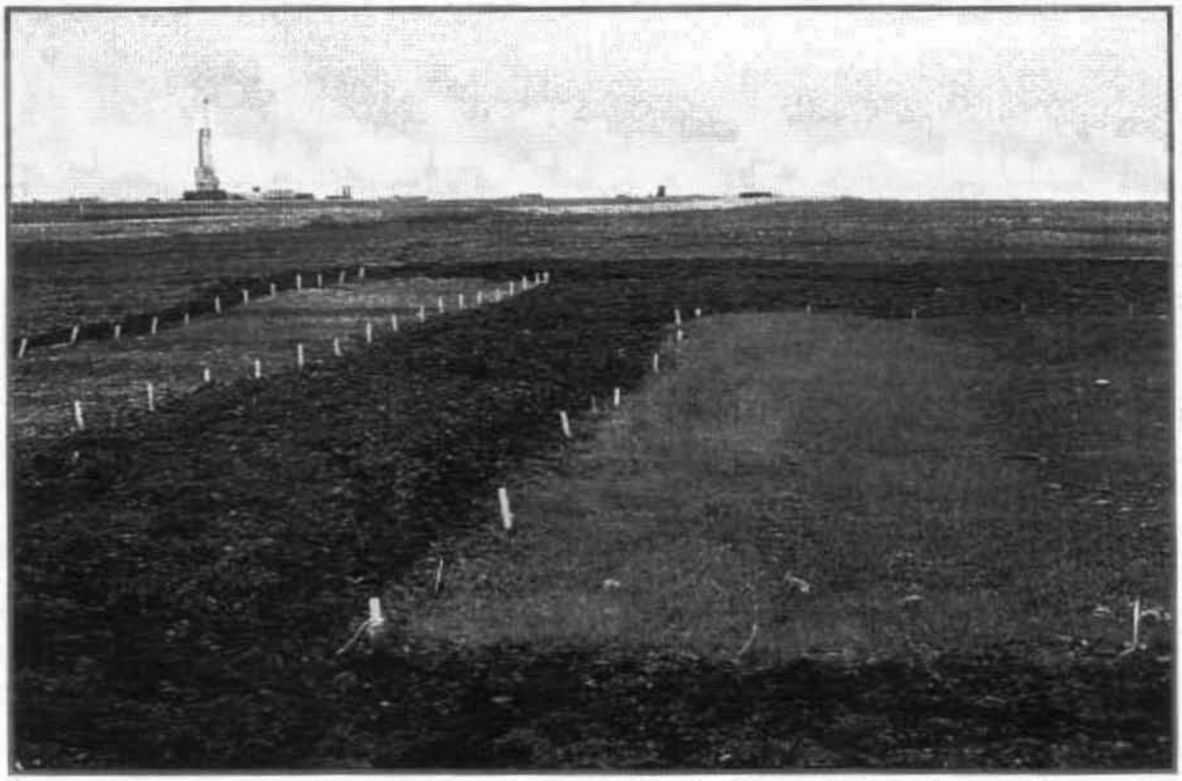
Assisted and Natural Tundra Recolonization Prudhoe Bay Oil Field, Alaska

A Quarter-Century of Soil and Plant Studies Including
Physical Removal of Soil and Plants, Hydrocarbon Spills,
Gravel Revegetation, Sand Stabilization,
and Soil Salinization



Jay D. McKendrick
Professor of Agronomy Emeritus
University of Alaska Fairbanks
Palmer, Alaska

Lazy Mountain Research
P.O. Box 136
Prudhoe Bay, Alaska 99734

LAZY MOUNTAIN RESEARCH
15705 Shawn Drive East
P.O. Box 902
Palmer, Alaska 99645

Telephone: (907) 745-3432
Fax: (907) 745-3431

MEMORANDUM

TO: Linda Perry Dwight

FROM: Jay D. McKendrick *Jay D. McKendrick*

DATE: 9 July 1998

RE: Handbook for Arctic Research Commission Tour

Accompanying this memorandum are: 1) one handbook used in Wetlands Conference Tour 12 June 1998, 2) a slightly revised hard copy of the text and captions for the handbook, 3) a disk copy (WordPerfect 5.1+) of slightly revised text and captions.

All photos in the handbook were scanned and should be on file with Jim Lukin[1]. The cover page was created by Kathleen, who works with Jim Lukin, and I do not have a disk copy of that page.

