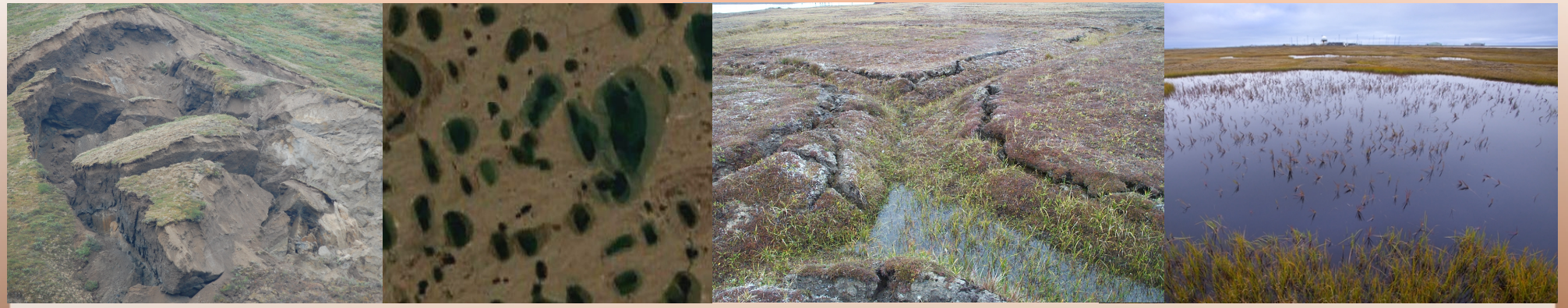


Conceptualization and Initial Application of Arctic Landscape Evolution Using the Alaska Thermokarst Model

W. Robert Bolton
Mark Lara
Vladimir Romanovsky
A. David McGuire

Importance of Permafrost / Thermokarst

- Estimated 1700 billion tons of organic carbon stored in northern soils
- Amount, rate, and form of carbon release is unknown, but is tied to permafrost thaw
- Permafrost thaw & subsidence are also tied to habitat change

COMMENT

E.A. SCHUUR

Abrupt thaw, as seen here in Alaska's Noatak National Preserve, causes the land to collapse, accelerating permafrost degradation and carbon release.

High risk of permafrost thaw

Northern soils will release huge amounts of carbon in a warmer world, say **Edward A. G. Schuur, Benjamin Abbott** and the Permafrost Carbon Network.

Arctic temperatures are rising fast, and permafrost is thawing. Carbon released into the atmosphere from permafrost soils will accelerate climate

largely because of the realization that organic carbon is stored much deeper in frozen soils than was thought. Inventories typically measure carbon in the top metre of soil. But the

greenhouse gas with about 25 times more warming potential than CO_2 over a 100-year period. However, waterlogged environments also tend to retain more carbon within the

Schuur & Abbott, Nature, 2011


Philip Martin

Alaska Dispatch News

NEWS POLITICS VOICES ARCTIC CULTURE SPORTS ADVENTURE MULTIMEDIA

Obituaries Nation-World Anchorage Fairbanks Mat-Su Crime Business Energy Science Cannabis Nor

