Vegetation Impacts of Ice Roads and Pads—Lessons Learned from Case Studies

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Overview

- Factors that affect vegetation sensitivity
- Review of two case studies:
    1. Ice road demonstration project
    2. Ice pad left in place over summer
- Recommendations for mitigating impacts

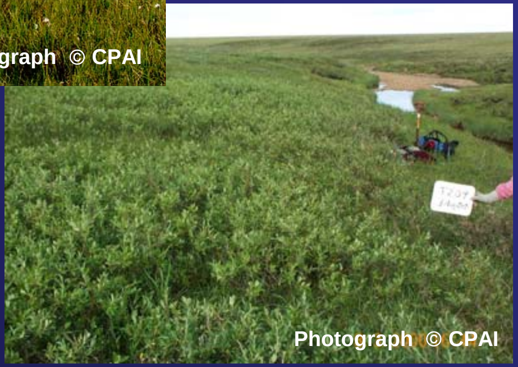
Vegetation Sensitivity to Ice Roads and Pads —Contributing Factors

- **Plant Morphology and Life History Characteristics**
  1. Plants with more specialized leaf structures are more sensitive to disturbance
  2. Plants adapted to disturbance (e.g., willows), less likely to show long-term effects ice road impacts
  3. Plants with a more uniform growth pattern allow for better ice road coverage


Photograph by Rolf Stange


Photograph by Laurie Consaul

Photograph © CPAI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Vegetation Sensitivity to Ice Roads and Pads —Contributing Factors

- **Landscape Characteristics**
    1. Diverse terrain (ridges and valleys)
    2. Hummocky terrain (e.g., tussock tundra)
    3. Patterned ground (e.g., high and low-centered polygons)

These conditions tend to result in an uneven distribution of snow cover

Photographs by Katherine McLeod, Arctic Monitoring and Assessment Programme

Vegetation Sensitivity to Ice Roads and Pads—Contributing Factors

- **Soil Properties**
  1. Thick organic surface—provides some resilience to long-term vegetation damage but may cause disruption of the thermal regime in ice-rich soils if removed.
  2. Ice content—can result in significant thaw settlement if insulation disturbed
  3. Thin organic soils—more susceptible to surface disturbance; overlying plant community typically slower to recover
  4. Soil hydrology—wetter soils tend to be more resilient in response to disturbance, but can accelerate erosion under certain conditions (e.g., slopes)