I suggest you review the text and consider it for this group, making modifications that seem appropriate to you. Perhaps sufficient copies of the handout should be made to ensure not only the visitors but also the presenters can each receive one. I also recommend keeping a master file of the materials to facility preparations for future tours. These kinds of events seem to occur a few times each year, and preparing often starts from scratch for each one. I think BPX could save some of the expense by keeping such materials readily available, recognizing there will be unique needs for some tours and information changes with time.

Thanks for the help with this. If you have questions, please don't hesitate to call.

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1 Jim has not billed Lazy Mountain Research yet for the Wetland Conference handbook work. I am not sure what the costs would be for making new prints, but a phone call to Jim will probably give you a sound estimate of his charges for supplying the color images.

WELCOME TO THE NORTH SLOPE

This booklet has been prepared to give visitors an appreciation for the resilience of tundra vegetation and soils. If you desire publications on this work, express your wished to a tour guide or contact Jay McKendrick, Lazy Mountain Research, P.O. Box 902, Palmer, AK 99645 or contact the Alaska Agricultural & Forestry Experiment Station, 533 E. Fireweed, Palmer, AK 99645.

INTRODUCTION TO TUNDRA RECOLONIZATION

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Acquiring long-term monitoring demanded consistency of personnel with interest and expectation of results from that realm of ecological research, in combination with willing sponsors. It was a narrowly recognized (few at the time saw its value) need-driven process, rather than a purely academic pursuit. The role of the land-grant university system in providing continuity of personnel was as vital to this success as was the funding and logistical support from industry. It is important that those interested in the arctic environment continue to recognize and encourage whenever possible the need for this partnership between the university, industry, and appropriate government agencies.

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Recovery treatments in the design included burning immediately, burning after a delay, and leaving the oil without cleanup. We found that burning immediately was easily accomplished, but delaying 24 hours allowed the oil to seep into the soil, and that in combination with evaporation of volatile fractions precluded igniting the spill. As a consequence, the experimental treatments defaulted to burning immediately, and leaving the oil in place.

All plants eventually died in the oil-treated plots after a year, regardless of burning or leaving the oil in place. Where the oil was burned, vegetation recovered within about 10 years. After 25 years, vegetation recovered in the wet-sedge meadow even where the oil was left in place. However, in a mesic habitat, the vegetation has not recovered even after 25 years. It is a fact that oil spill damage to tundra vegetation is inversely related to habitat wetness. It is also a fact that rate of recovery is positively related to site wetness.

Photo 5. View of a 4-square meter wet sedge meadow plot to which 40 l/m^2 of fresh crude oil was applied and burned immediately 25 years prior (photographed 20 August 1997).

Photo 6. View of a 4-square meter wet sedge meadow plot to which 40 l/m^2 of fresh crude oil was applied and left in place 25 years prior (photographed 20 August 1997).

Photo 7. View of a 4-square meter mesic tundra plot to which 40 l/m^2 of fresh crude oil was applied and left in place 25 years prior (photographed 20 August 1997).

EXPERIMENTAL TUNDRA VEGETATION REMOVAL (SCRAPED SITE)

Tundra revegetation research commenced prior to the development of the Prudhoe Oil Field. Thus, the types of disturbances which would eventually require revegetation were left to the imagination and extrapolation from other developments. Furthermore, finding areas in which experiments could be conducted was difficult. Tests plots require uniformity and sufficient area for replication, etc. To accommodate the need for revegetation tests, approximately 1 acre of tundra was removed by bulldozing in the spring of 1972. The area had to be bulldozed twice to remove all the vegetation, because the ground was only slightly thawed, when the first scraping occurred. Even with two scrapings by the bulldozer, some plants survived. To eliminate those survivors, the site was rototilled for two growing seasons (1972 and 1973) to kill the final remanents of the vascular plant community, and provide an open soil for fertilizer and seeding test plots. Portions of this area not included in test plots were left untreated to demonstrate effects of applying a 'no remediation' alternative.

Photo 8. Plots to right in this view of the scraped site were in their second growing season following seeding (seeded 28 June 1973, photographed 17 September 1974). Plots are 4 ft X 52 ft in size. From left to right seeded species were: *Puccinellia arctica*, *Deschampsia beeringensis*, *Festuca rubra* (var. Arctared), and *Poa pratensis* (var. Nugget).

Photo 9. After 4 years, the seeded grasses were still dominating the vegetation, and little natural recolonization had occurred adjacent to the seeded plots (7 September 1976).