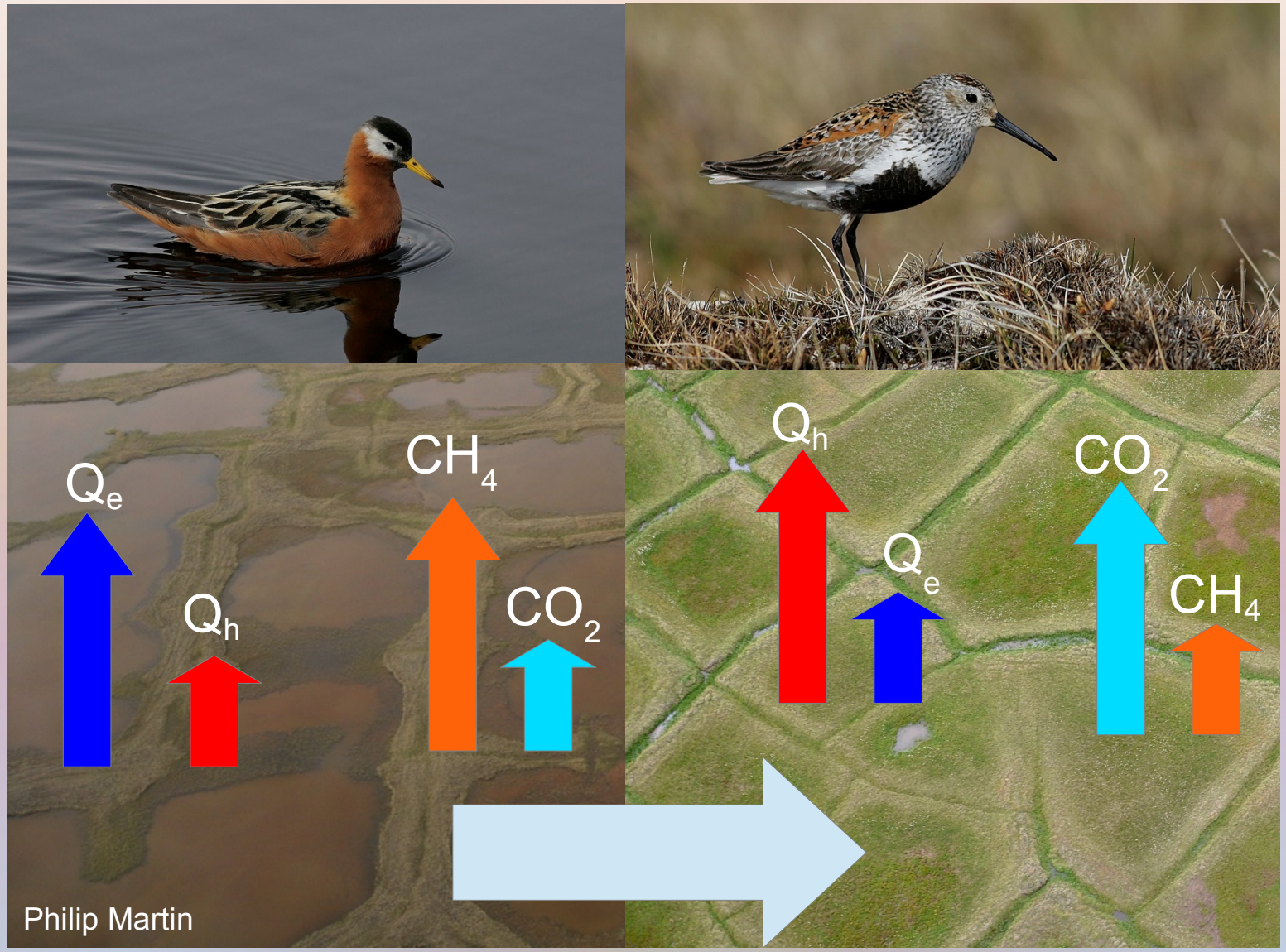
Wildlife

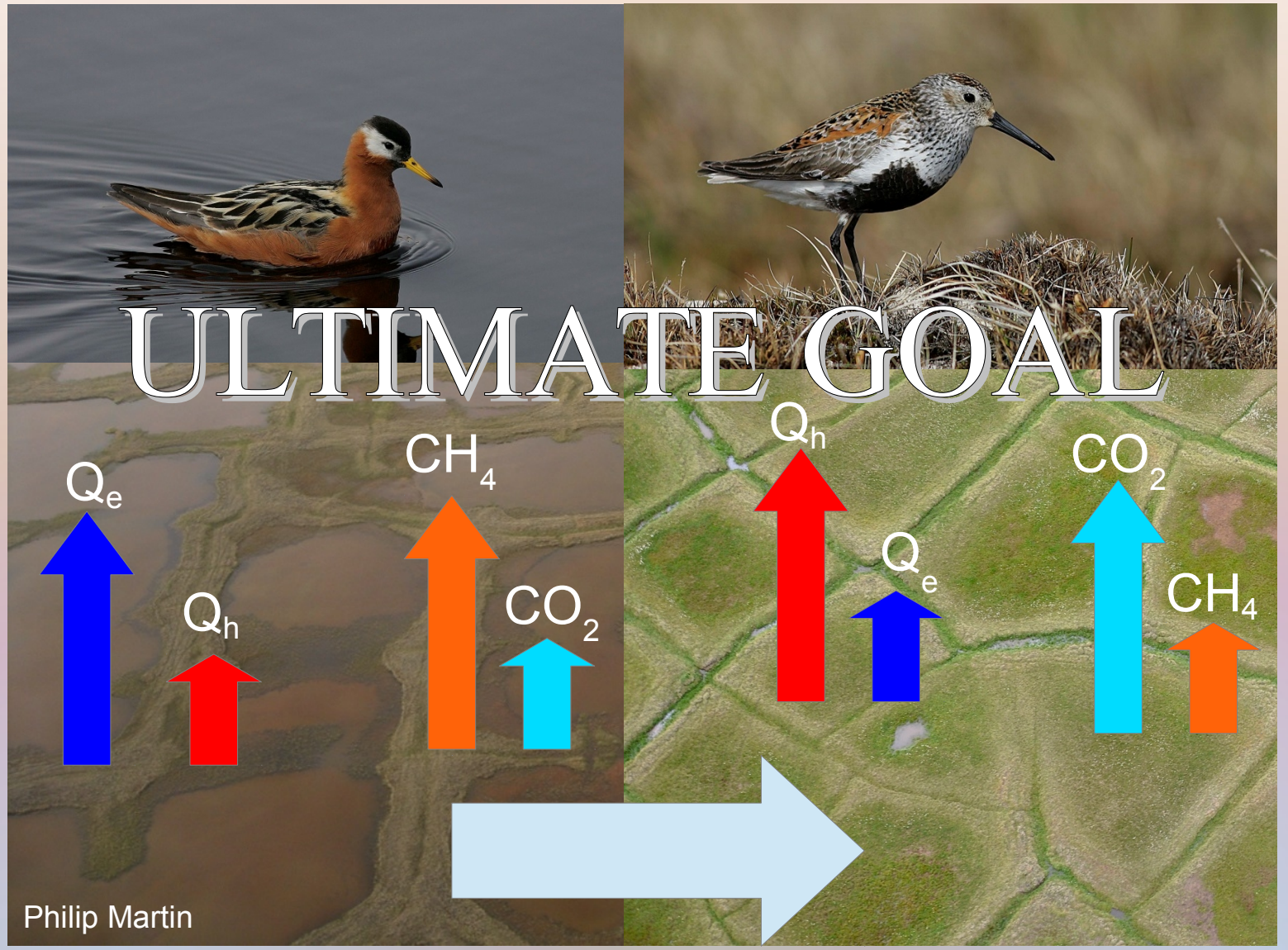
As spring comes sooner, geese arriving earlier to Colville River Delta nesting sites

Yereth Rosen | Alaska Dispatch News | October 23, 2015