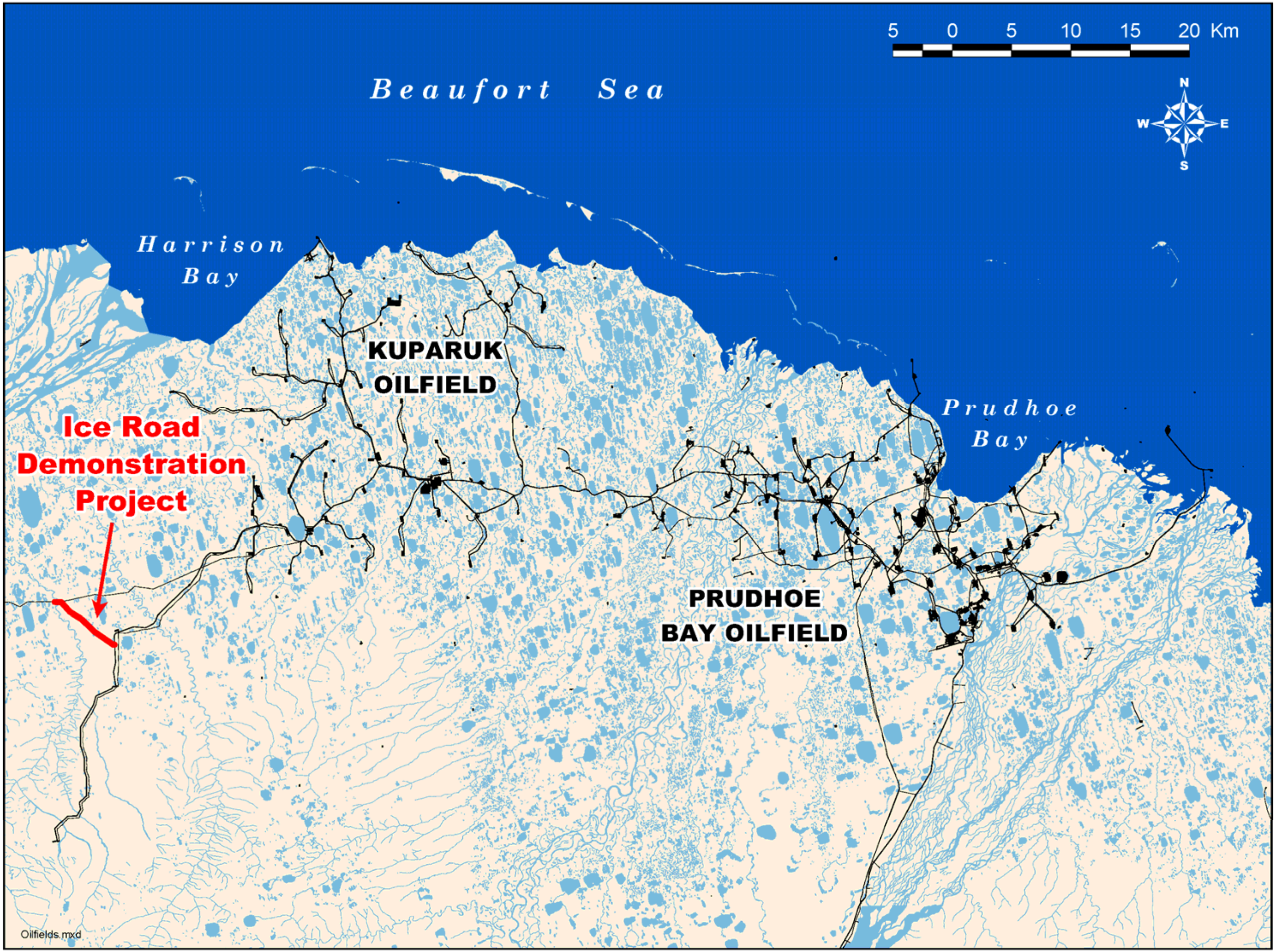
Histic Epipedon

Typic Dystrocryept

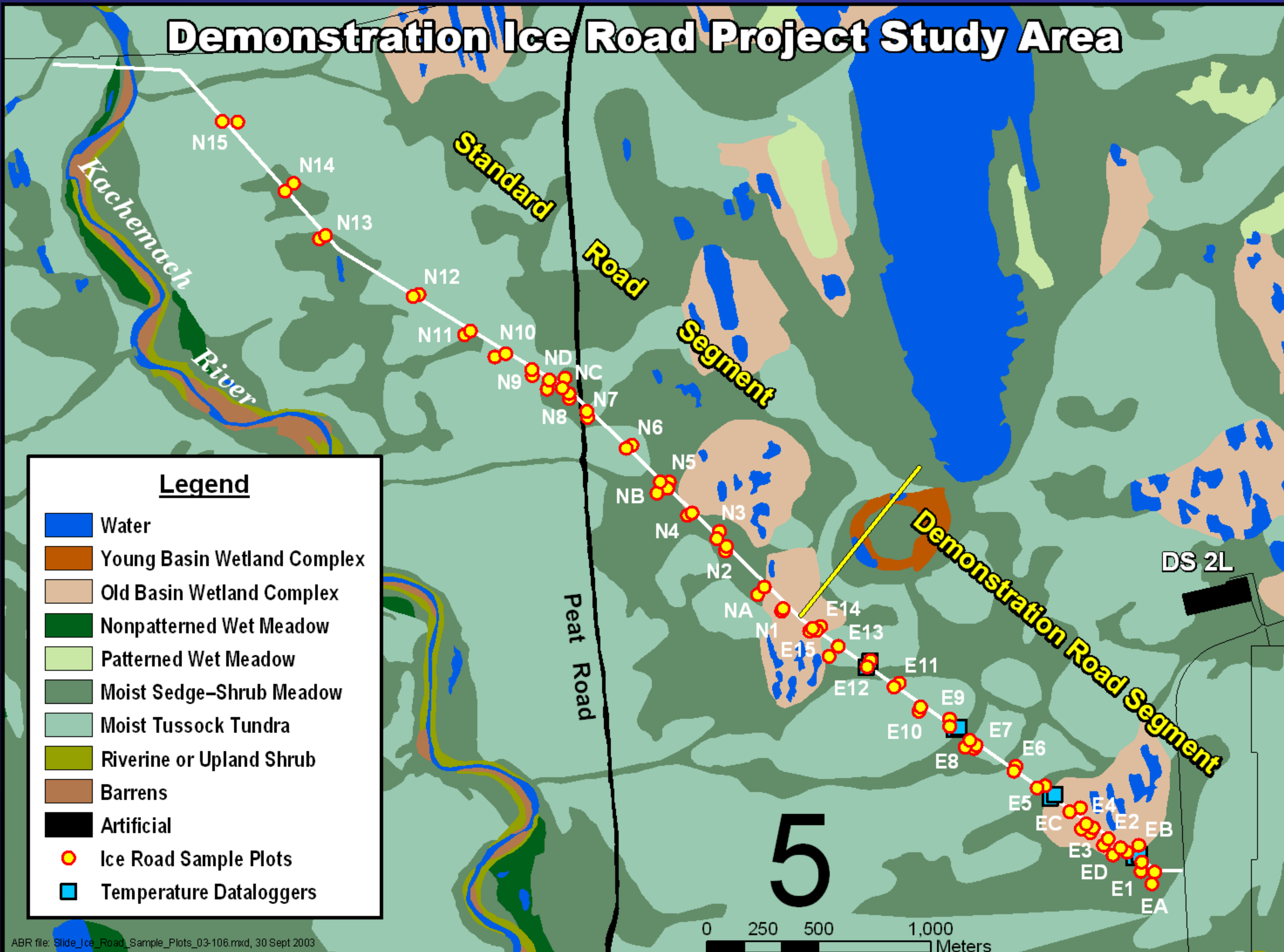
Case Study 1—Ice Road Demonstration Project (2003)

Research Objectives

1. Can new penetrometer/pressure plate methods be used to provide a longer window for ice road construction than the traditional slide hammer technique used by ADNR?
2. Was tundra disturbance along demonstration ice road measurably different from that on the standard ice road segment?
3. Was the level of disturbance related to tundra vegetation type in either ice road segment?
4. Will the observed disturbances result in vegetation or habitat alterations?



5 0 5 10 15 20 Km
N
W
E
S
Beaufort Sea
Harrison Bay
KUPARUK OILFIELD
Prudhoe Bay
Ice Road Demonstration Project
PRUDHOE BAY OILFIELD
Oilfields.mxd