Photo 10. After 23 growing seasons (26 August 1995), natural recolonization by wet sedge tundra dominant species (*Eriophorum angustifolium*, *Carex aquatilis* and *Dupontia fisheri*) have overtaken the surrounding area and most of the seeded plots. Seeded plots on the left are still apparent and differ in color and texture from the surrounding tundra.

EXPERIMENTAL TUNDRA VEGETATION REMOVAL (SCRAPED SITE)

Phosphorus, potassium, and magnesium fertilizers were tested on the scraped site with *Puccinellia arctica* as the indicator plant. Plots were established in September 1974. The emergence and establishment of the seeded grass occurred only in plots containing phosphorus fertilizer. Subsequently, the entire area was overtaken by natural wet sedge tundra plant species.

Photo 11. Plots after applying seed and fertilizer (21 September 1974).

Photo 12. Plots with *Puccinellia arctica*, four growing seasons after seeding (1 September 1978).

Photo 13. Plots dominated by natural wet-sedge tundra species 23 growing seasons after seeding (9 September 1997).

After 26 growing seasons, we have found that:

- Phosphorus fertilizer was critical in the early establishment of seeded grasses, encourages mosses to recolonize, and stimulates organic matter decomposition in the soil.

- Several species of grass could be seeded and established on mesic mineral soils, including: *Arctagrostis latifolia*, *Festuca rubra*, *Poa glauca*, *Deschampsia beeringensis*, and *Puccinellia arctica*. *Arctagrostis latifolia*, *Deschampsia beeringensis*, *Festuca rubra*, and *Poa glauca* were recommended for revegetation by Dr. Wm.W. Mitchell, based on these tests.

- *Arctagrostis latifolia*, *Festuca rubra*, and *Poa glauca* have been used most extensively for revegetation across the Alaska North Slope, including production oil fields, the Trans Alaska Pipeline, exploration wells in NPR-A and one in ANWR (Arctic National Wildlife Range).

- *Deschampsia beeringensis* does not occur naturally in the Prudhoe vicinity, and where it has been established along the Spine Road, it grows taller than the natural vegetation and does not blend well with the texture of the tundra. It probably has greater potential for stabilizing sand dunes in river deltas and seashore habitats.

- *Puccinellia arctica* was not included in the original recommendations. It establishes easily over a wide array of habitats. It does not resist the reinvasion of natural tundra species, in contrast to the other grasses. Furthermore, it is unpalatable to geese and caribou, which often graze seedings and slow the development of plant cover. The recommended grasses usually do not establish well in wet habitats, which are quite common to the region.

- If the disturbed habitat is mesic mineral soil, and *Arctagrostis latifolia*, *Festuca rubra*, and *Poa glauca* are seeded, these grasses will establish. Such stands have persisted for 26 growing seasons, with little indication of relinquishing their territories to natural tundra. Selecting objectives of seeding and fertilizing must be clearly understood.

WINTER HAUL ROADS (A.K.A. PEAT ROADS)

During the 1960s 'dirt' roads were constructed across the tundra to haul equipment to exploration sites. These roads were constructed in August, when the seasonal thaw was near its maximum. Two bulldozers worked in tandem, moving soil from edges to the center of the road. Roads were only used during winter, when the soil was frozen. About 1970, the practice was banned in Alaska.

One such road was used for tundra revegetation research. Observations over the course of time have revealed that:

1. Wet borrow pits recolonized first with *Eriophorum angustifolium*, *Carex aquatilis*, and *Dupontia fisheri*. Flooded areas were colonized by *Arctophila fulva* and *Hippuris vulgaris*. These habitats colonized within 10-15 years.

2. Surfaces that were well-drained became drier habitats than the adjacent undisturbed tundra. These recolonized more slowly, requiring 25 or more years.

3. Tundra recolonization can be accelerated by attracting wildlife to the site. Several features seem to attract wildlife to disturbances:

   a) Diversity of terrain, which creates a variety of niches.
   b) Thermokarst, which creates pools of water.
   c) Establishing swards of palatable forage plants, i.e. some grass species.

Photo 14. Winter Haul Road between DS-2 and Borough Landfill as it appeared on 27 June 1972; age 3 years.

Photo 15. Same view of Winter Haul Road 25 July 1994; age 25 years.

Photo 16. Same view of Winter Haul Road 10 September 1997; age 28 years.