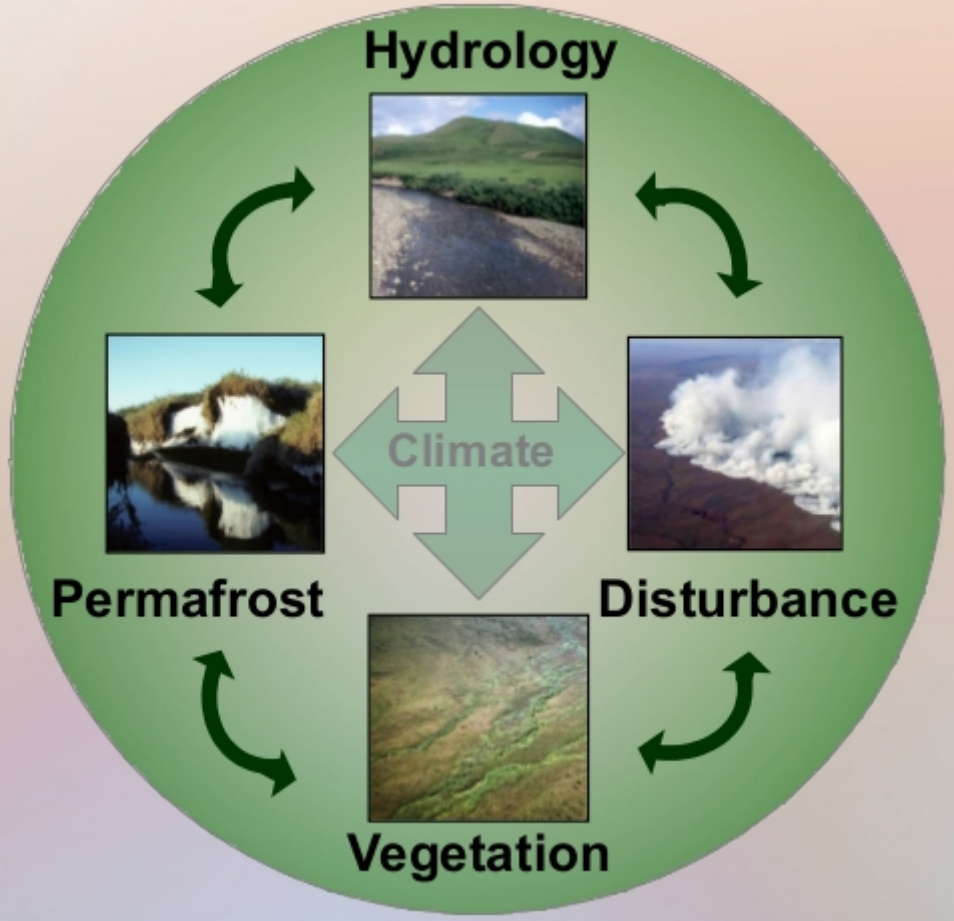
"Black brant have increased dramatically in number on the North Slope...sags in permafrost are changing hydrology and favoring the salt-tolerant plants that are most beneficial to brant..."

