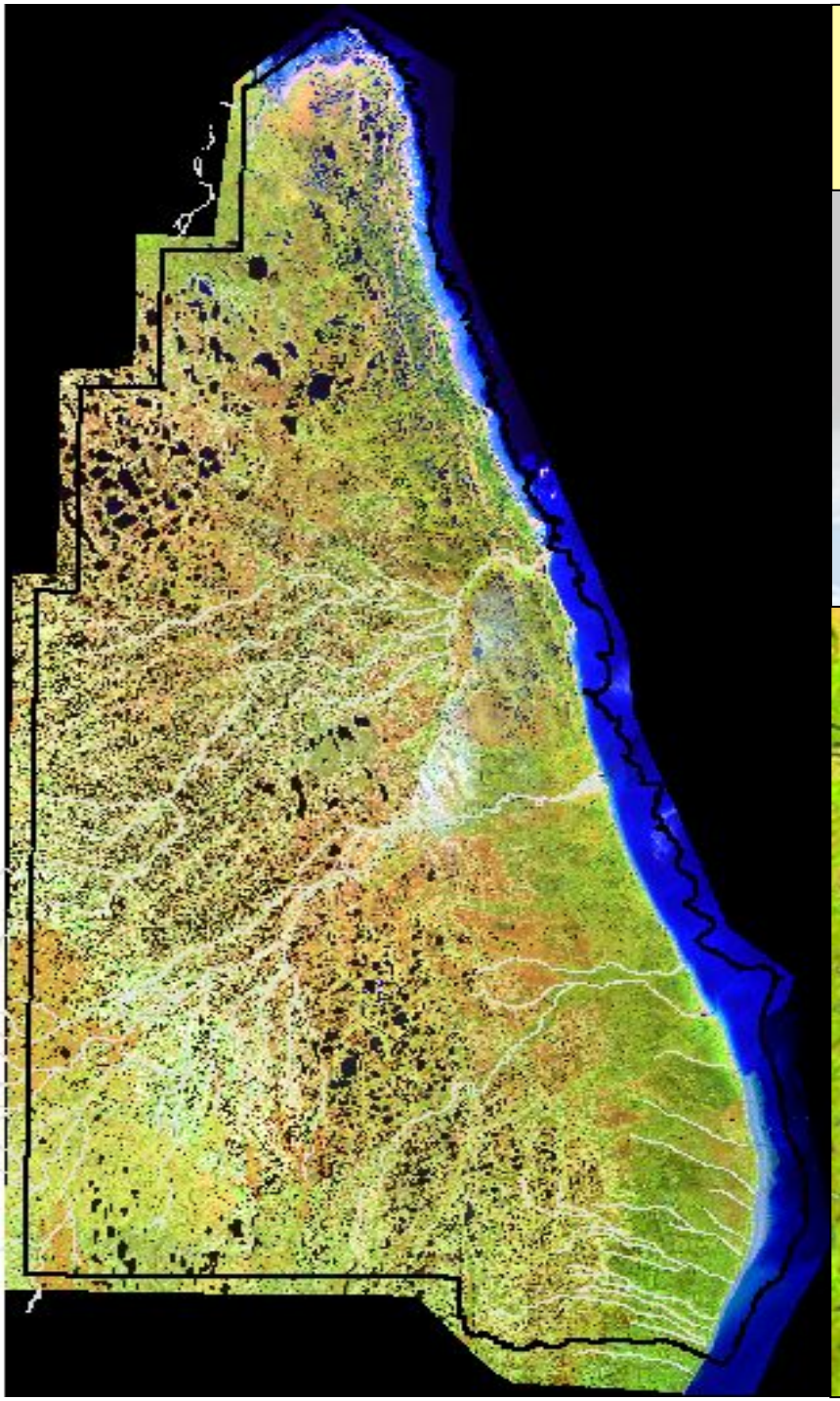
Fraser et al (in prep)

# I–PEM Model Accuracy

| PARK | Torngat Mountains NP | | Ivvavik NP | |
|---|---|---|---|---|
| Model | Training | Testing | Training | Testing |
| All variables | 99.9 | 96.6 | 99.6 | 84.7 |
| Spectral Variables | 75.0 | 61.5 | 59.9 | 43.3 |
| Terrain variables | 99.7 | 94.9 | 98.9 | 76.1 |



Fraser et al (in prep)



# Wapusk NP

- wetland complexes, low relief
- I-PEM based on terrain not applicable
- SPOT 5; Ecognition and RS2
- goose disturbance