Demonstration Ice Road Project Study Area
Standard Road Segment
Demonstration Road Segment
Kachemach River
Peat Road
DS 2L
N15
N14
N13
N12
N11
N10
N9
ND
NC
N8
N7
N6
N5
NB
N4
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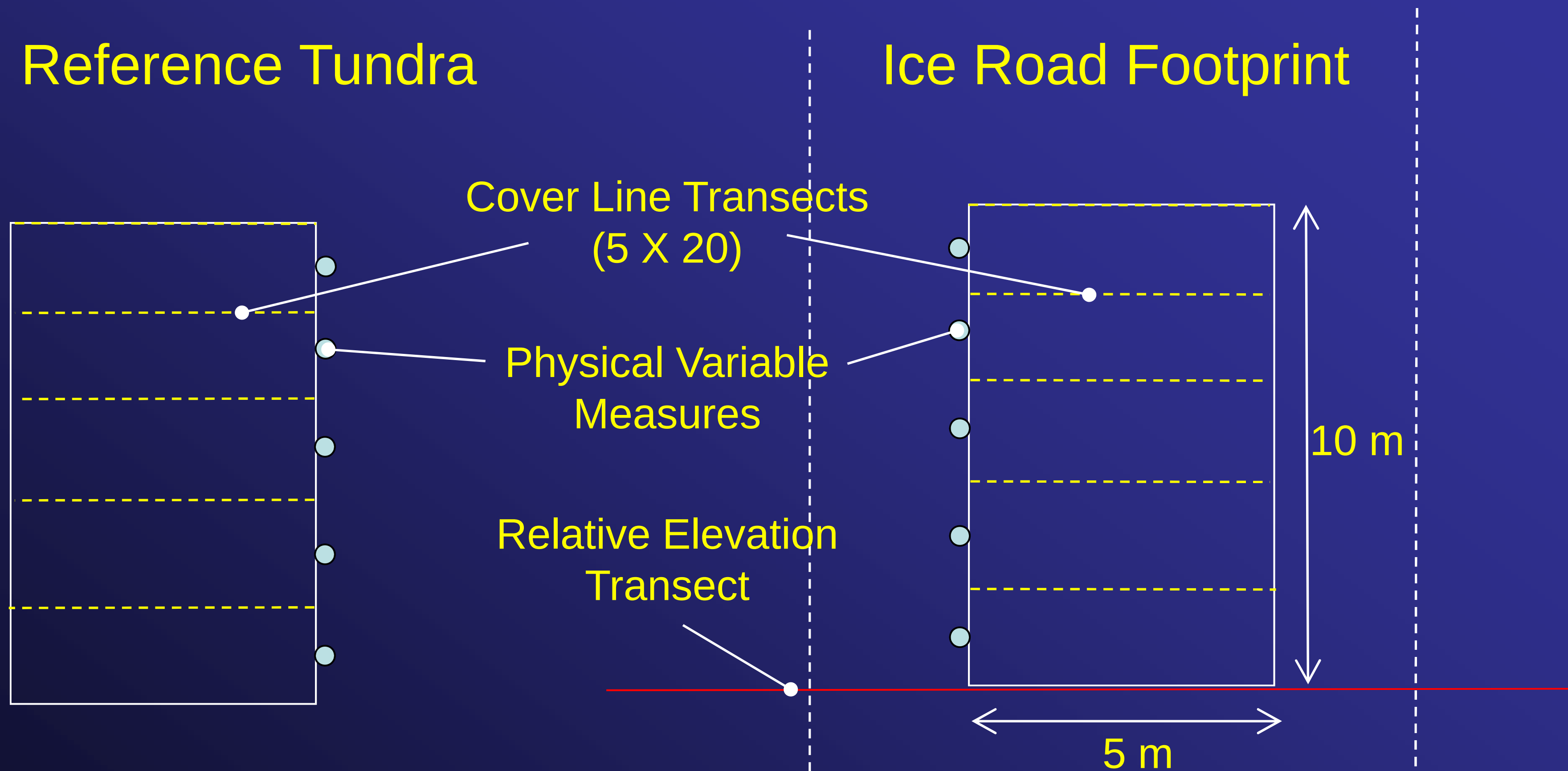
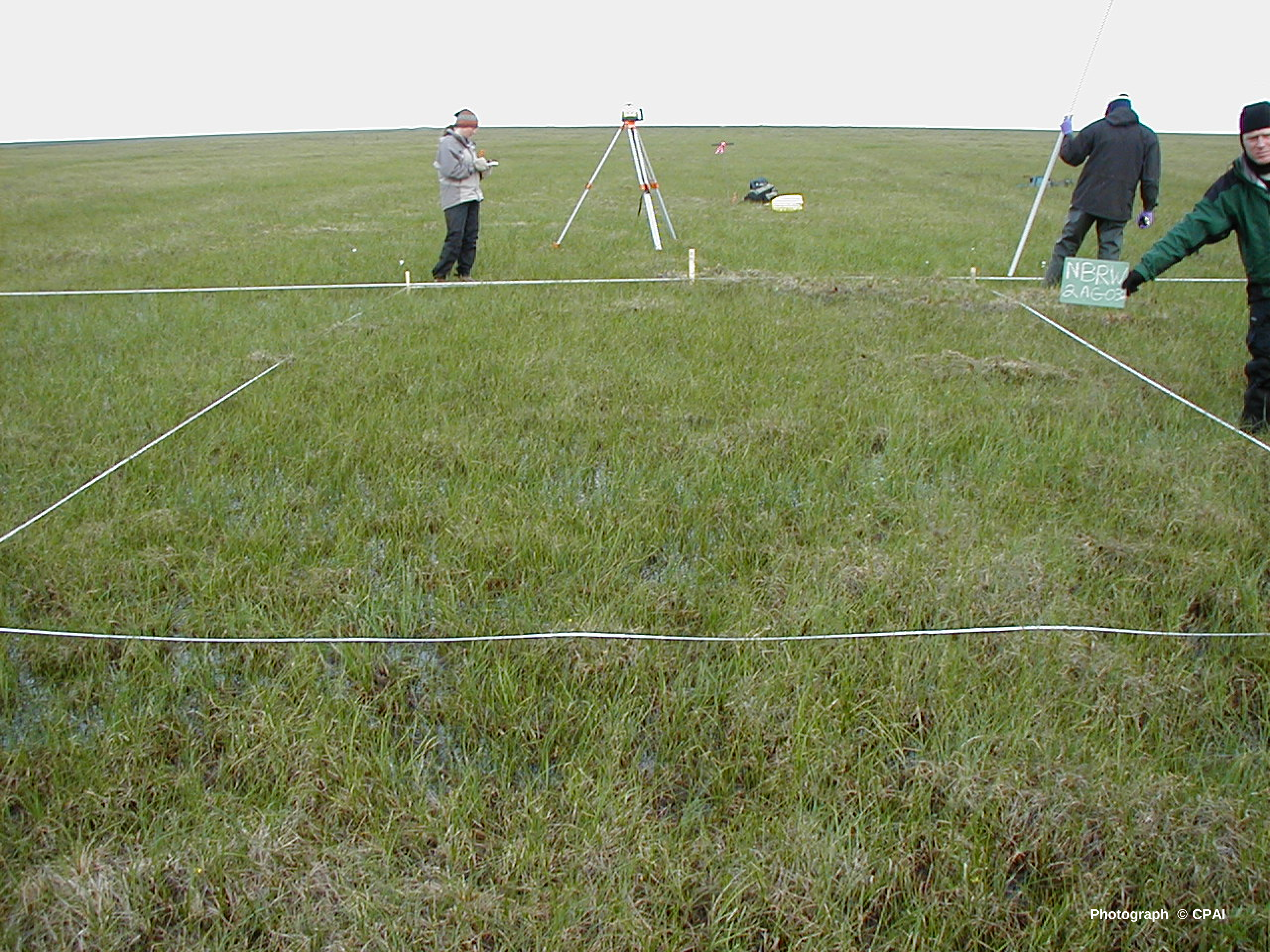
E13
E15
E12
E11
E10
E9
E8
E7
E6
E5
EC
E4
E2
EB
E3
ED
E1
EA
Legend
Water
Young Basin Wetland Complex
Old Basin Wetland Complex
Nonpatterned Wet Meadow
Patterned Wet Meadow
Moist Sedge–Shrub Meadow
Moist Tussock Tundra
Riverine or Upland Shrub
Barrens
Artificial
Ice Road Sample Plots
Temperature Dataloggers
0 250 500 1,000 Meters
5
ABR file: Slide_Ice_Road_Sample_Plots_03-106.mxd, 30 Sept 2003