www.imgneed.com


Q_e
Q_h
CH_4
CO_2
Q_h
Q_e
CO_2
CH_4
Philip Martin


ULTIMATE GOAL
Q_e
Q_h
CH_4
CO_2
Q_h
Q_e
CO_2
CH_4
Philip Martin

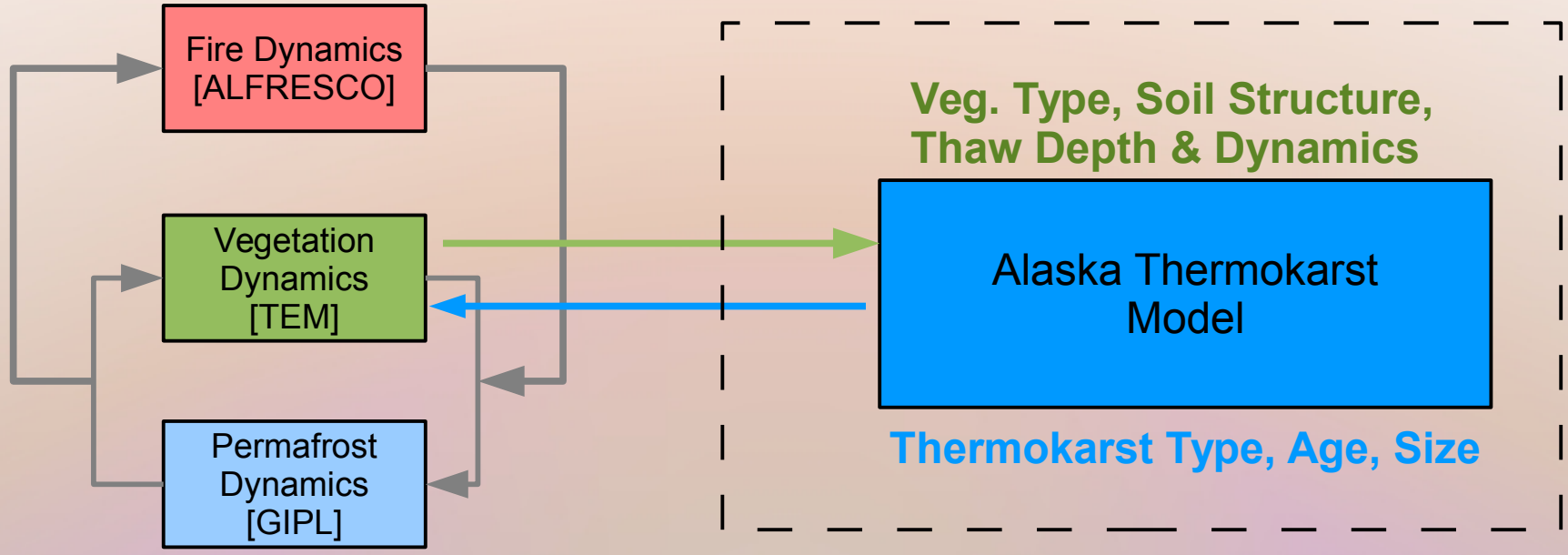
Integrated Ecosystem Model



The Integrated Ecosystem Model is a decision support tool to:

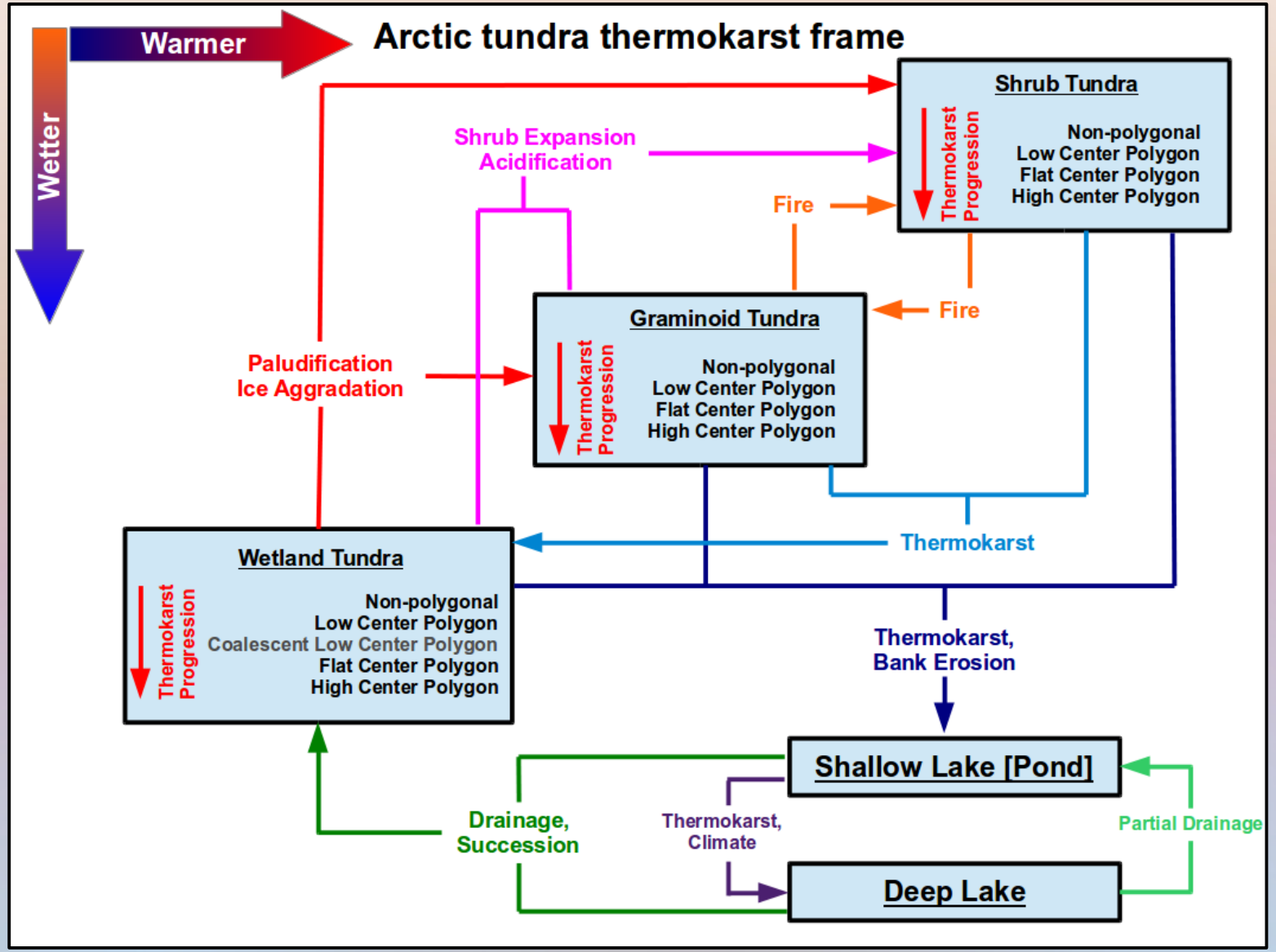
- Aid in understanding the nature and rate of landscape change
- Illustrate how landscapes are expected to respond to climate driven changes
- The Alaska Thermokarst Model is being developed as part of the IEM project