WINTER HAUL ROADS (A.K.A. PEAT ROADS)

Natural vegetation recovery on uppermost surfaces of abandoned winter haul roads differs between the foothills and coastal plain. In the foothills, shrubs, willow (*Salix alaxensis*, *Salix planifolia* ssp. *pulchra* var. *pulchra*, *Salix lanata* ssp. *richardsonii*, and *Salix arctica*) and dwarf birch (*Betula nana*) colonize. On the coastal plain, grasses colonize on the uppermost surfaces (*Puccinellia langeana*, *Festuca baffinensis*, *Trisetum spicatum*, *Arctagrostis latifolia*, *Poa glauca*, *Poa arctica*, *Deschampsia caespitosa*).

The same wet sedge meadow species colonized the wet borrow pits of both roads shown in this sequence, indicating the wettest environments between the two locations are more similar between regions than their dry habitat counterparts.

Photo 17. View of winter haul road in foothill region east of Umiat, Alaska. This road was constructed by British Petroleum in August 1964. Photo was taken 16 July 1991; age 28 years. Natural recolonization is responsible for all vegetation recovery on this site.

Photo 18. View of winter haul road on coastal plain west of Oxbow Road, Prudhoe Bay, Alaska. Road was constructed by British Petroleum in 1969. Photo was taken 9 September 1997; age 28 years. Natural recolonization is responsible for all vegetation recovery on this site.

LONG-TERM GRAVEL REVEGETATION PROJECT

Gravel fill constitutes the most extensive habitat disturbance on the Alaska North Slope. These pads and roads are dry, in contrast to the natural tundra. Consequently, the plants adapted to the adjacent wetlands are unsuited to the gravel fill. An experiment was begun with the restructuring of a gravel pad in 1989. Treatments included:

- Three thicknesses of gravel: 2-ft, 3-ft, and 5-ft.
- Topsoil (silt loam soil): 0 and 3-inches
- Tillage: none and tilled
- Snow capture: none and 2-ft snow fencing
- Collecting seed from native plants and applying to plots for 3 years: 1990 (880 PLS/ft^2, grass dominated), 1991 (80 PLS/ft^2, forb dominated), 1993 (40 PLS/ft^2 forb dominated), two plots left unseeded. (PLS = Pure Live Seed)

Findings:

- Grasses established best with topsoil, out competing forbs. Most grasses established within two growing seasons and reached sexual maturity within 2-3 years. At least one grass species required five growing seasons to reach maturity (began sexual reproduction).
- Forbs, particularly legumes established better on gravel than grasses and were competed with by grasses in topsoil treatments. It required 5-7 years for legumes to reach sexual maturity.
- The most aggressive grass, *Puccinellia langeana*, began dying after about 5 years, giving way to natural colonizers and other seeded species.
- Tillage and snow capture had mixed results. Overall the effects were positive in terms of vegetation cover. Snow fencing improved flowering, and presumably seed production of several native plant species.
- Mosses established naturally on gravel and soil mainly on the 2- and 3-ft lifts. Mosses were have not been successful on the 5-ft lifts. This response appears to be related to the presence of moist substrate. Phosphorus fertilizer in combination with substrate moistness is very effective in promoting the colonization by moss species. This is true for a wide range of substrates, including oil-damaged habitats, saline soils, gravel, and organic soils.

Photo 19. Aerial oblique view of gravel vegetation plots → southwest. Photo by David Predeger, July 1991.

LONG-TERM GRAVEL REVEGETATION PROJECT

Photo 20. View of barren gravel fill plot, Block 1, Rep III, 2-ft lift, no-topsoil, no-till. Upper center plot seeded approximately 1 month prior to this photo (23 July 1991).

Photo 21. View of same plot shown in Photo 20. Age of the first-seeded plot eight growing seasons (28 July 1997). Foreground plot seeded 1991. Brown cast in this image is the result of natural colonization by mosses.

Photo 22. View of barren gravel fill plot, Block 1, Rep III, 5-ft lift, no-topsoil, no-till. Upper center plot seeded approximately 1 month prior to this photo (23 July 1991).

Photo 23. View of same plot shown in Photo 22. Age of the first-seeded plot eight growing seasons (28 July 1997). Foreground plot seeded 1991. Note absence of moss on this lift and abundance of legume establishment, in contrast with photo 21, same treatment at 2-ft lift.

