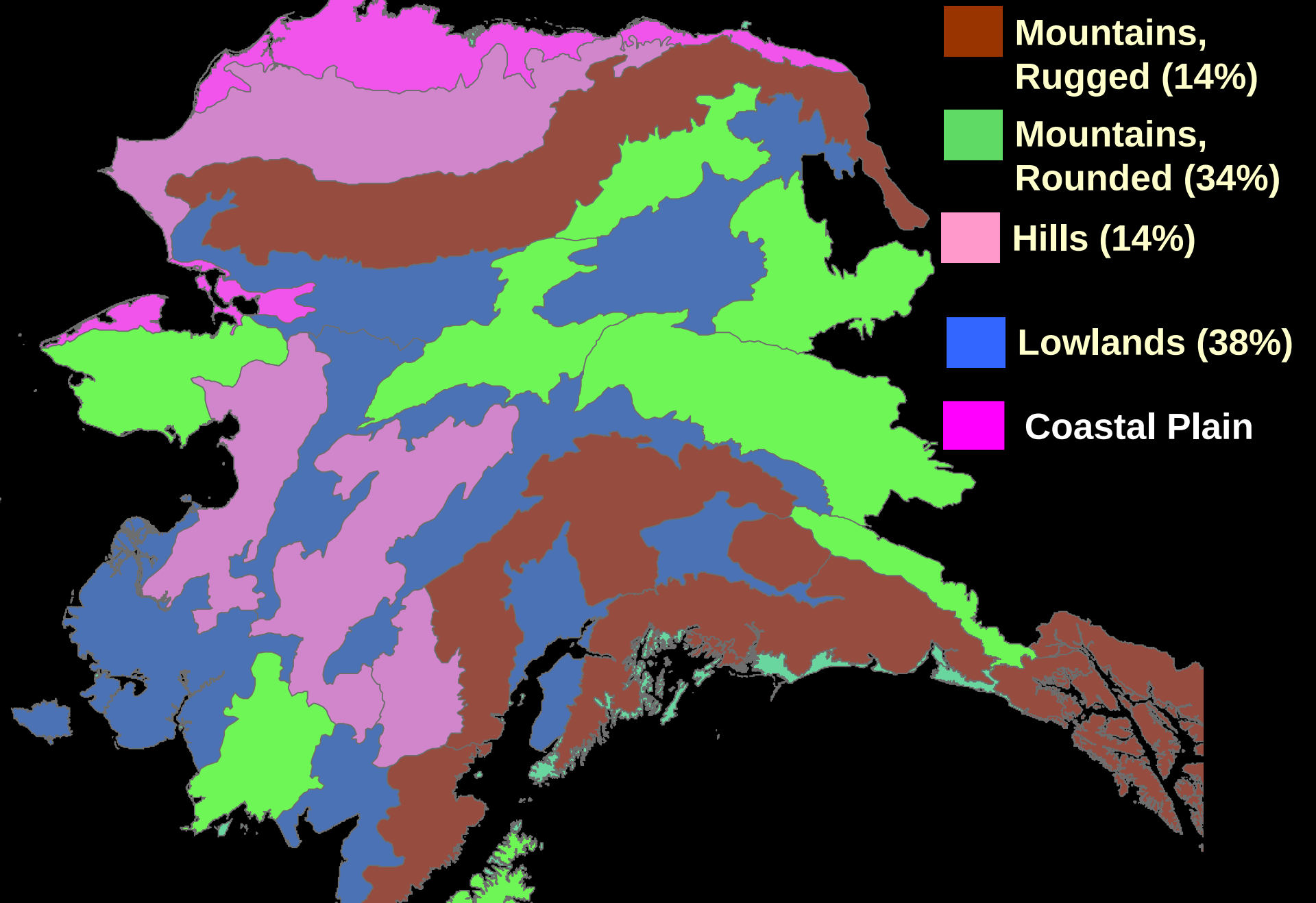
Habitat Changes Associated with Permafrost Influenced Geomorphic Processes

Torre Jorgenson

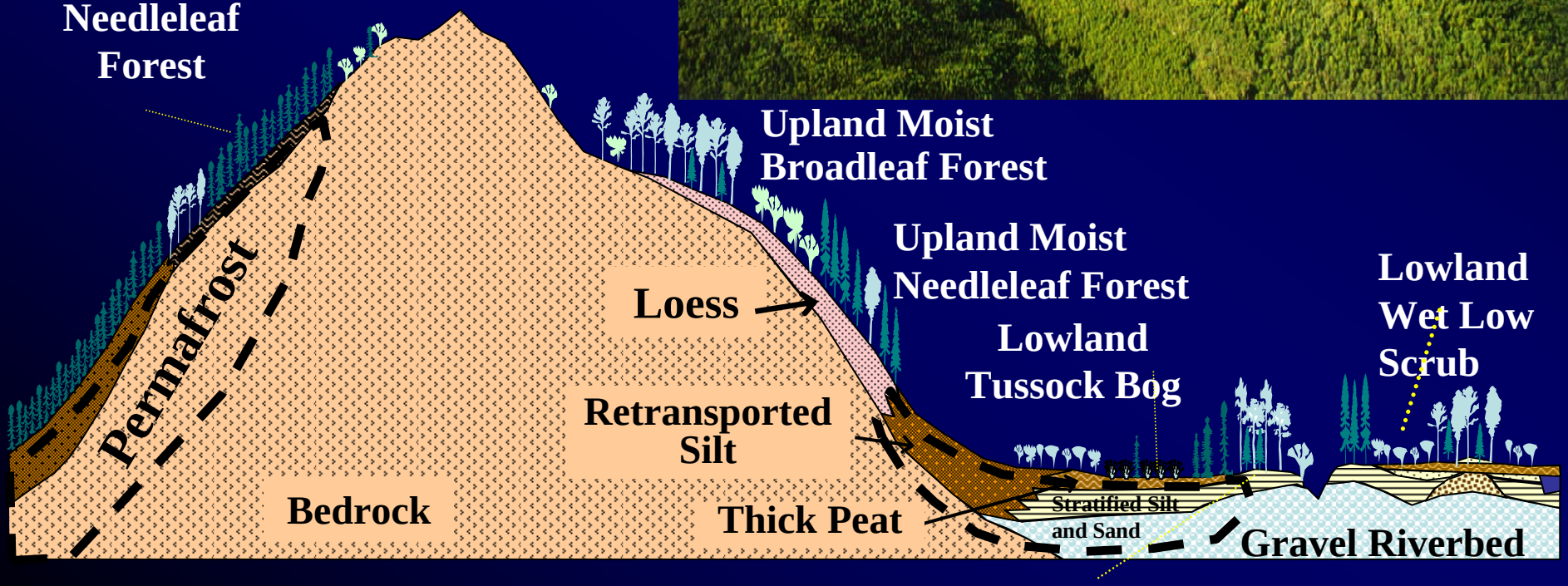
Change Associated with Geomorphic Processes

- Mountains
  - Glacial retreat, meltwater
  - Slope Failure
- Uplands
  - Loss of permafrost aquatard, drainage
  - Thaw slumps
  - Thermokarst Lakes in Extremely ice-rich loess (yedoma)
- Lowlands
  - Thermokarst lakes, waterbody creation
  - Forest conversion
  - Paludification in Thermokarst Bogs and Fens
  - Lake shrinkage: evaporating, draining, infilling
- Floodplains
  - Changing flooding, sedimentation, channel migration
- Coastal
  - Storm surges, sedimentation, salinization, permafrost degradation

PHYSIOGRAPHY OF ECOREGIONS



Topography and Soils



Slope Processes

Thaw Slumps on Ice-rich Colluvium

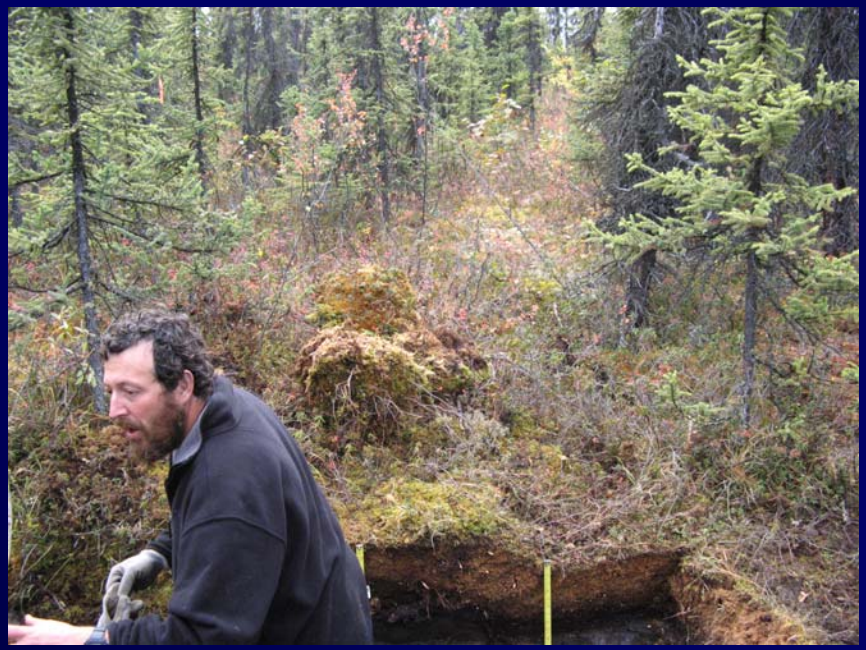
Interaction of Slopes, Permafrost, and Fire

Active-layer Detachment Slides

After fire in summer 2004

Photograph by Will Putman

Drying Uplands after Permafrost Thaw:



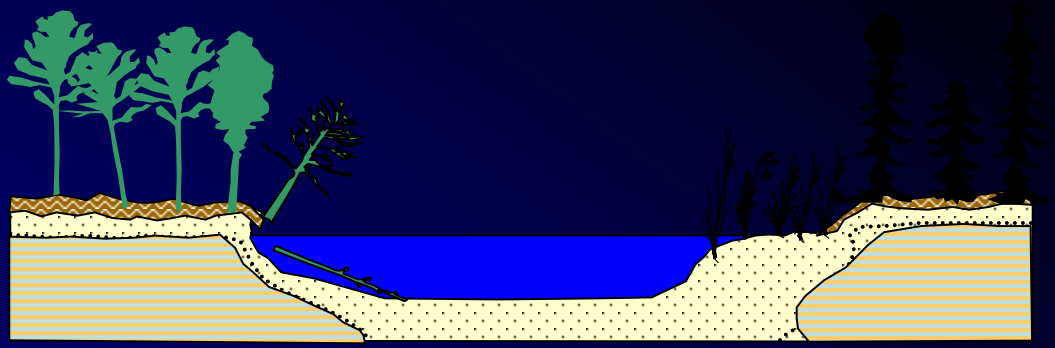
Ecosystem Driven Permafrost

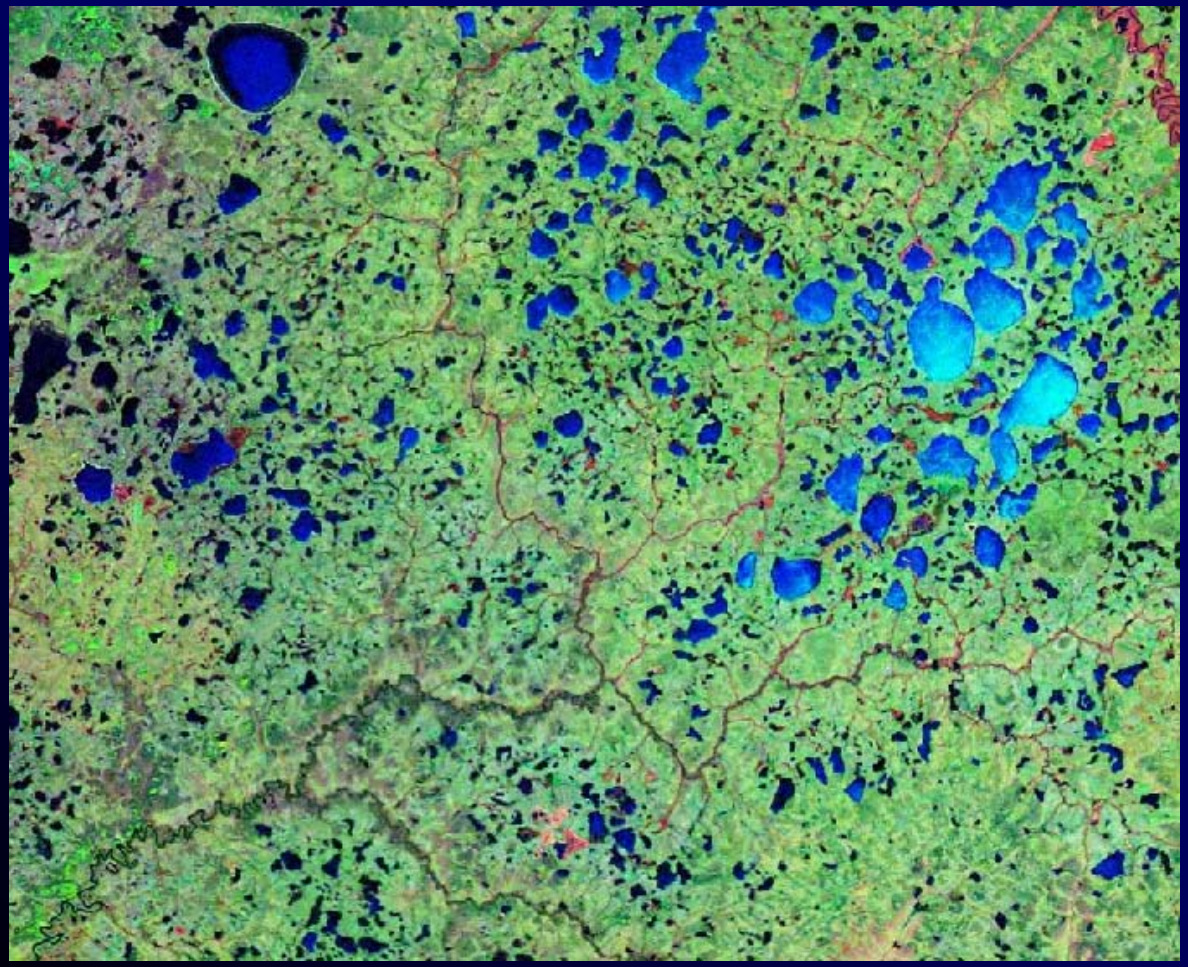
Common Permafrost-Dominated Ecosystems

Layered, Broken

Organic-Matrix Ice

Thermokarst Lake





<u>Ecosystems</u>

Eutrophic Lakes

Shore fens (paludification)

Wet/Moist Meadows (drainage)

Koyukuk National Wildlife Refuge

Thermokarst Lake Evolution

<u>Lake Drainage:</u>

Tapped Lakes (lateral drainage)

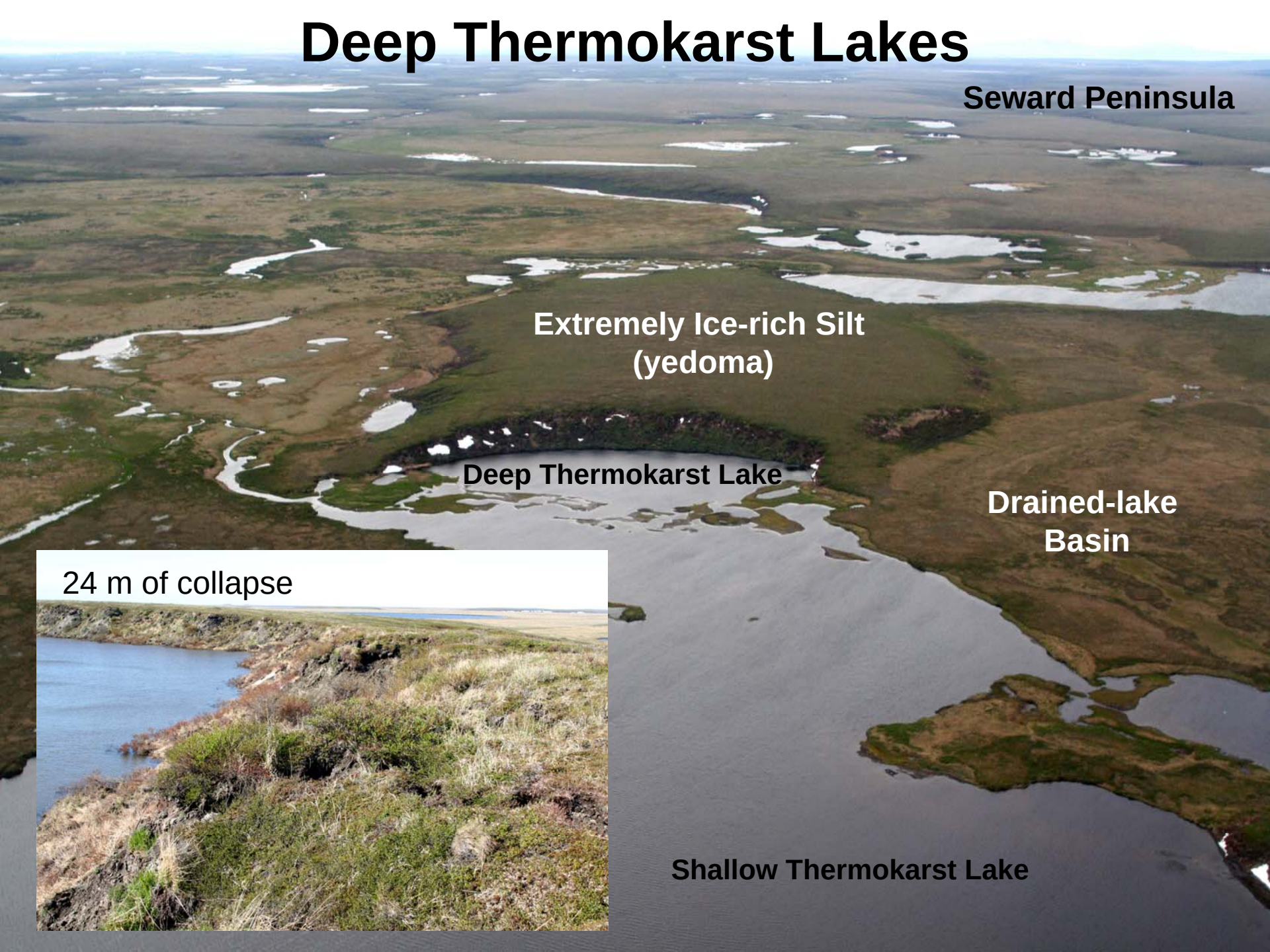
Drainage (lost of permafrost containment)

Organic Infilling

Drying (water balance)