Alaska Thermokarst Model



- State-and-transition model
- Frame-based methodology to track cohorts
  - Unique, representative landscape unit
- The ATM tracks cohorts by fractional area of model element (NOT spatially-explicit)
- 1 km^2 resolution, 1-year time step
- Simulation period ~100 years from current
- Landscape transitions include: arctic tundra, boreal forest, and lakes

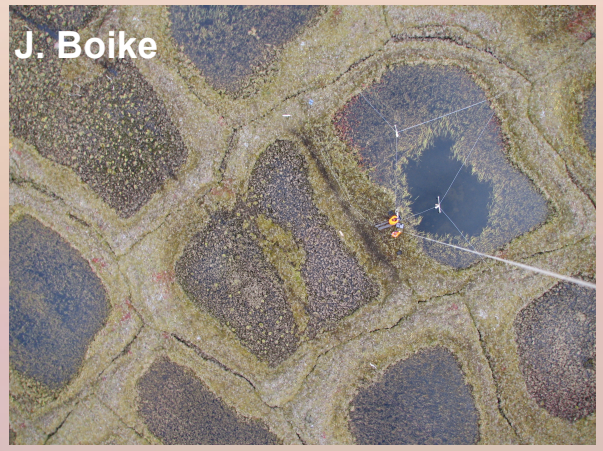
Alaska Thermokarst Model: Arctic Tundra



Alaska Thermokarst Model: Arctic Tundra

Non-Polygonal Ground

Low Centered Polygon



Coalescent Low Centered Polygon

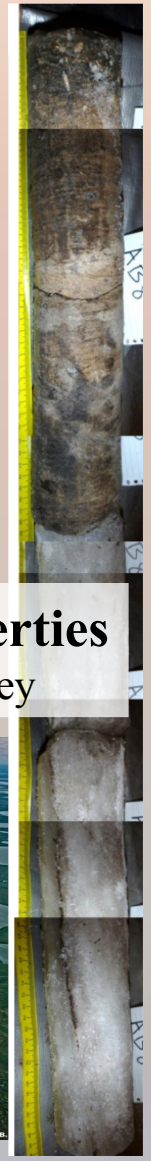
Flat Centered Polygon

High Centered Polygon

Lakes

ATM Data Requirements

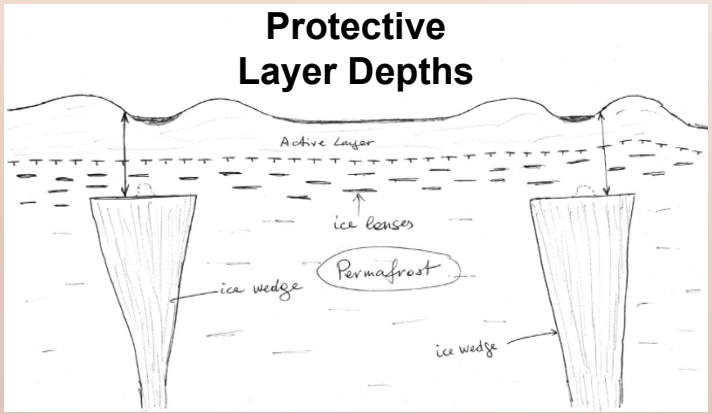
Landform Distribution



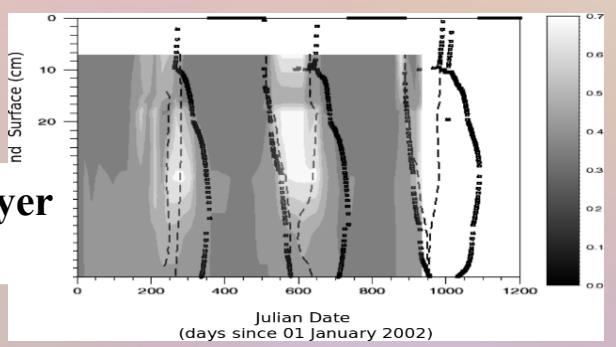
Soil Properties
Bob Busey

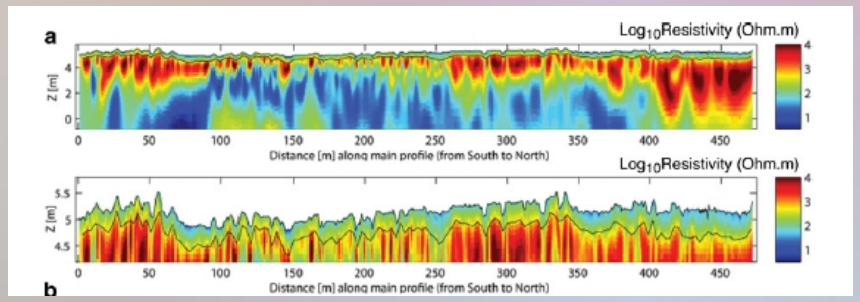
Drainage Efficiency

Protective Layer Depths



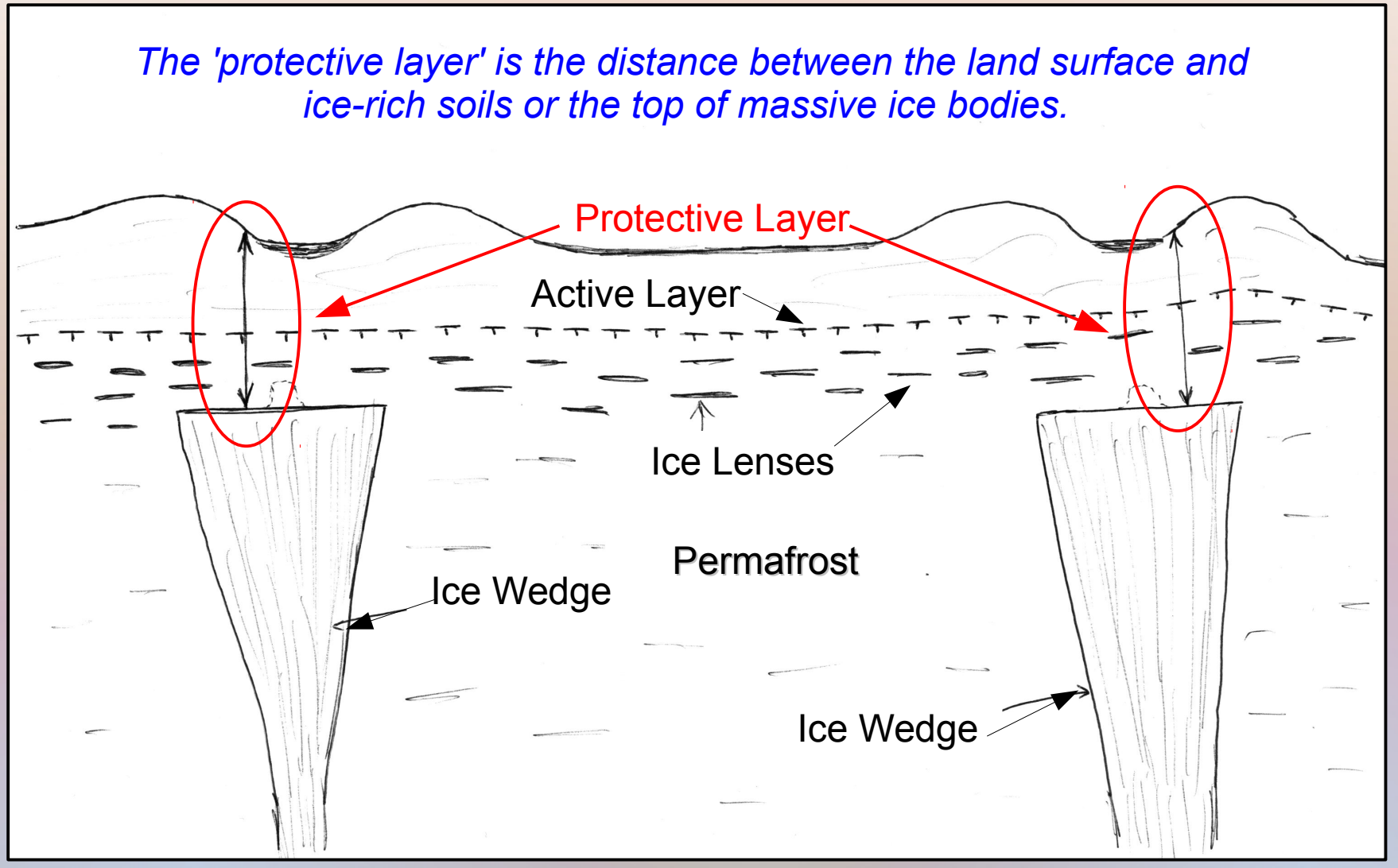
Active Layer Depth





Ice Content and Structure
Hubbard et al [2013]