Sample Station Layout



Variables measured included plant cover, tussock disturbance frequency, relative surface elevation, moss thickness, organic horizon thickness, thaw depth, soil moisture, water table depth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Tundra Vegetation Types

Tussock Tundra (Moist Tundra)

Minimum of 15% cover of cotton grass tussocks (litter + live shoots). Other common plants include white arctic mountain heather, entireleaf mountain-avens (Dryas), and mountain cranberry.

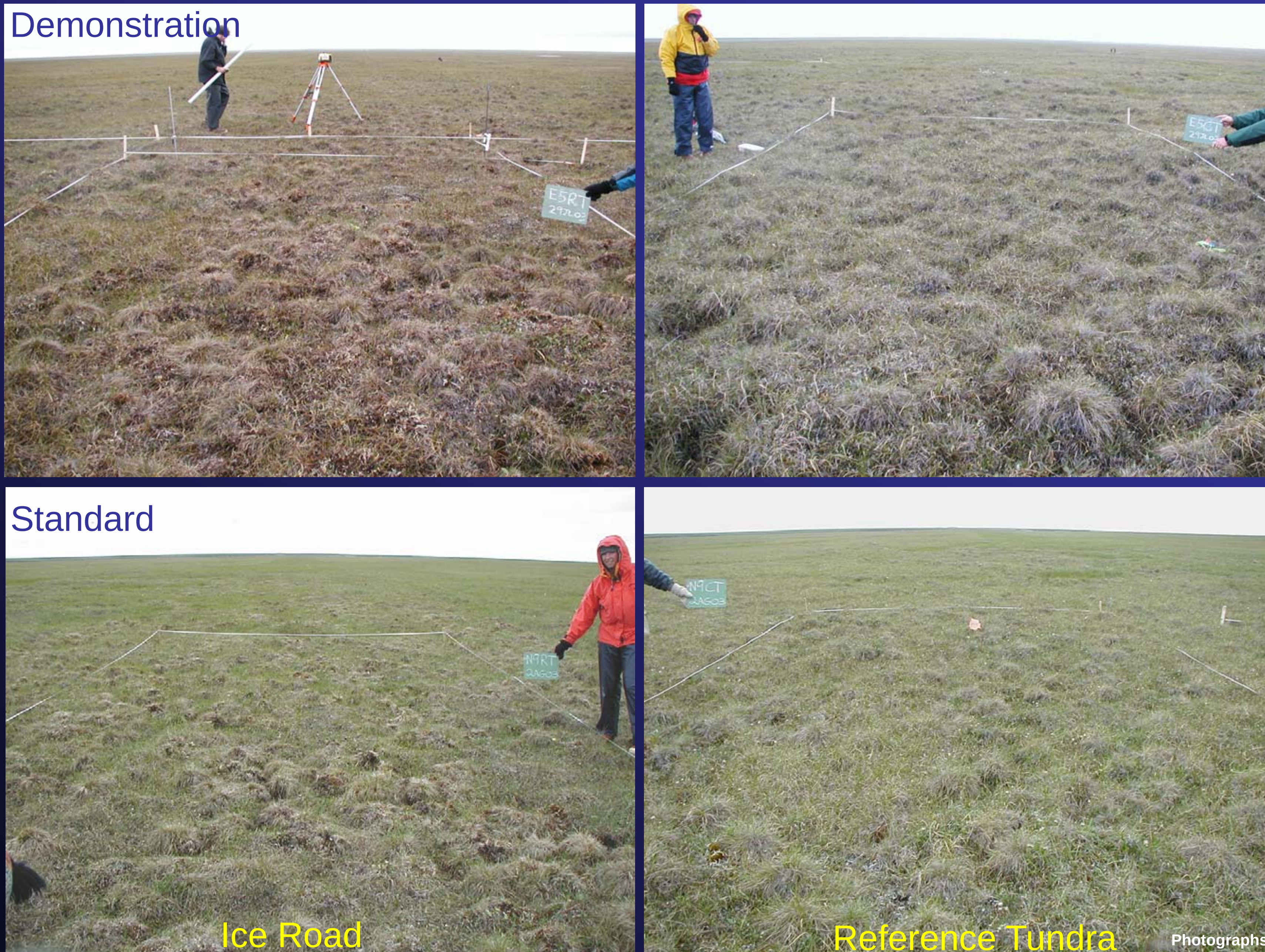
Moist Sedge-Shrub Tundra (Moist Tundra)

Tussock cover <15%, dominant plants include tall cottongrass, Bigelow sedge, entireleaf mountain-avens, and dwarf willows.