Yukon Flats

Deep Thermokarst Lakes



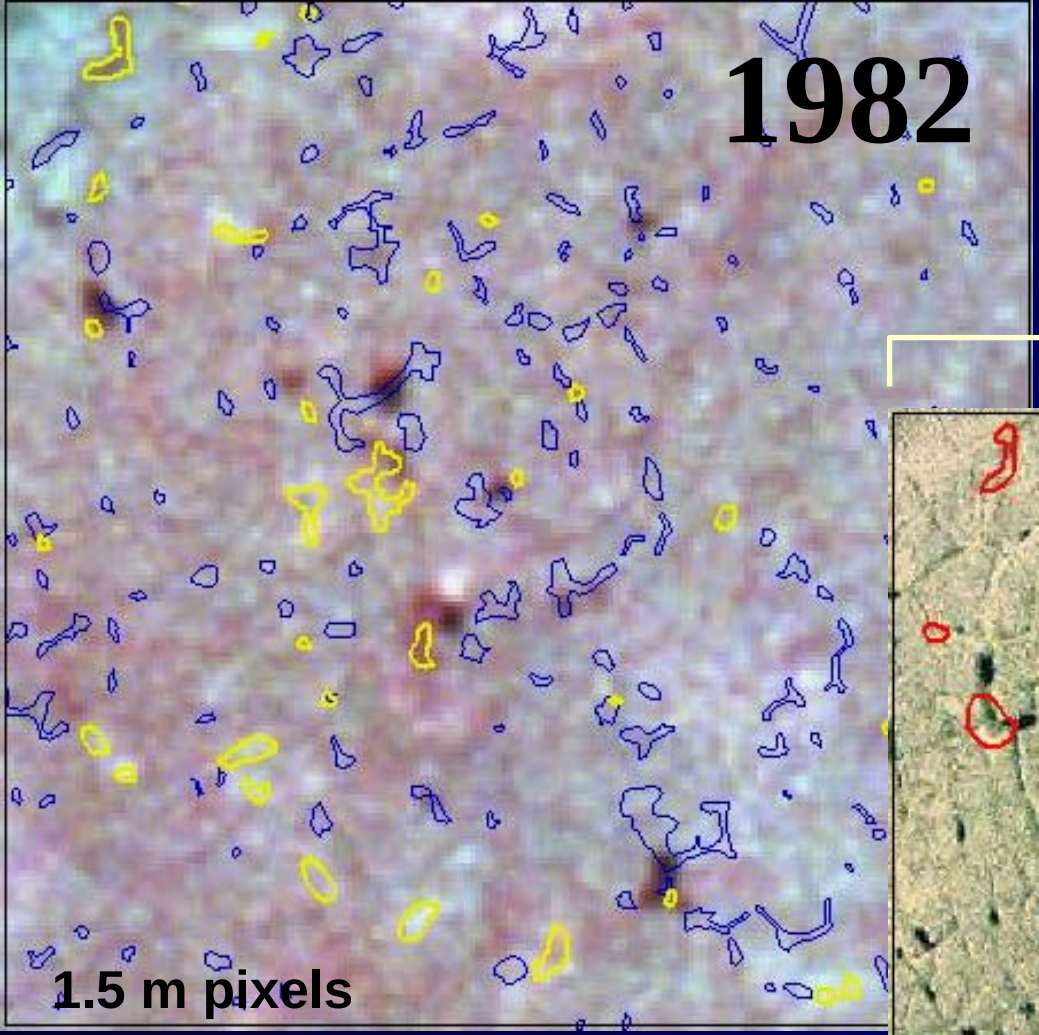
Innoko Flats

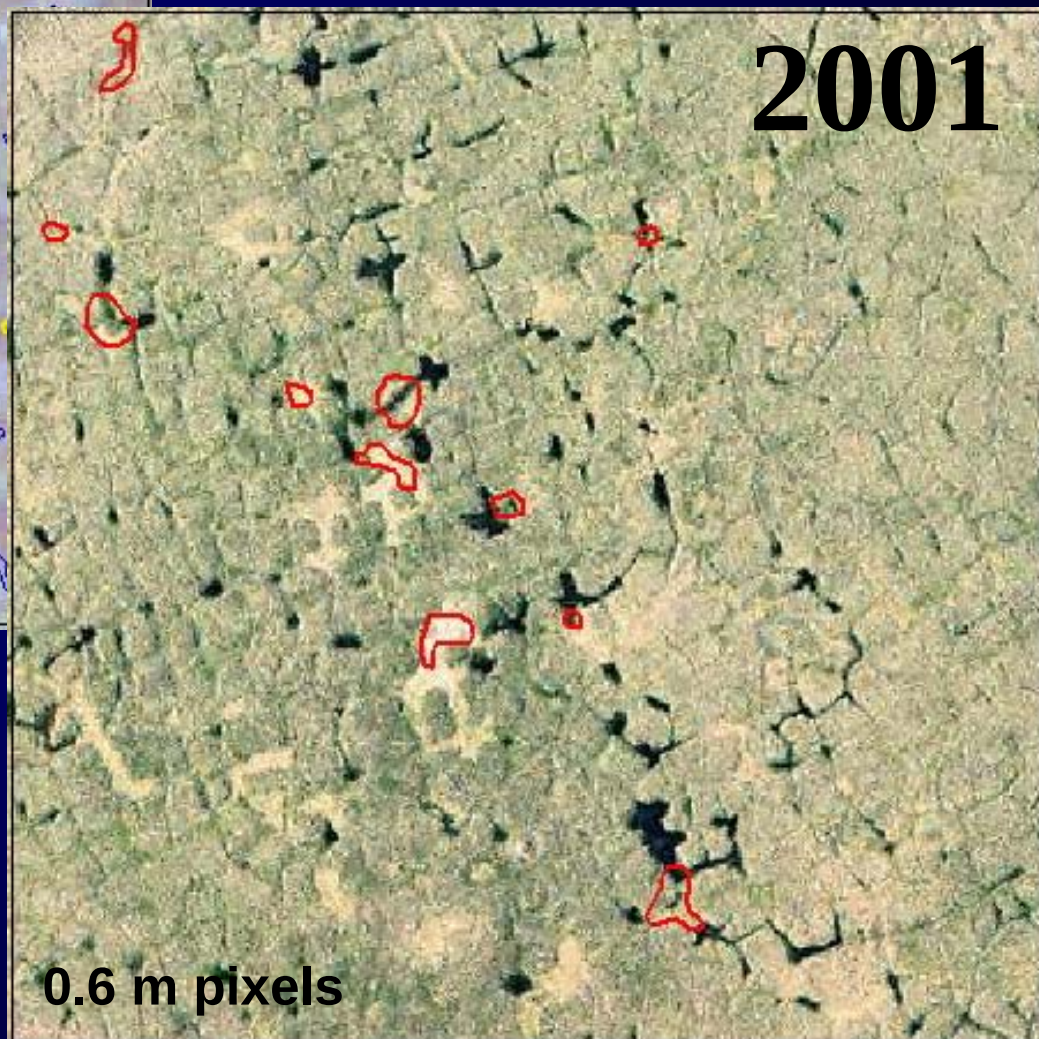
Collapse-scar Bog, Innoko Flats

Thermokarst Pits

1945 1982 2001

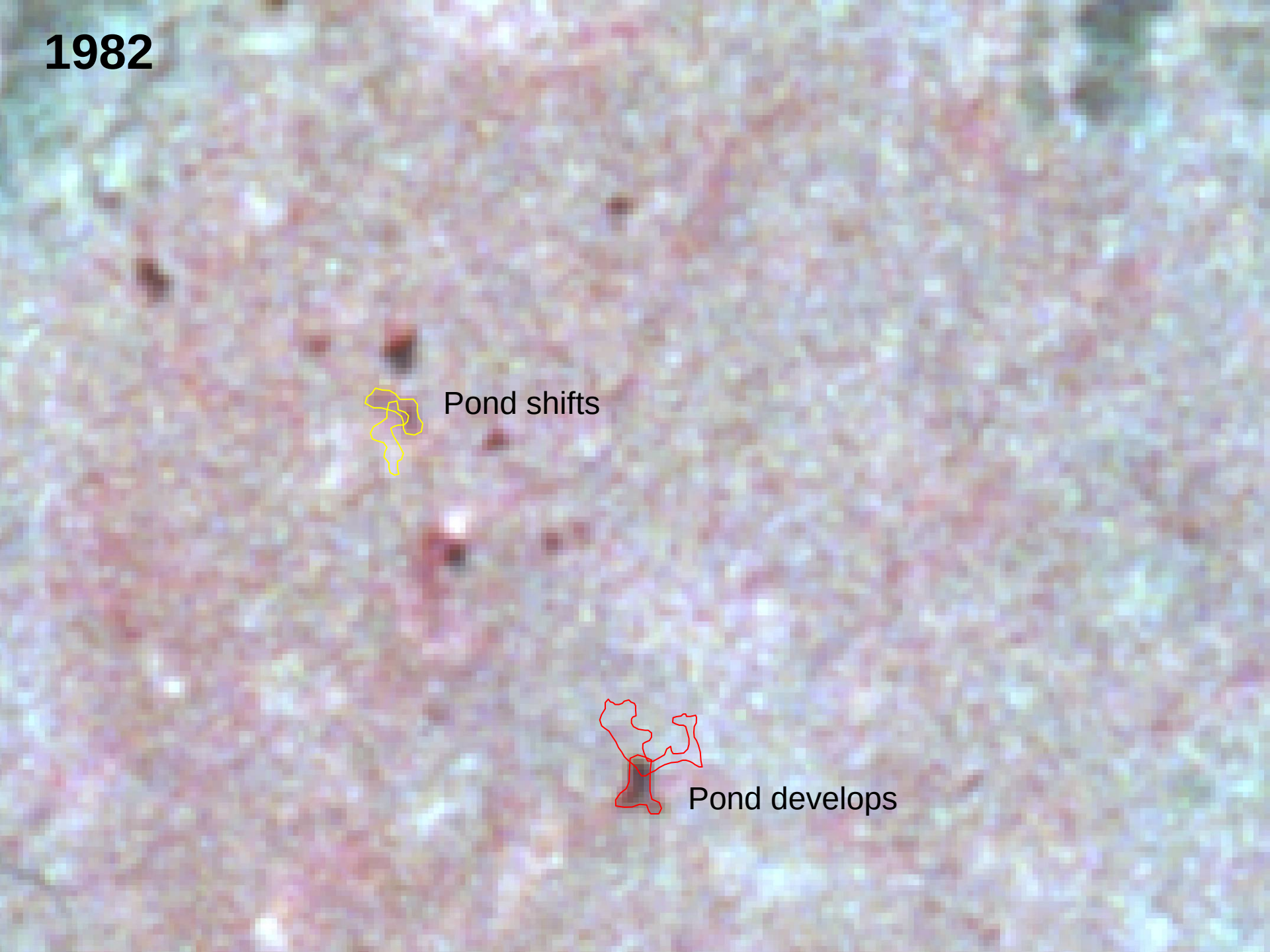
250 m

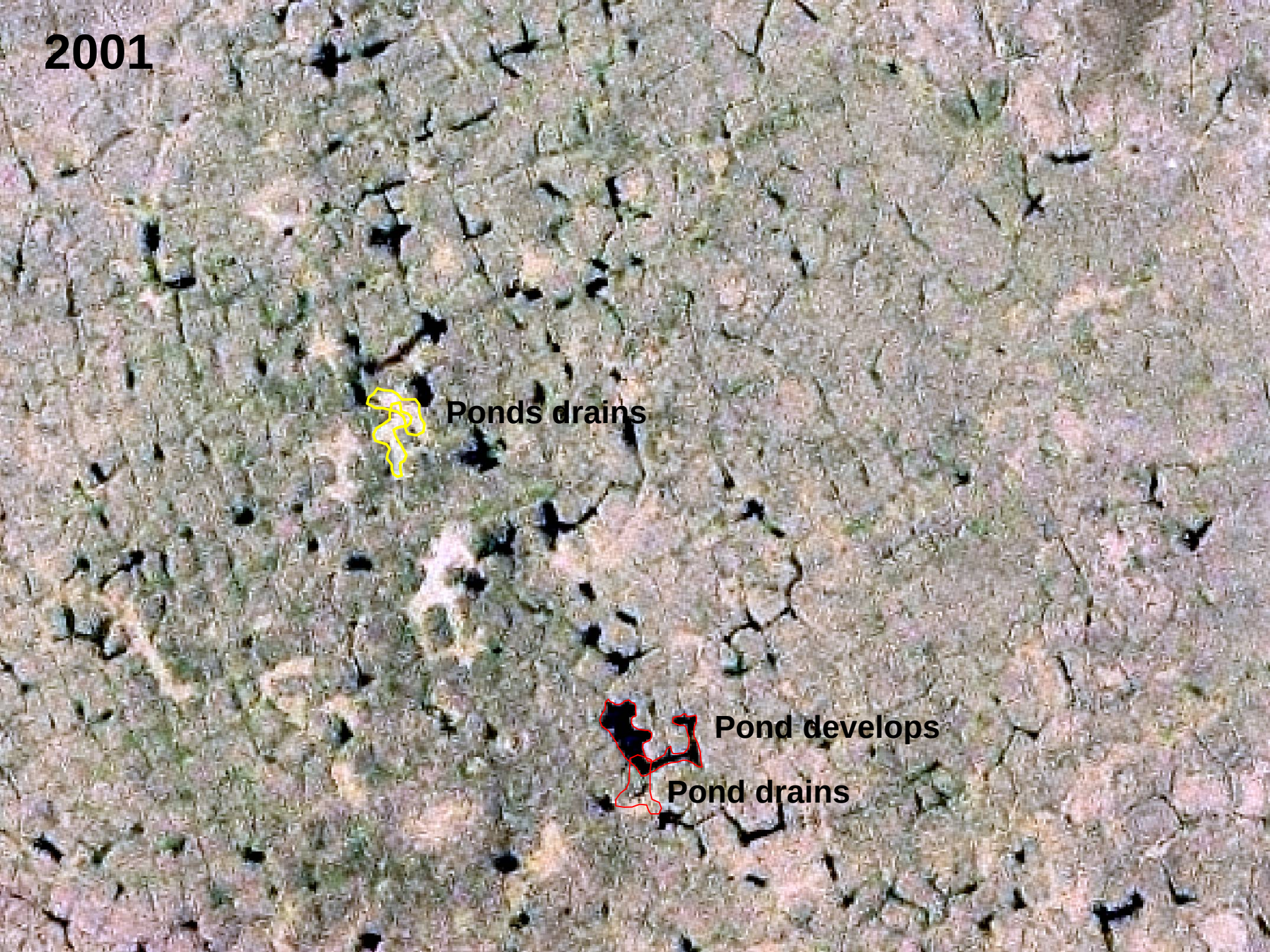




- 93% (n=202) of easily visible large pits (>9 m^2) in 2001 not evident in 1982
- Area increased from 1.0% in 1982 to 5.4% in 2001