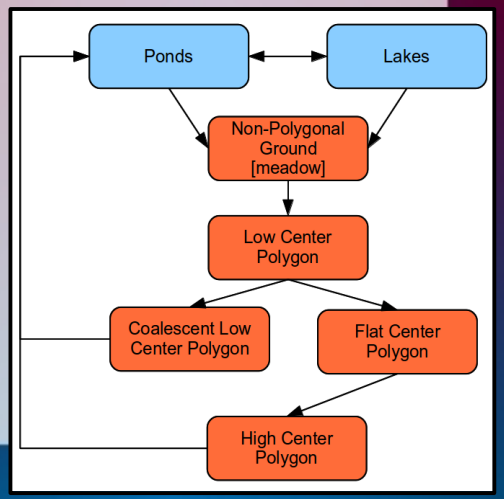
Protective Layer



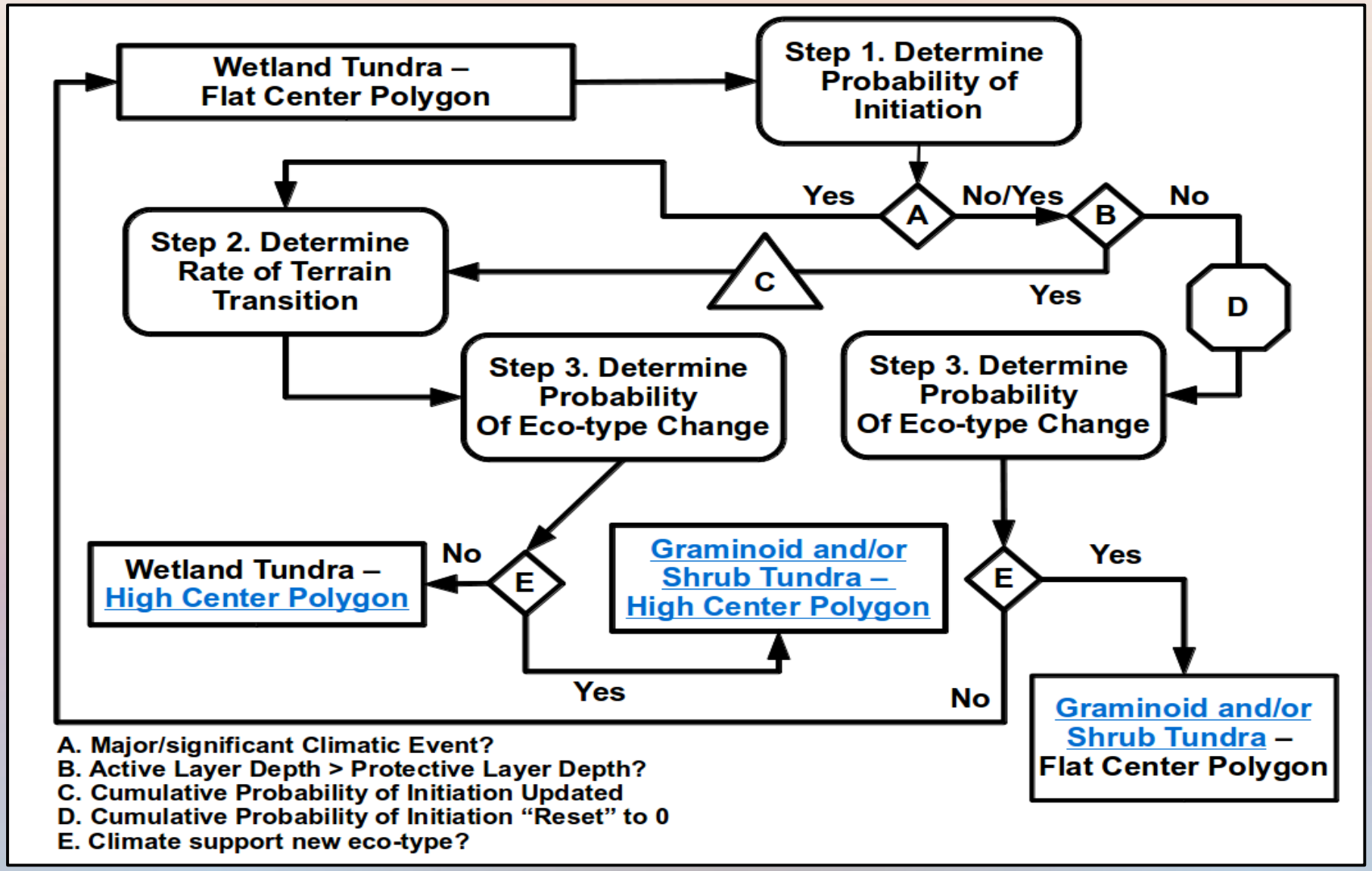
- Effectively the 'protective layer' is the maximum active layer depth over time.
- Provides a buffer between surface processes and the subsurface.

ATM - Arctic Tundra Assumptions

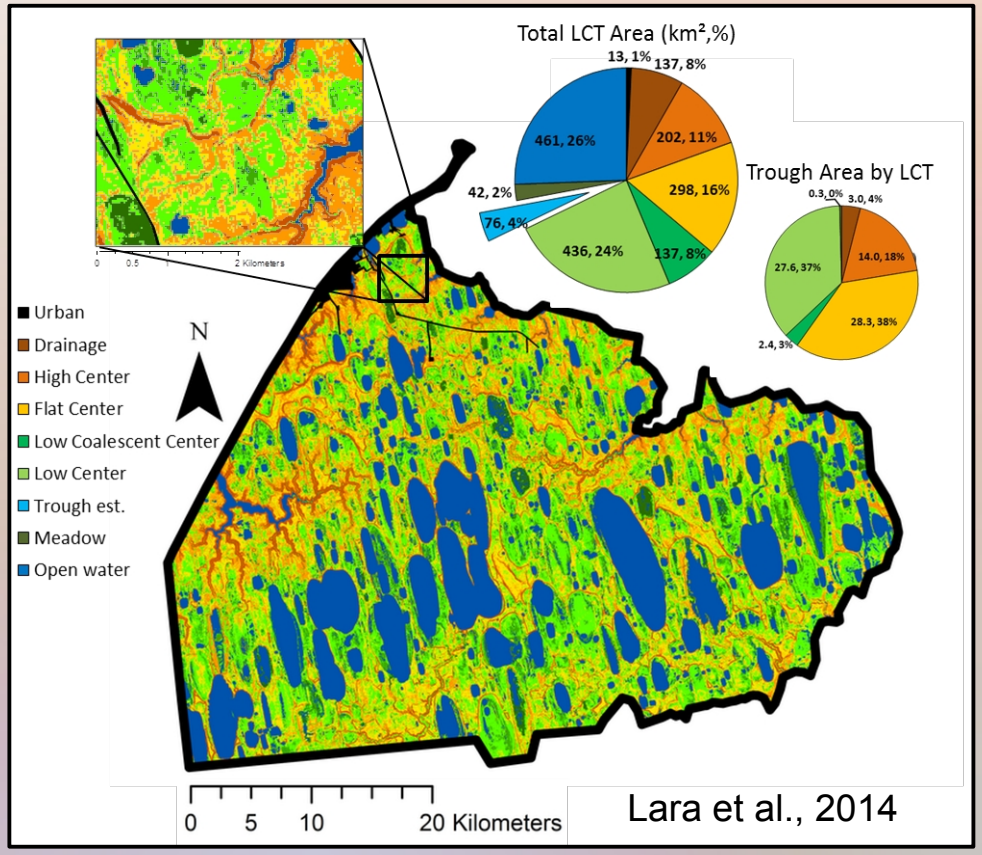
- Lakes and Ponds
  - Thick permafrost ≠ Vertical drainage
  - Lakes and Ponds expand at a prescribed rate (↓ and ↔)
  - Lakes ⇔ Ponds is determined by the Lake/Pond depth : Ice thickness ratio
  - Climatic events → Lateral drainage → Non-polygonal ground [meadows]
- Terrestrial Cohorts
  - 1-directional transitions
  - Transition occurs when the Active Layer Depth > Protective Layer Depth
  - Coalescent Low Center Polygons & High Center Polygons ⇒ Ponds