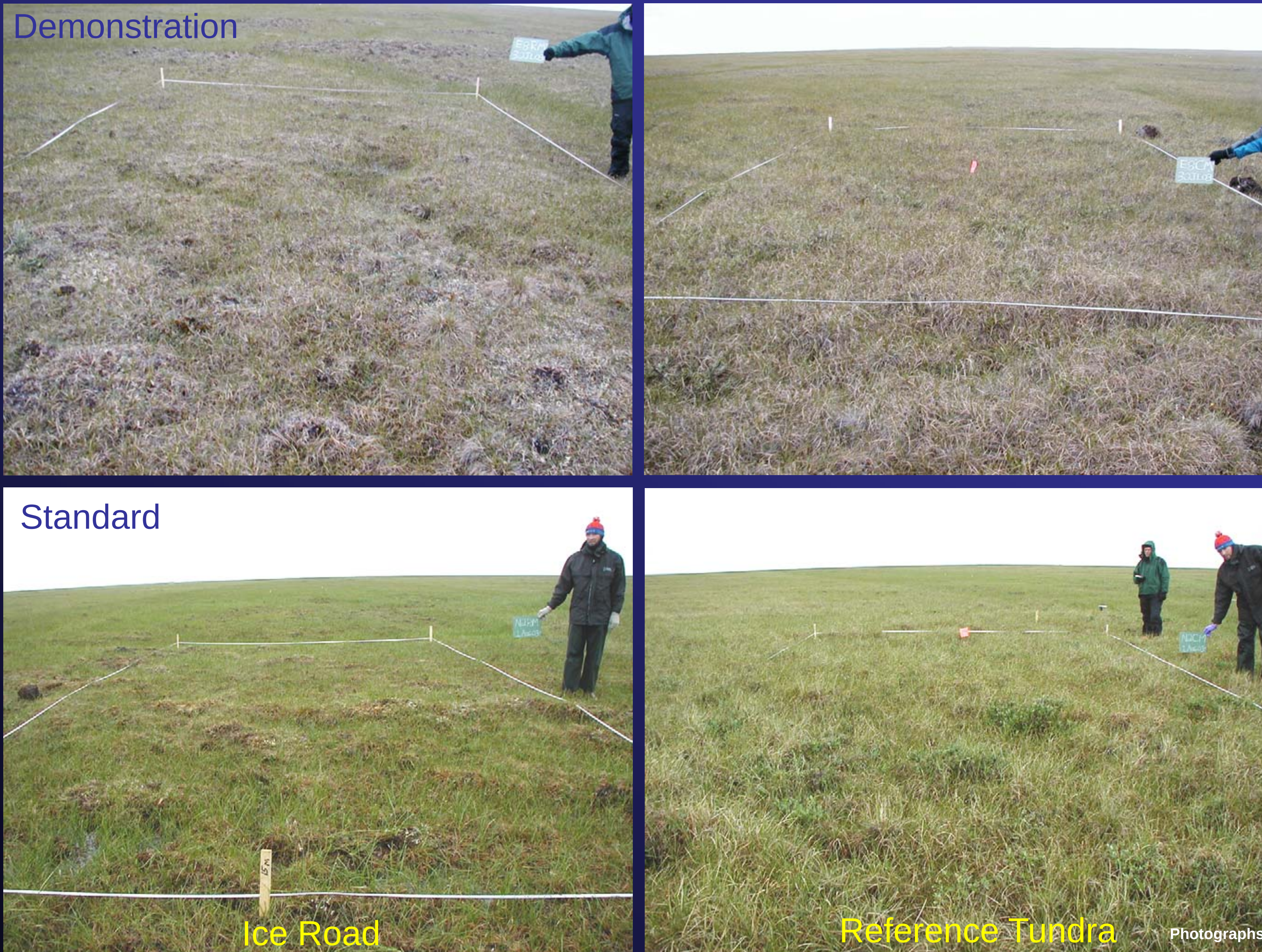
Wet Sedge Tundra

Areas of flooded soils dominated by water sedge, tall cottongrass and other sedge species.