Time Series: Beaufort Coastal Plain

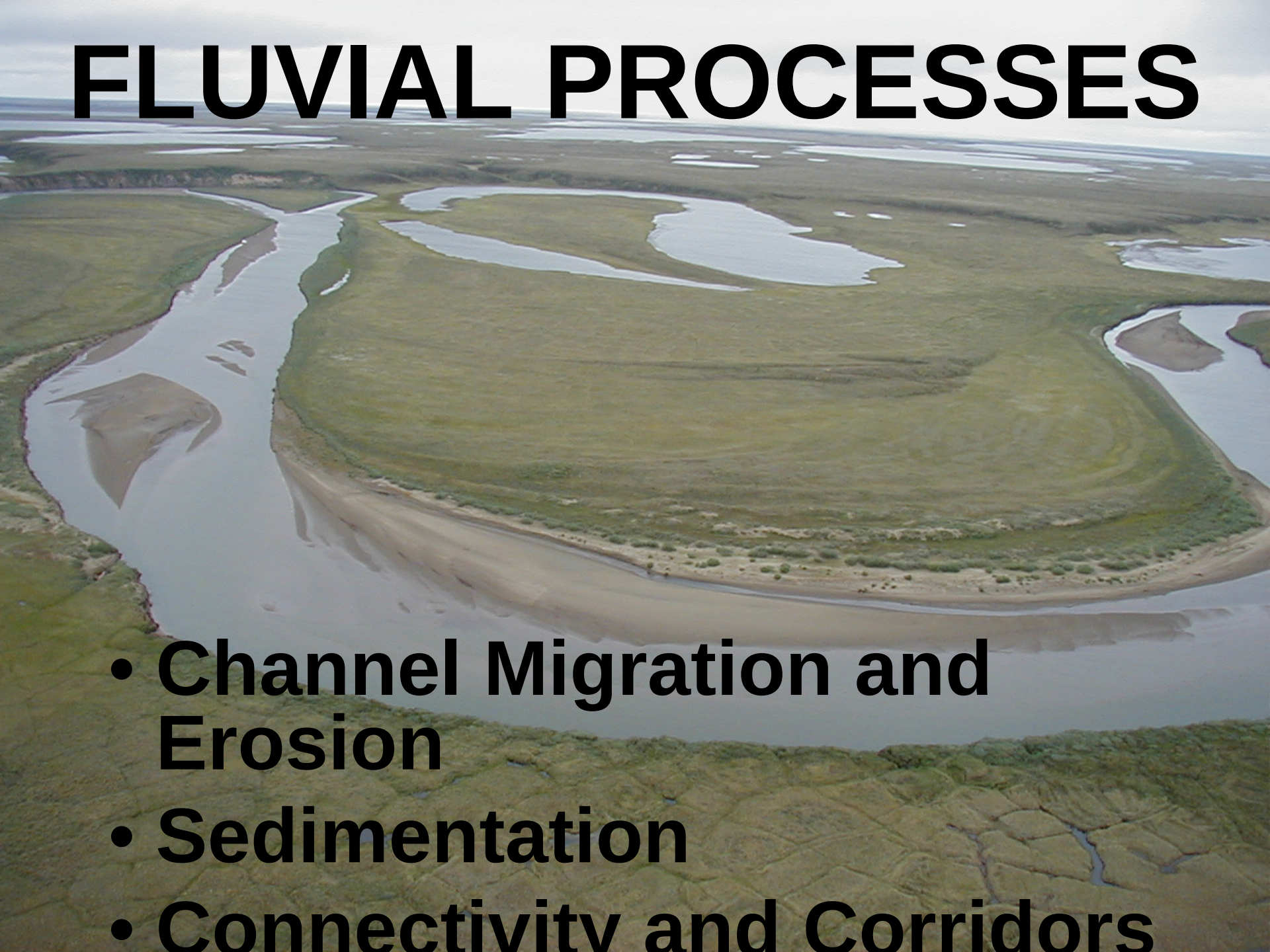

1982
Pond shifts
Pond develops


2001
Ponds drains
Pond develops
Pond drains

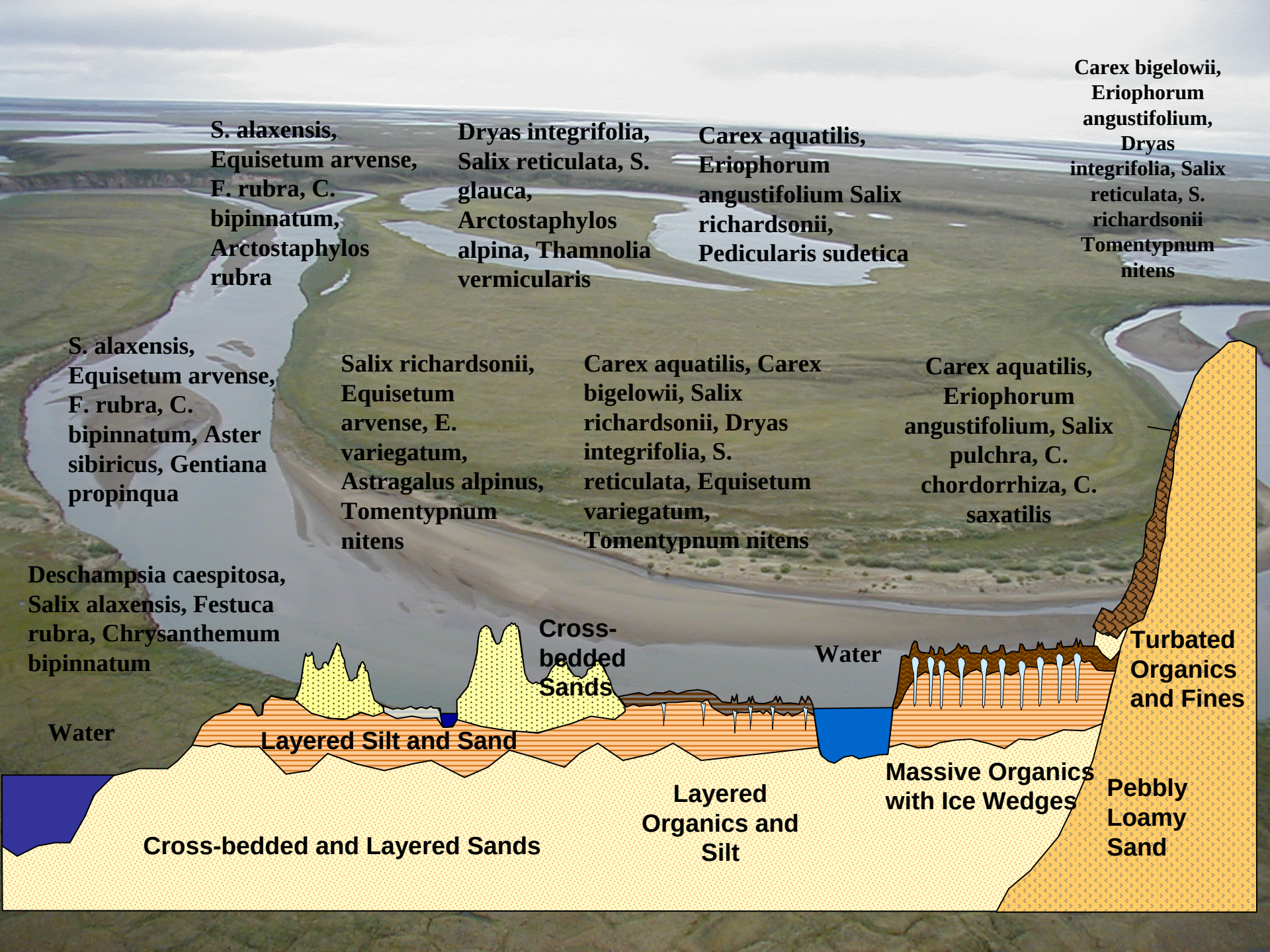
1982

2001

FLUVIAL PROCESSES



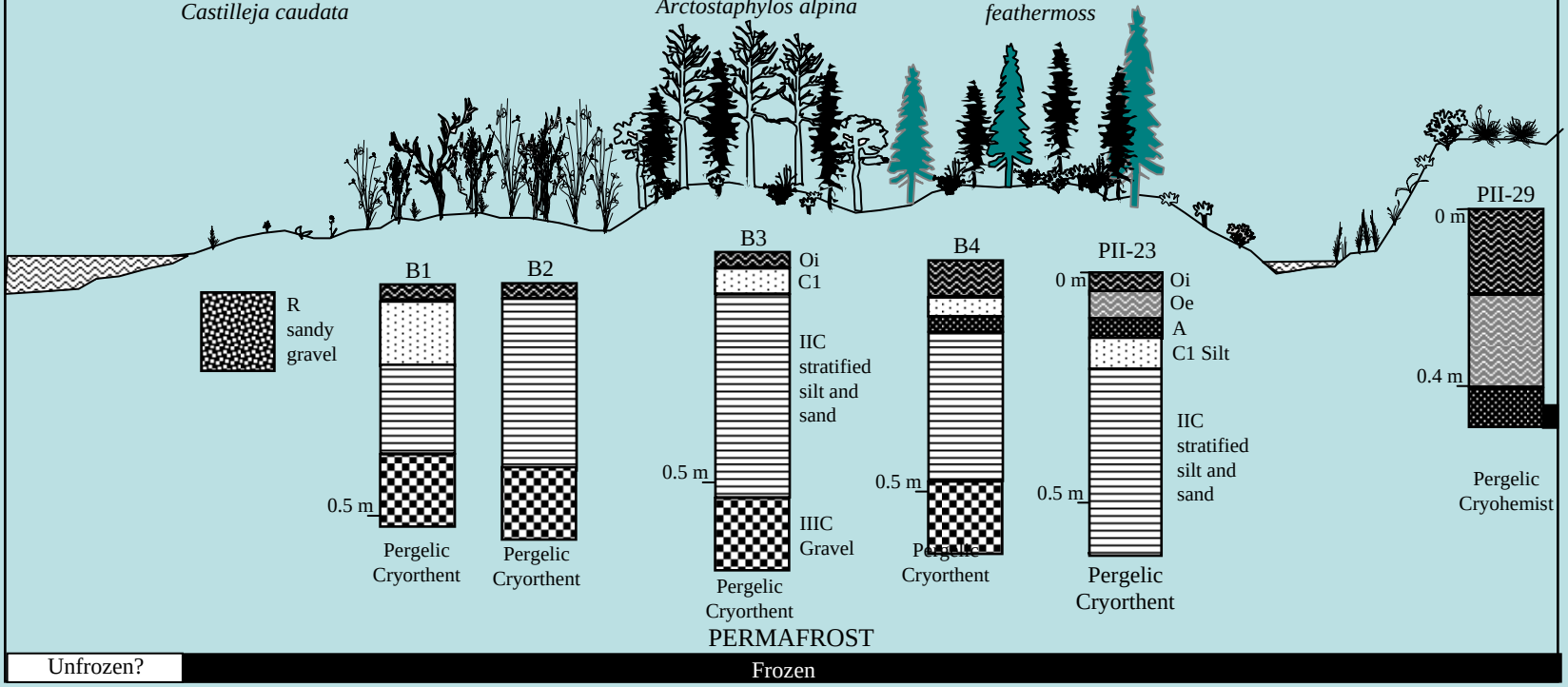
- Channel Migration and Erosion
- Sedimentation
- Connectivity and Corridors


S. alaxensis, Equisetum arvense, F. rubra, C. bipinnatum, Arctostaphylos rubra
Dryas integrifolia, Salix reticulata, S. glauca, Arctostaphylos alpina, Thamnolia vermicularis
Carex aquatilis, Eriophorum angustifolium Salix richardsonii, Pedicularis sudetica
Carex bigelowii, Eriophorum angustifolium, Dryas integrifolia, Salix reticulata, S. richardsonii Tomentypnum nitens
S. alaxensis, Equisetum arvense, F. rubra, C. bipinnatum, Aster sibiricus, Gentiana propinqua
Salix richardsonii, Equisetum arvense, E. variegatum, Astragalus alpinus, Tomentypnum nitens
Carex aquatilis, Carex bigelowii, Salix richardsonii, Dryas integrifolia, S. reticulata, Equisetum variegatum, Tomentypnum nitens
Carex aquatilis, Eriophorum angustifolium, Salix pulchra, C. chordorrhiza, C. saxatilis