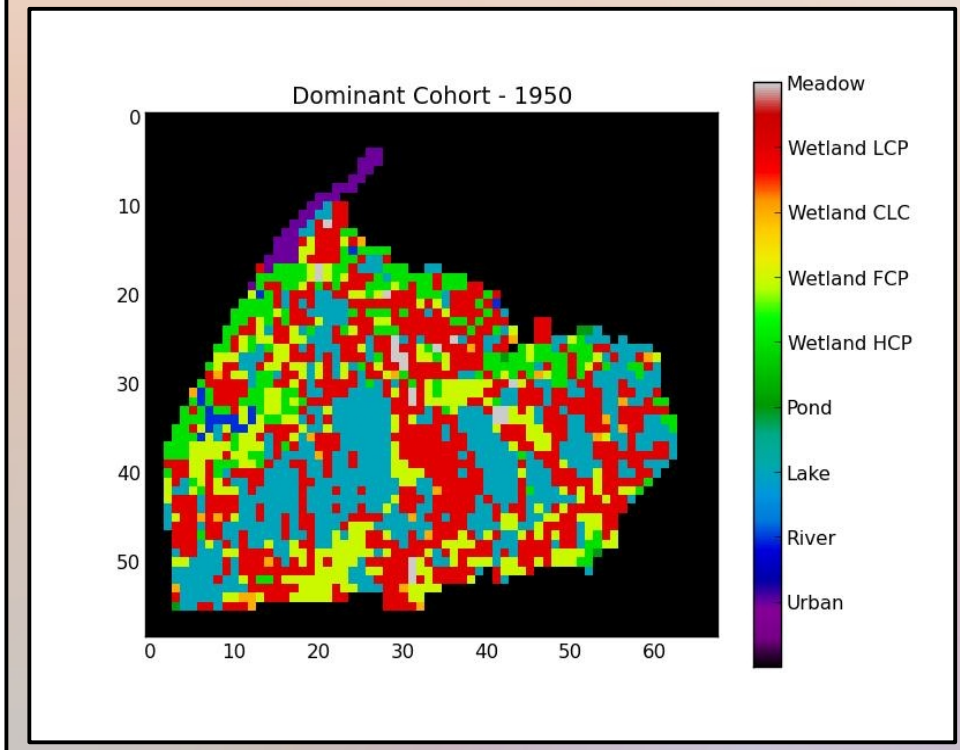


Cohort Frame Example



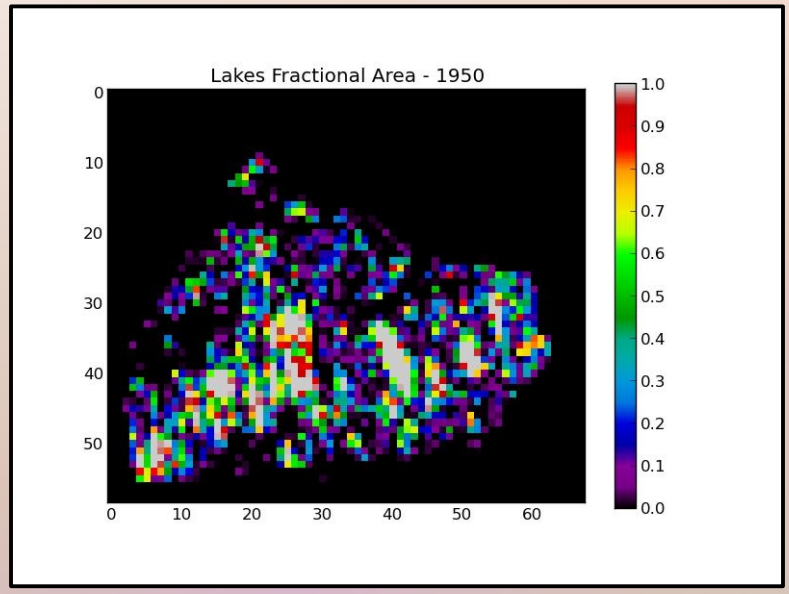
ATM Test Area: Barrow Peninsula

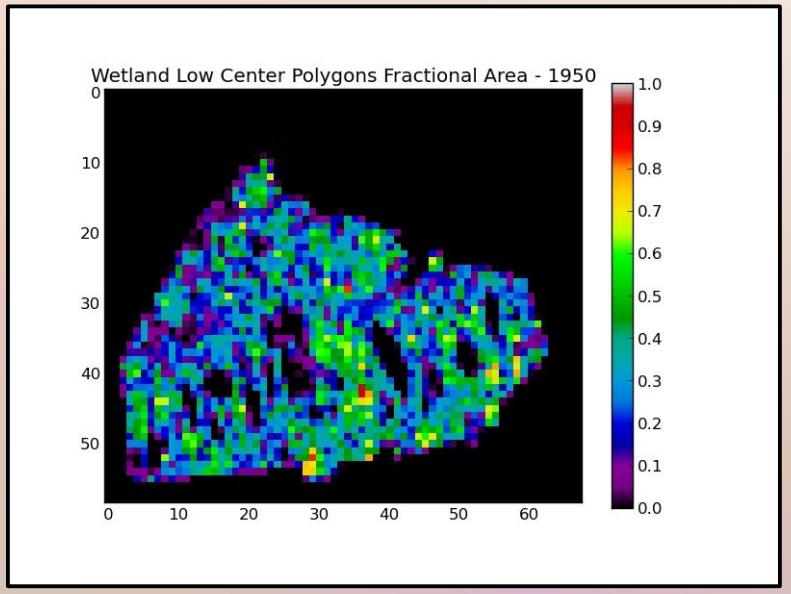


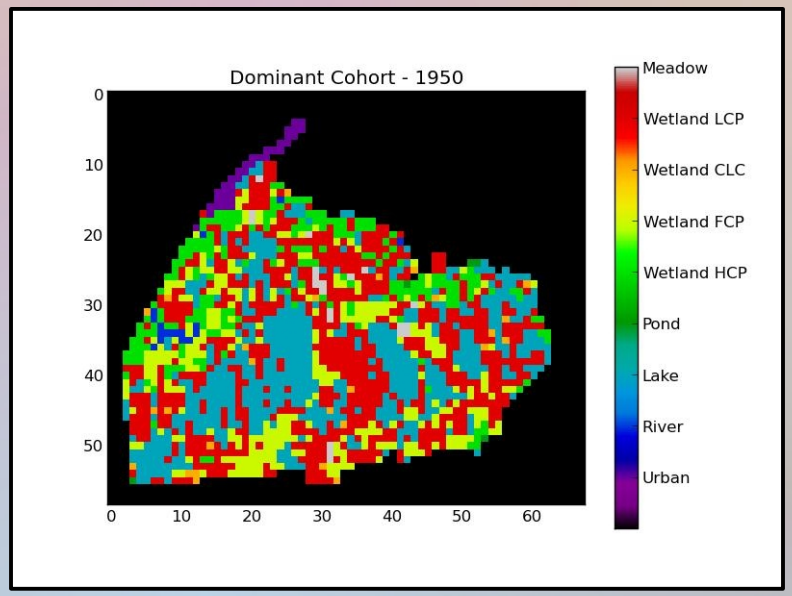


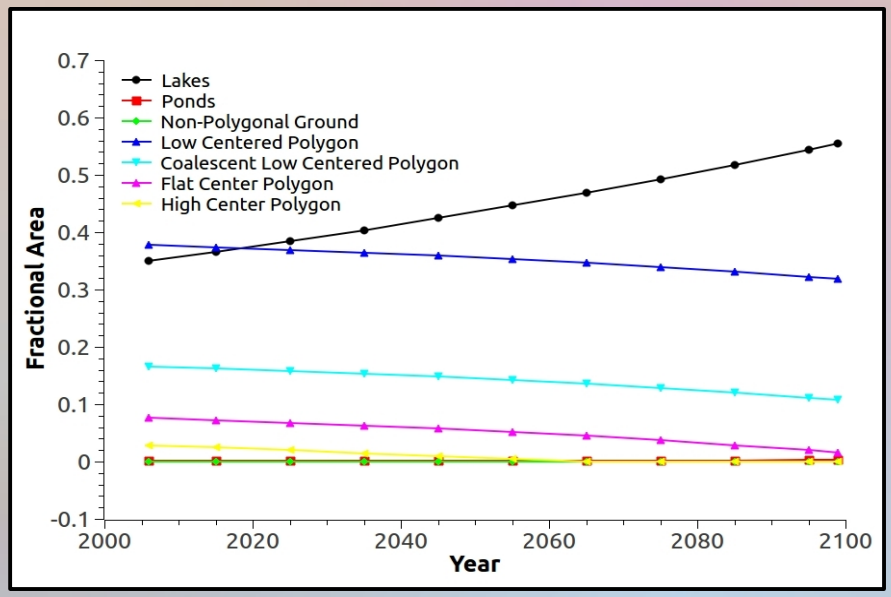
The Barrow Peninsula (1972 km^2) is being used to develop transition rates for all of the Wetland Tundra cohorts, Lakes and Ponds.

Alaska Thermokarst Model Output



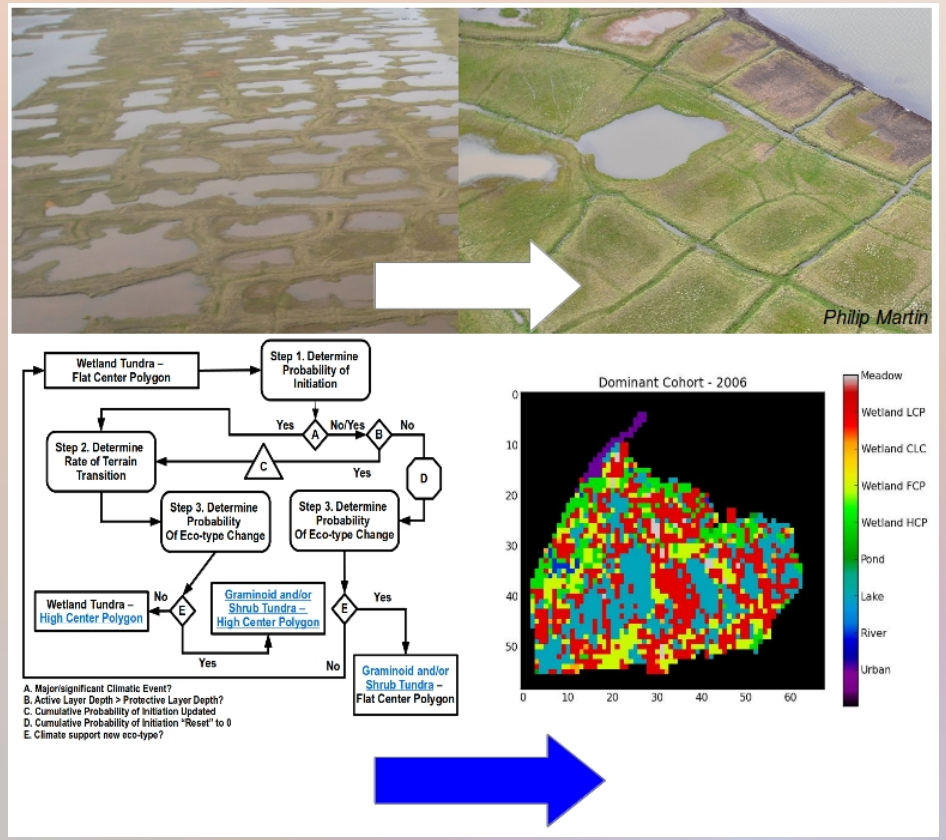






Discussion

- Thermokarst has an important role for both climate scientists and resource managers