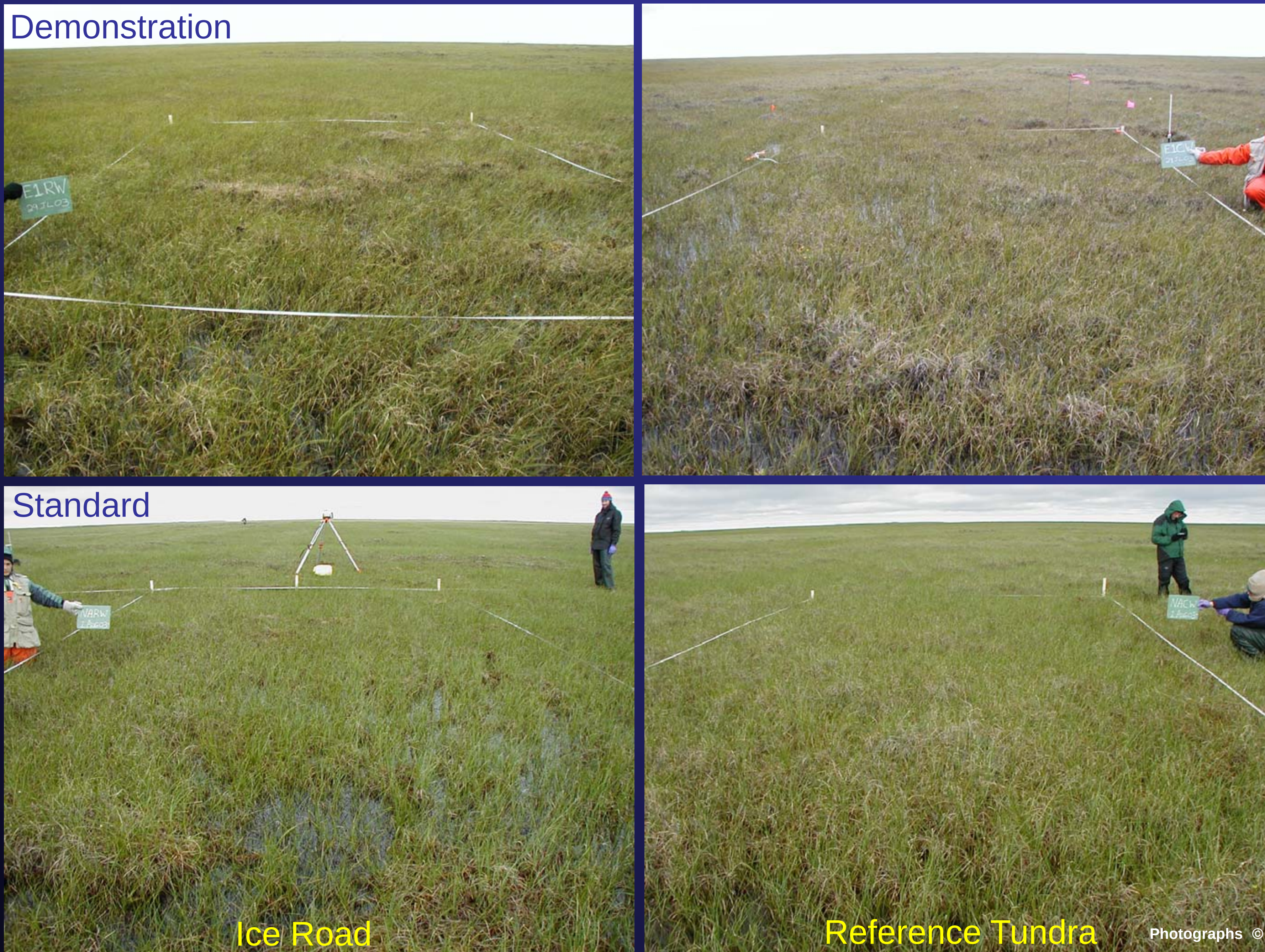
Tussock Tundra Plots



Moist Tundra Plots



Wet Tundra Plots



Photographs © CPAI

Results—Plant Cover

Summary of Significant Results:

- Total live cover was similarly reduced in both road segments compared to reference tundra.
- Reductions in vegetation cover were more pronounced for tussock tundra and moist sedge-shrub tundra than wet sedge tundra
- Main differences between the two ice road segments was significantly ($p = 0.001$) lower cover of evergreen species and significantly ($p = 0.02$) higher cover of bare soil in the standard segment compared to the demonstration segment
- Overall cover of bare soil, however, was very low (< 2%) in both road segments.

Results—Physical Variables

Summary of Results:

- Surface live moss layer was compacted in ice road plots, as indicated by thinner live moss mat than in reference plots
- There was no difference, however, in the extent of compaction between road segments.
- Thaw depth was greater in the demonstration and standard road segments for tussock and moist tundra compared to reference tundra, but the results were not significant
- Soil moisture was similar to reference tundra in the demonstration ice road plots, but was higher in the standard ice road segment.