Deschampsia caespitosa, Salix alaxensis, Festuca rubra, Chrysanthemum bipinnatum
Cross-bedded Sands
Water
Turbated Organics and Fines
Water
Layered Silt and Sand
Massive Organics with Ice Wedges
Pebbly Loamy Sand
Layered Organics and Silt
Cross-bedded and Layered Sands

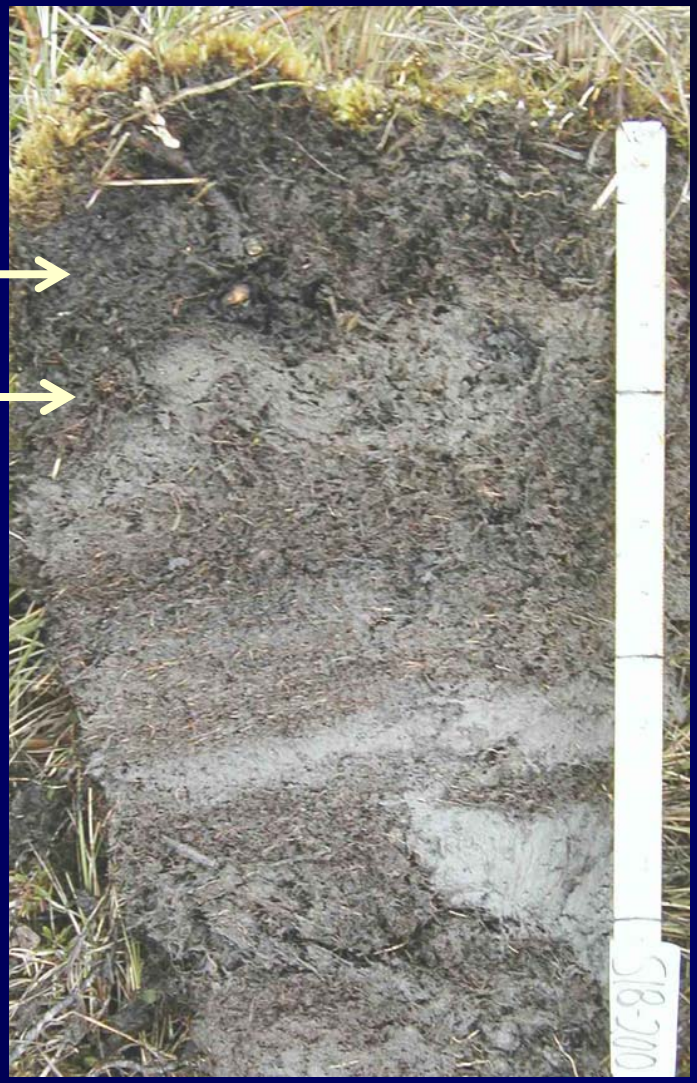
TOPOGRAPHIC GRADIENTS

LOWER NOATAK FLOODPLAIN

Non-glacial River	Meandering Channel	Active Floodplain Cover Deposit	Inactive Floodplain Cover Deposit		Abandoned Channel	Loess/ Alluvial Terrace
Water	Nonpatterned	Nonpatterned	Non-patterned		Nonpatterned	Frost boils
Water	Partially Vegetated *Aster sibirica* *Equisetum arvense* *Artemisia tilesii* *Epilobium latifolium* *Castilleja caudata*	Closed Tall Willow *Salix alaxensis* *Salix planifolia* *Salix lanata* *Equisetum arvense*	Closed Cottonwood-Spruce Forest *Populus balsamifera* *Picea glauca* *Sheperdia canadensis* *Potentilla fruticosa* *Arctostaphylos alpina*	Open Spruce Forest *Picea glauca* *Salix lanata* *Salix glauca* *V. Uliginosum* *Equisetum arvense* *feathermoss*	Wet Sedge-Meadow Tundra *Carex aquatilis* *Equisetum fluviatile*	Mesic Shrub-Tussock Tundra