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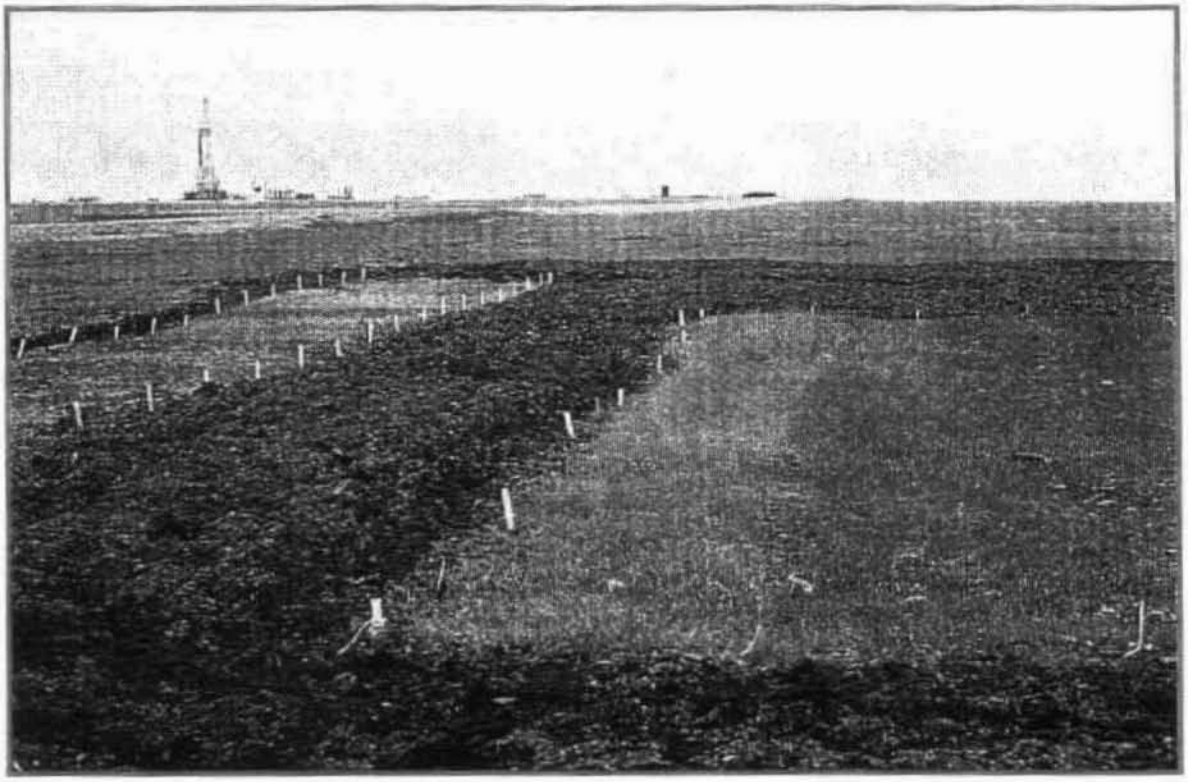

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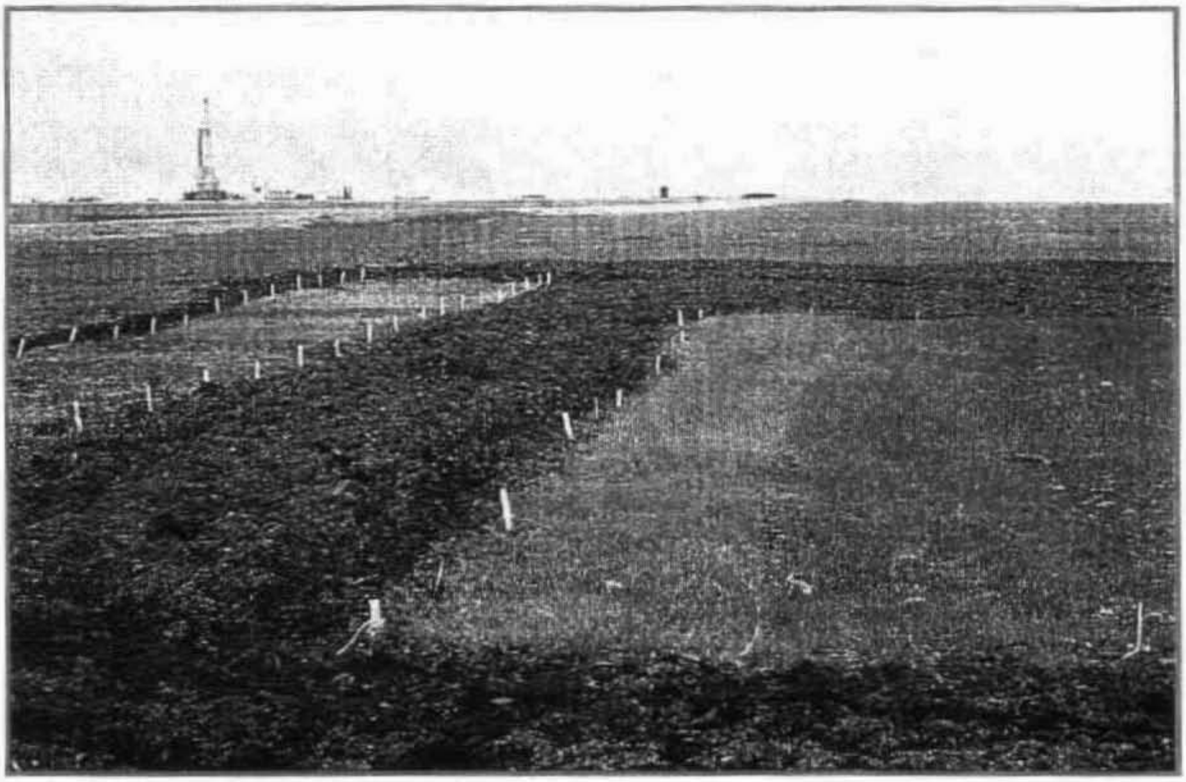