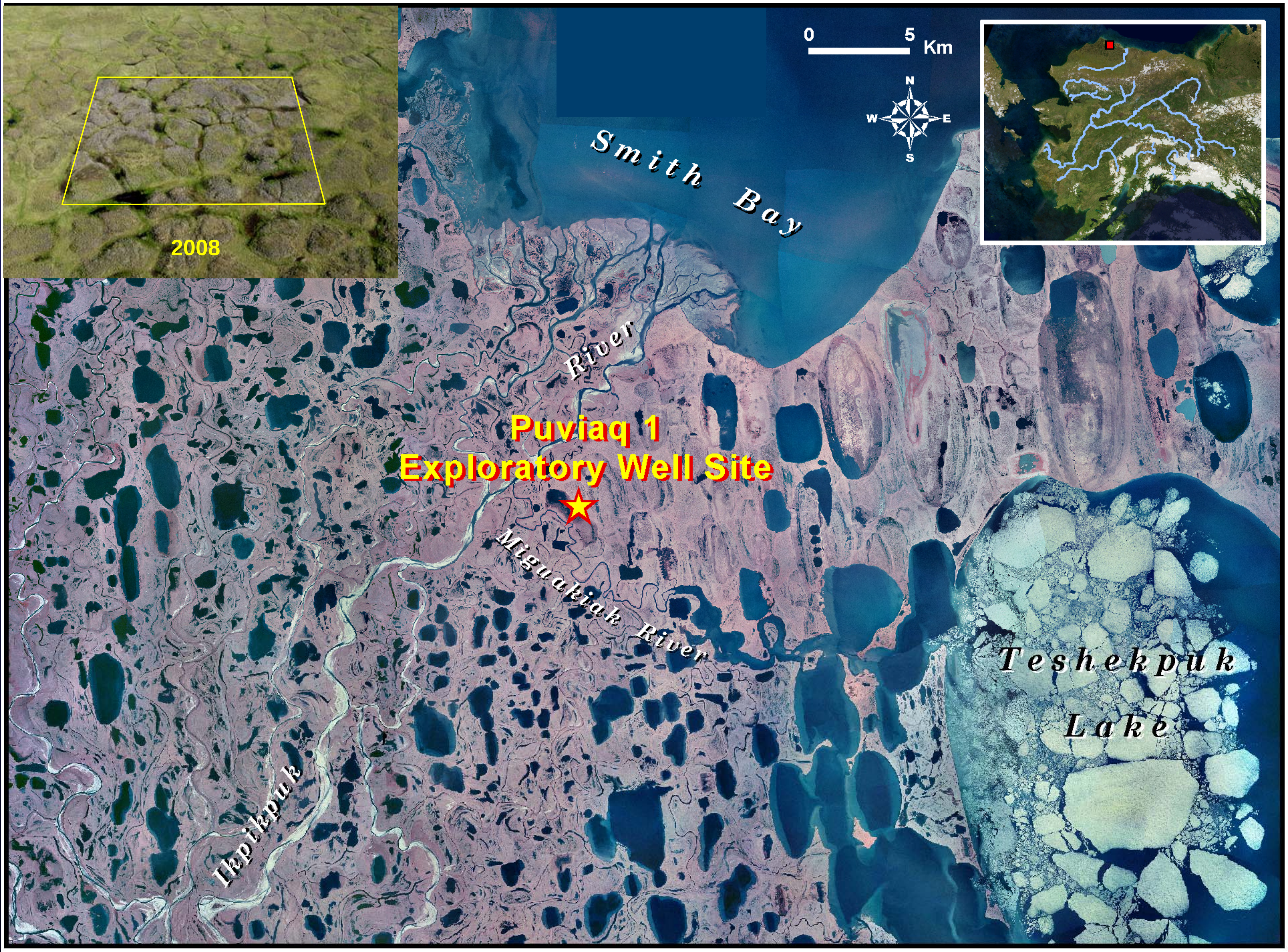
Conclusions

- Disturbances due to ice roads included:
    1. measurable reduction in live vegetation
    2. compression or thinning of the live moss mat
    3. small changes (<10 cm) in active layer thickness
- Impacts were similar in the demonstration and standard road segments.
- Degree of disturbance varied among tundra types.
- Observed impacts were confined to the tundra surface and were unlikely to result in changes in plant communities in either road segment.

Case Study 2—Puviaq Oversummer Ice Pad

Overview

- Ice pad was constructed in winter 2001–2002; left in place through the following summer (2002); removed in February 2003.
- In August 2003, much of the vegetation appeared dead.
- Some cottongrass tussocks and sedges in wet depressions had survived.
- Research Objectives include:
  1. Quantify the extent to which vegetation was impacted by the ice pad;
  2. Determine whether changes in surface and thermal stability occurred as a result of vegetation mortality;
  3. Determine the extent to which vegetation will recover; and
  4. Identify potential treatment options for enhancing recovery, if needed

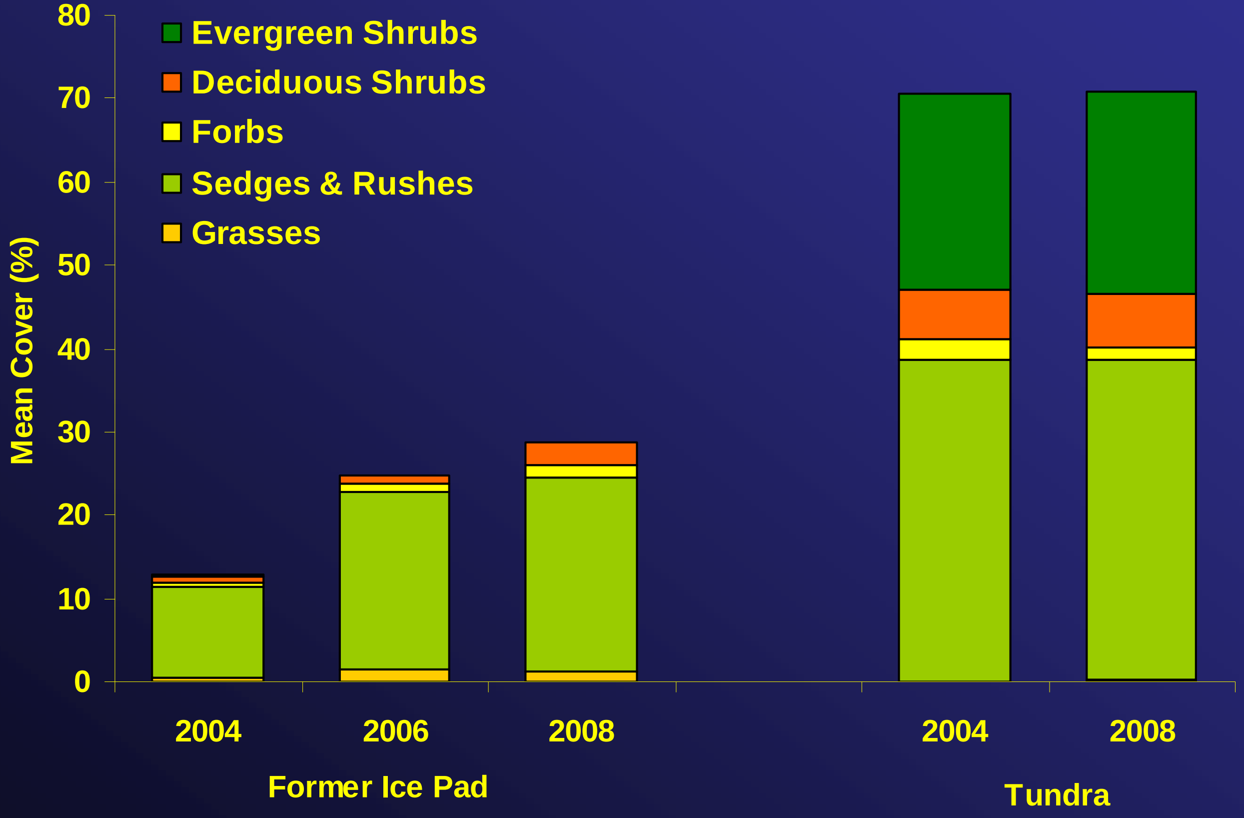

2008
0
5
Km
N
W
E
S
Smith Bay
River
Puviaq 1
Exploratory Well Site
Miguakiak River
Teshekpuk
Lake
Ikpikpuk