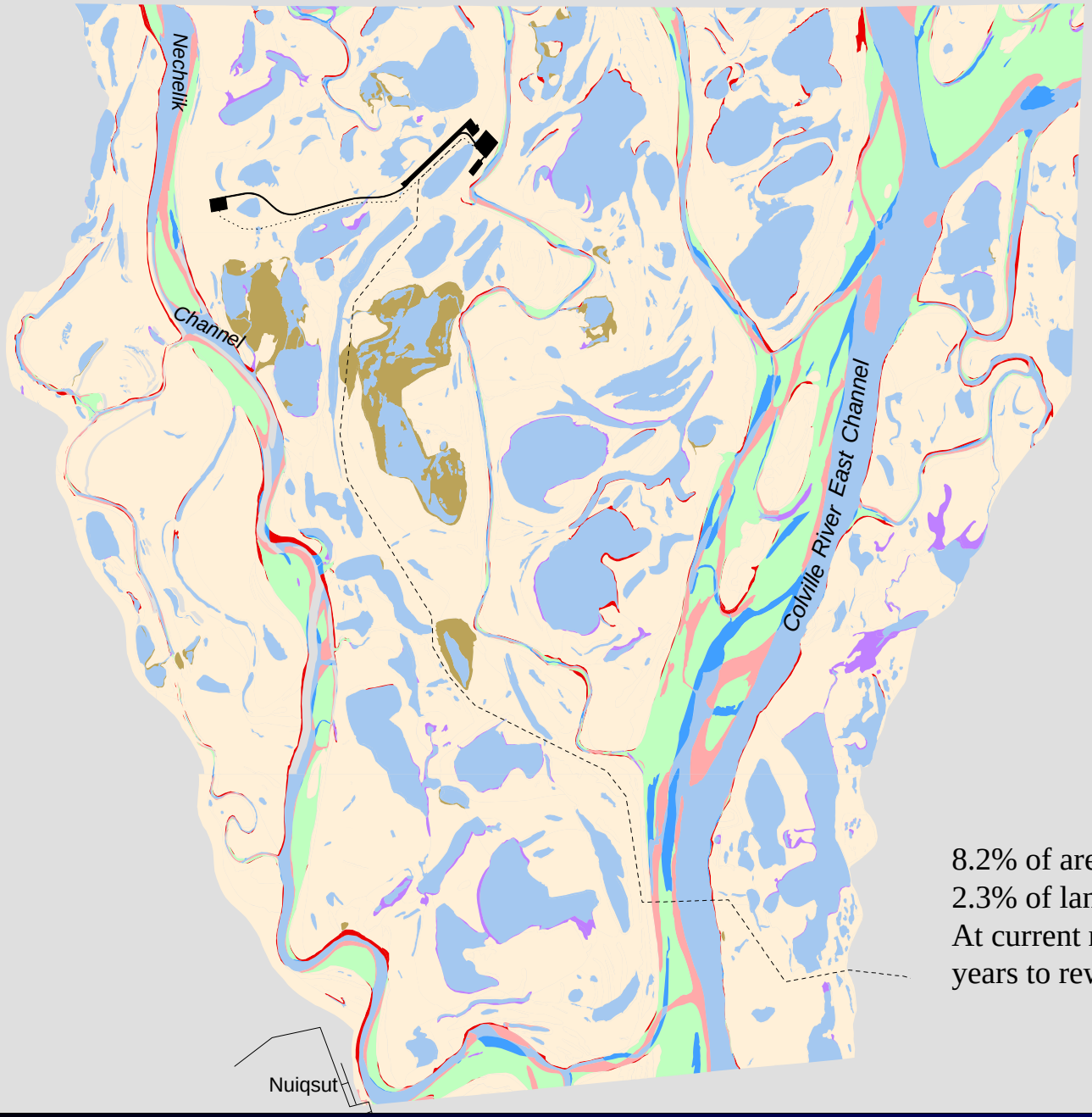
SEDIMENTATION



1993

1989

1996 **2003**



N

SCALE IN MILES

0 1 2

Areas of Erosion and Deposition

	Area (%)
Eroded Riverbed/Sandbar	1.3
Riverbed/Sandbar Deposition	2.6
Unchanged Riverbed/Sandbar	7.6
Thaw Basin Drainage/Deposition	1.8
Other Eroded Terrain	1.0
Unchanged Terrain	58.8
Lake-level Change	0.9
Unchanged Water	26.1

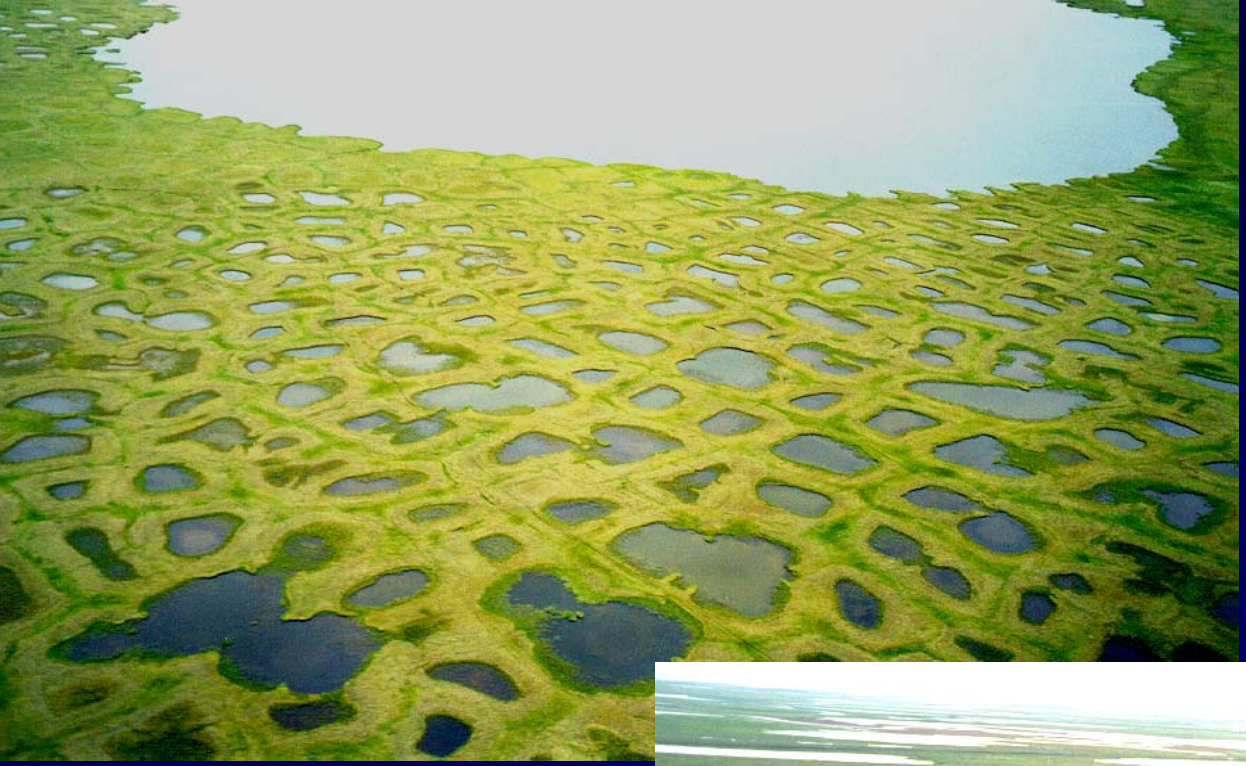
Proposed Project

In-field Facilities

Pipelines

8.2% of area changed over 37 yr
2.3% of land eroded
At current rate it would take about 1700 years to rework entire delta