- Input data sets are spatially variable and often difficult to measure
- Few studies document landscape change in the Arctic
- Creative approaches are needed in order to develop parameterizations and to test the model



Acknowledgements

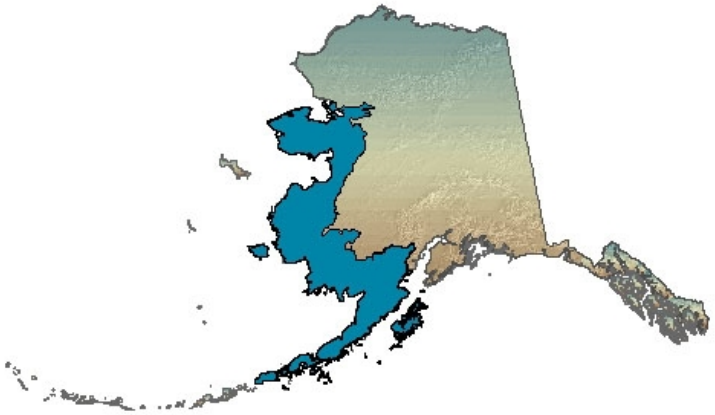
AK CSC
Alaska Climate Science Center

ALF TEM GIPL

Northwest Boreal
Landscape Conservation Cooperative

Arctic
Landscape
Conservation
Cooperative

Western Alaska LCC



Next-Generation Ecosystem Experiments: Arctic
Ecosystem Processes
Modeling, Prediction
Systems Understanding