Rehabilitation Goal, Performance Standards, and Monitoring

- The rehabilitation goal for the former ice pad area is natural recovery over time.
- The performance standard for determining success is total live vascular cover (TLVC) at least 60% of that in the adjacent undisturbed (reference) tundra, to be obtained within five years following removal of the ice pad (2008).
- Monitoring methods have included
  1. Measuring vegetation cover and species richness in the pad area and in adjacent undisturbed (reference) tundra; and
  2. Surveying relative surface elevation and thaw depth.

Results—Vegetation

- TLVC on the former ice pad in 2008 was 28.7%, equivalent to 40% of the TLVC in the reference tundra (70.9%);
- TLVC on the former ice pad nearly doubled between 2004 and 2006, but increased only slightly between 2006 and 2008.



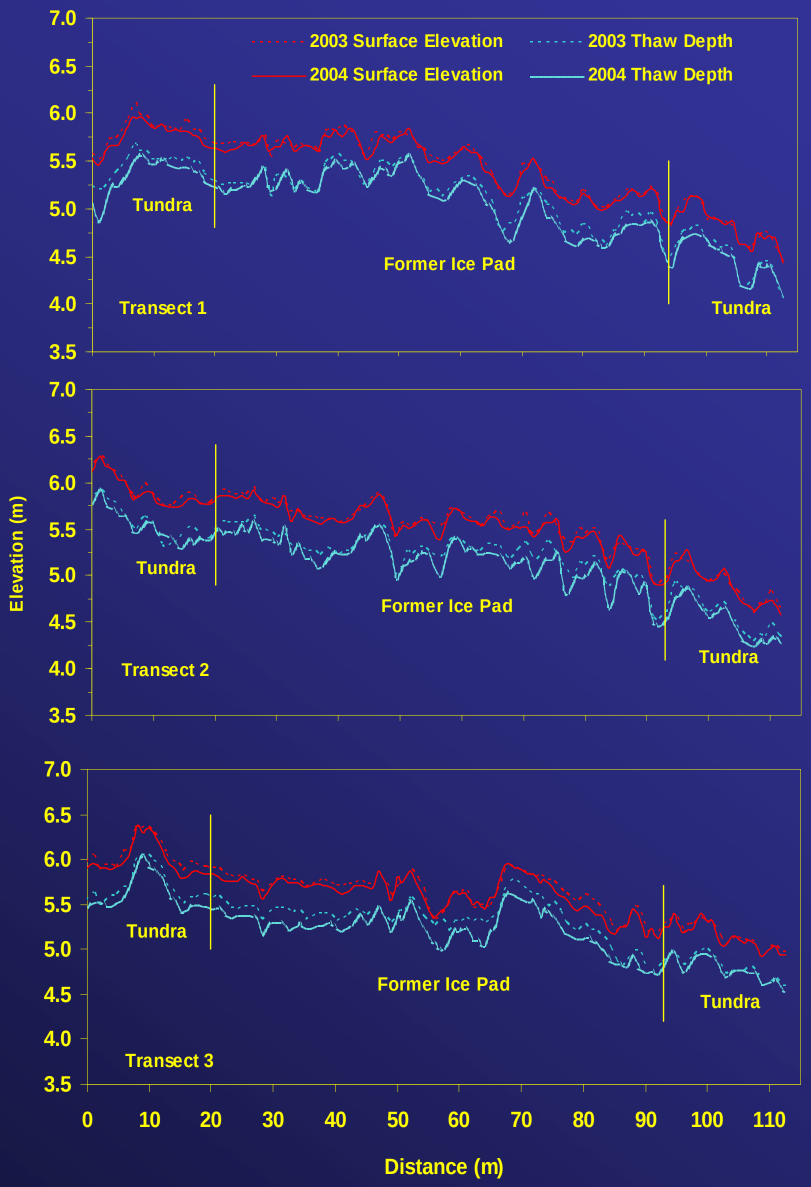
Results—Vegetation (continued)

- Cover was dominated by sedges in all years.
- The proportion of deciduous shrubs increased somewhat in 2008.
- In 2004, the number of species present on the former ice pad was half that in reference tundra.
- In 2006 and 2008, species numbers on the former pad were similar to those in reference tundra.

Tussock seedlings; 2008

Results—Surface Stability

- Thermokarst and subsidence have occurred in some polygon troughs, but there has been little visible change in these areas since 2004.



2003

2008

2004

2008

2006

2008

Discussion

- TLVC in 2008 (28.7%) was considerably lower than the value (42%) required to meet the performance standard.
- Since the cover increased only slightly between 2006 and 2008, the standard is unlikely to be met within the next few years unless rehabilitation treatments are applied.
- Despite the slow vegetation recovery, the site has experienced minimal thaw settlement, and we do not anticipate any additional notable surface instability.
- To enhance natural vegetation recovery, the former ice pad and a strip of the surrounding tundra will be lightly fertilized in 2010.

Mitigating Vegetation Impacts from Ice Road and Pad Construction

- Identify transportation route alternatives that:
  1) minimize impacts to sensitive vegetation types (e.g. Tussock tundra and Dwarf Ericaceous Tundra), and
  2) limit the extent to which the route encounters varying snow cover conditions
- Construction techniques that result in a thicker ice/snow surface may help minimize impacts in sensitive habitats
- Construction practices and tundra surface hardness both need to be considered during the planning stage of ice pad construction
- Ensuring the underlying vegetation and soil remain frozen during the summer may reduce vegetation impacts of oversummer ice pads