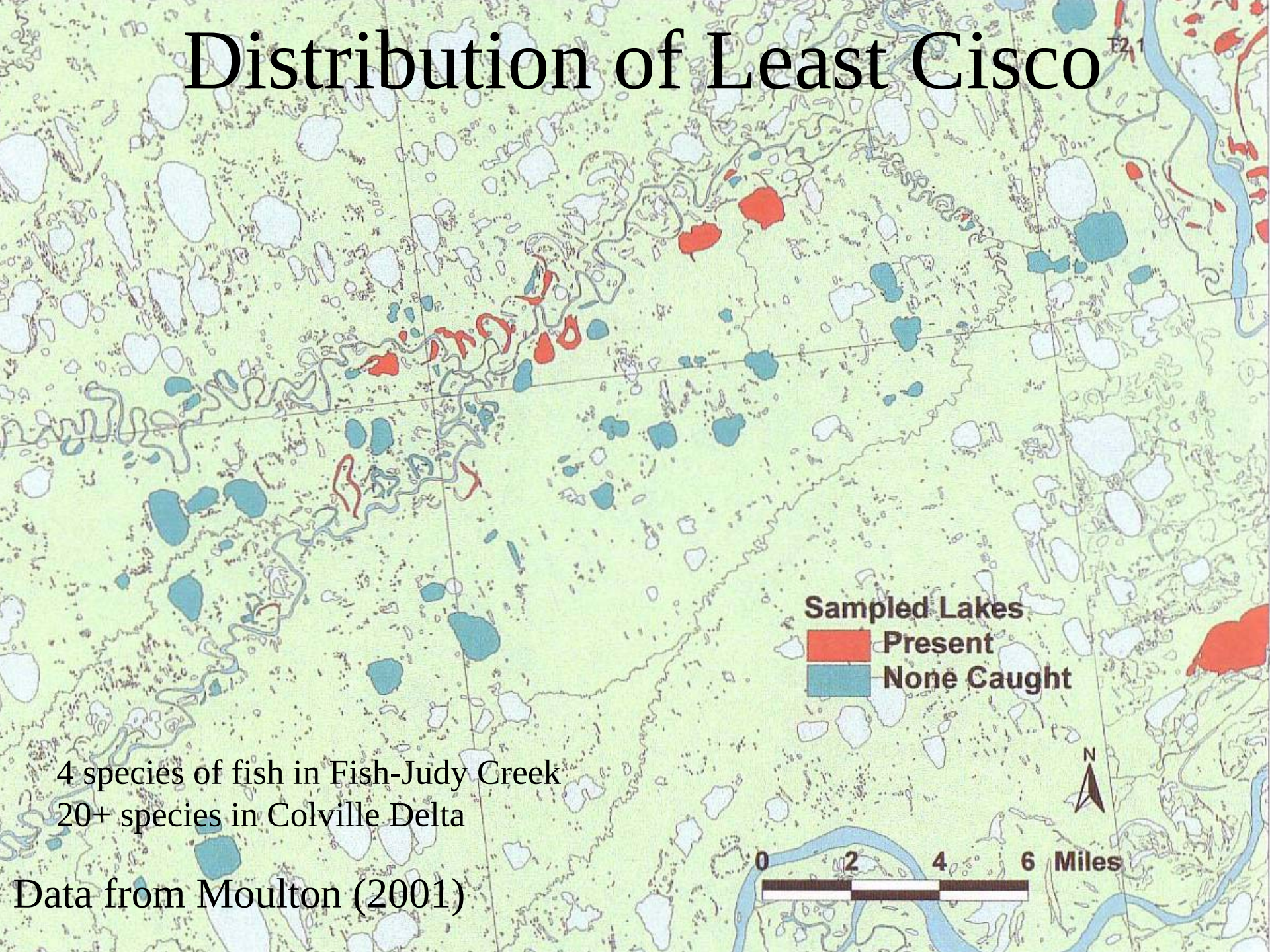
Landscape Change from 1955 to 1992, Central Colville River Delta



With very high ice contents surface becomes unstable

Channel migration eventually taps thaw lake

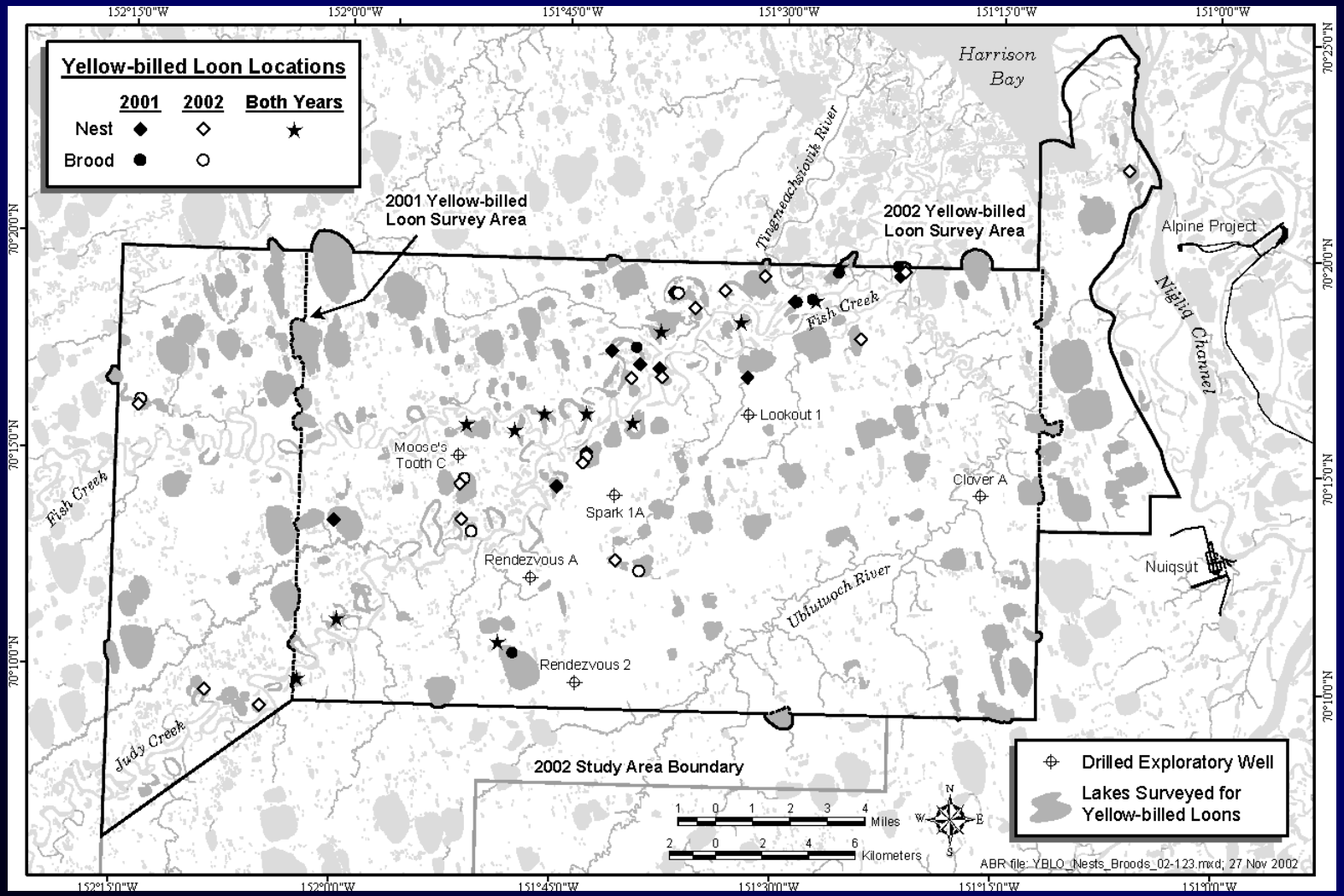
Distribution of Least Cisco



4 species of fish in Fish-Judy Creek
20+ species in Colville Delta

Data from Moulton (2001)

Yellow-billed Loon Nests & Broods in NPRA 2001-2002

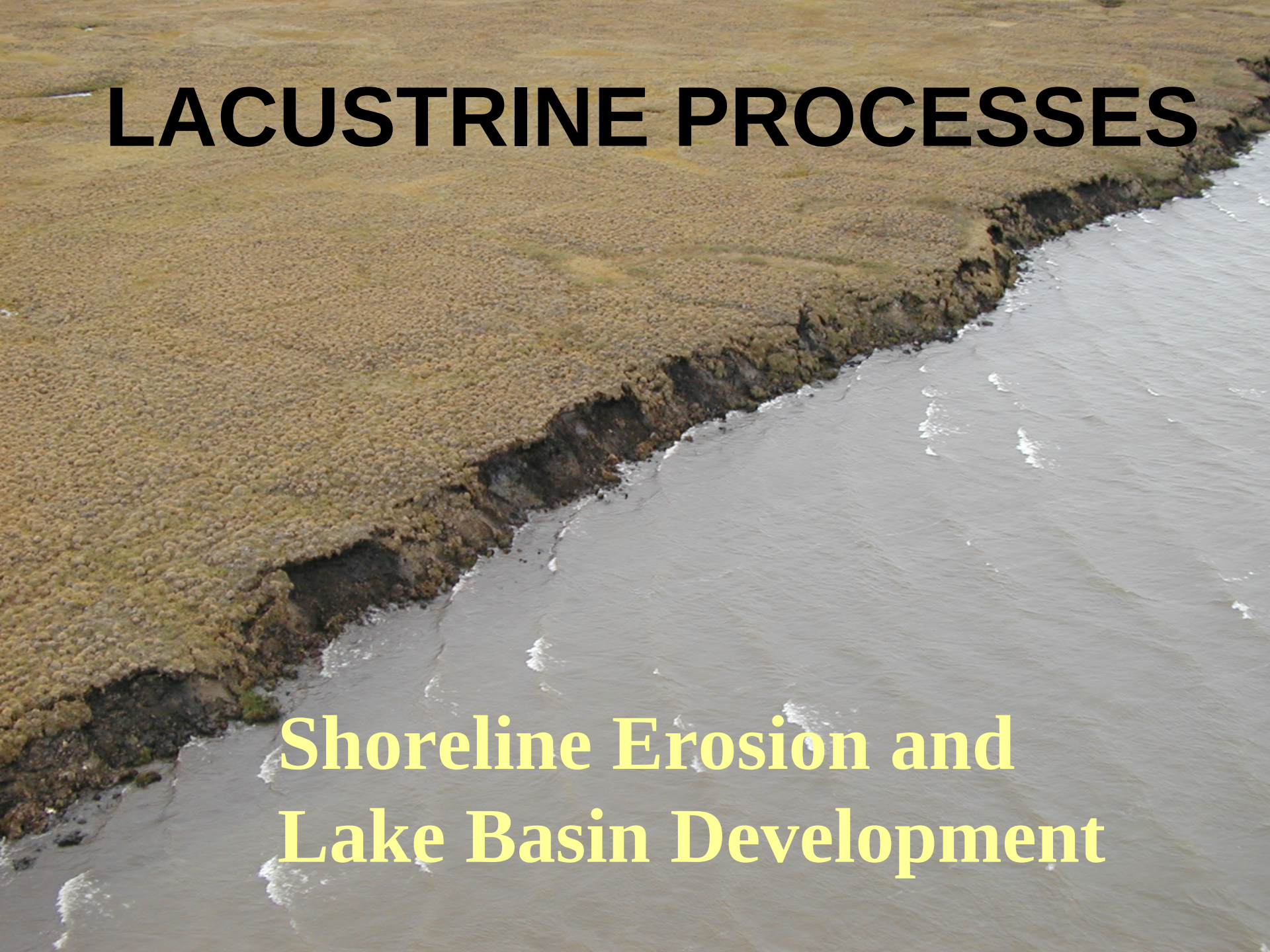


Data from Burgess et al. (2003)

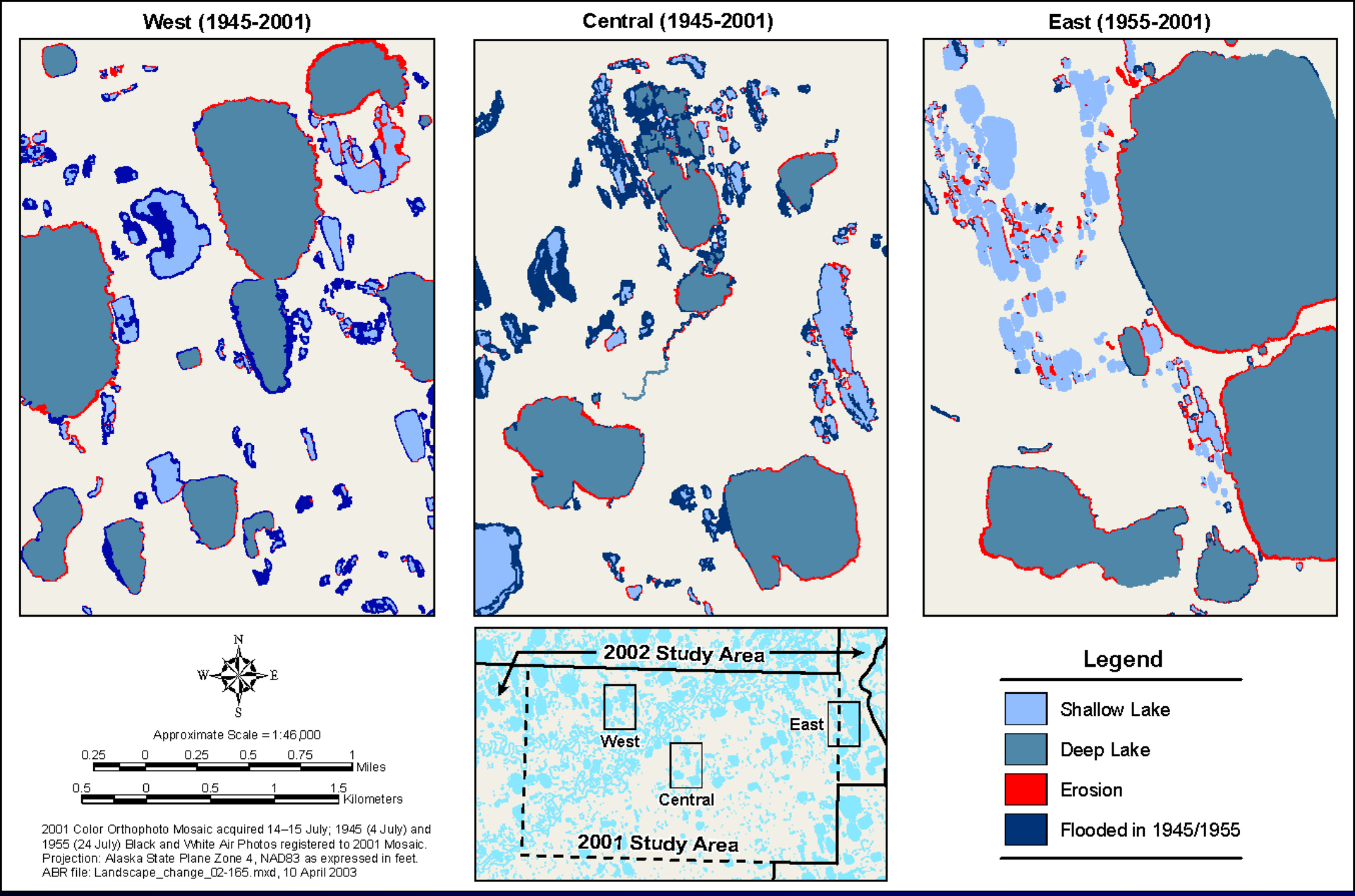
Floodplains as Migration Corridors

LACUSTRINE PROCESSES

LACUSTRINE PROCESSES



Shoreline Erosion and Lake Basin Development

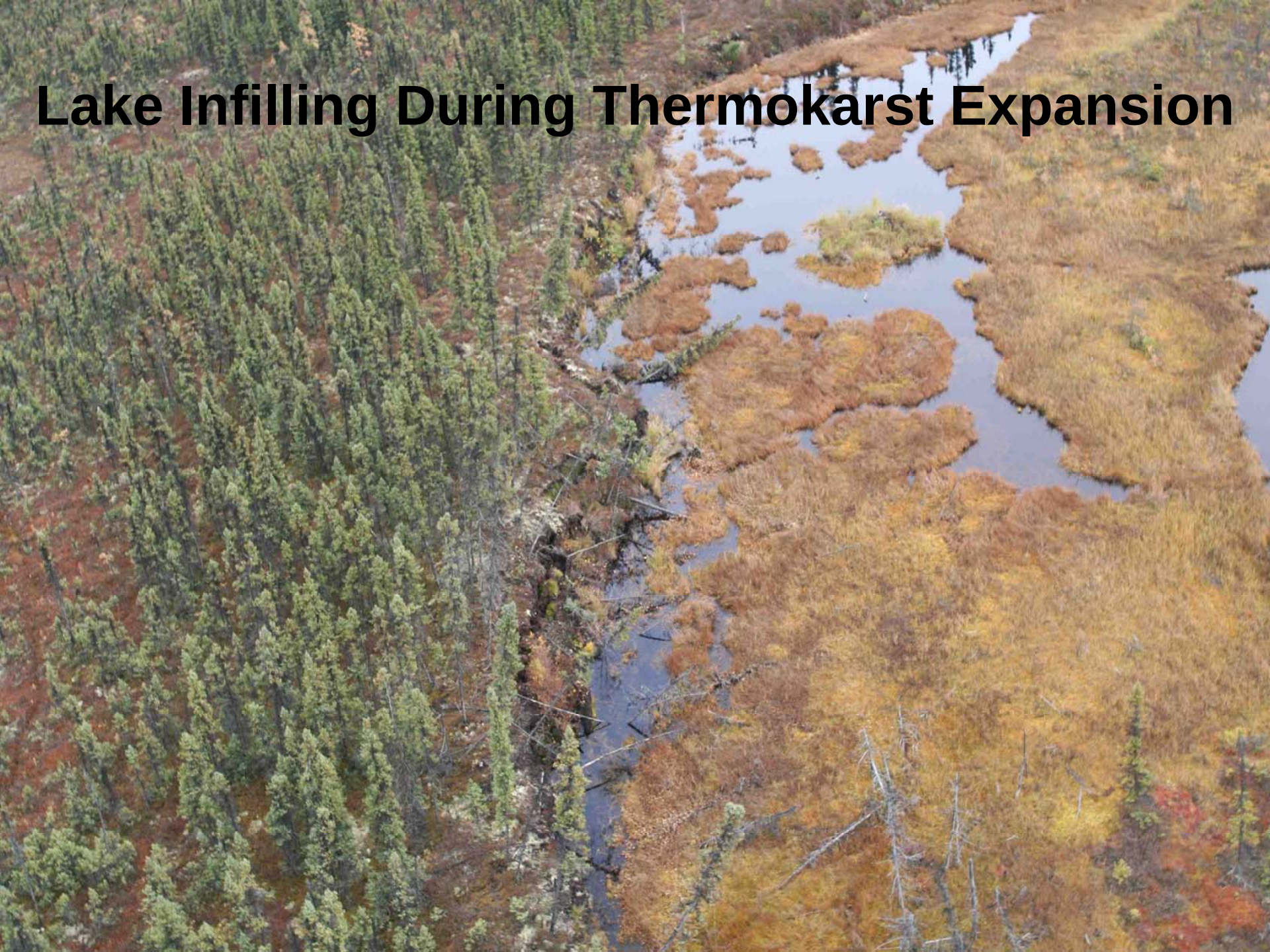


0.7% of land was eroded over 45-56 year period, 0.01%/yr

At this rate it would take 8400 years to rework the surface.

In-filling of Lake Margins

Lake Infilling During Thermokarst Expansion



COASTAL PROCESSES

- Sedimentation (up to 10 cm in big year)
- Storm Surges
- Salinization (up to many km inland)
- Sea Level Rise (3 mm/yr)

CONCLUSIONS

- Regional Factors
  - Cold climate leading to a range of permafrost-influenced geomorphic processes
- Permafrost Degradation
  - Approximately 7% of the boreal landscape has recently degraded and potentially 50-60% of the landscape has permafrost that can degrade.
- Fluvial Processes (5% of area)
  - Flooding leading to sediment deposition
  - Channel migration, erosion, and thaw lakes
  - Early succession plant communities

CONCLUSIONS

- Lacustrine Processes
  - (14% lakes, 39% lacustrine basins)
  - Differential sediment deposition
  - Shoreline Erosion (0.1%/yr)
  - Lake Drainage (3% of landscape over 100’s yrs)
  - Carbonate inputs, strong pH gradients
- Coastal Processes (narrow land margin)
  - Sediment deposition, salinization, thermokarst
  - Spread of halophytic vegetation, salt-killed tundra