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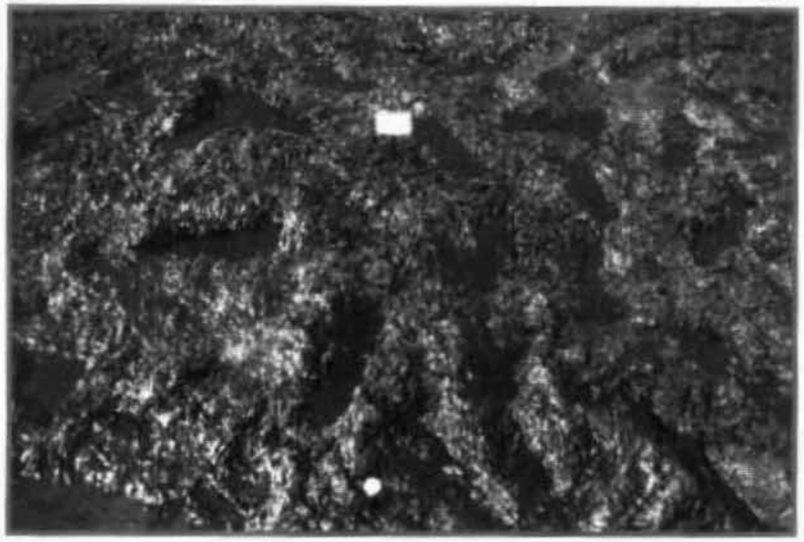

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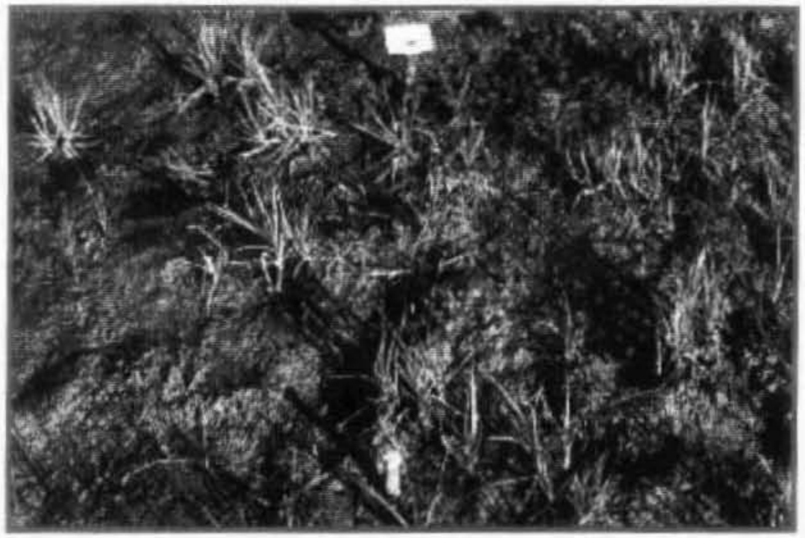

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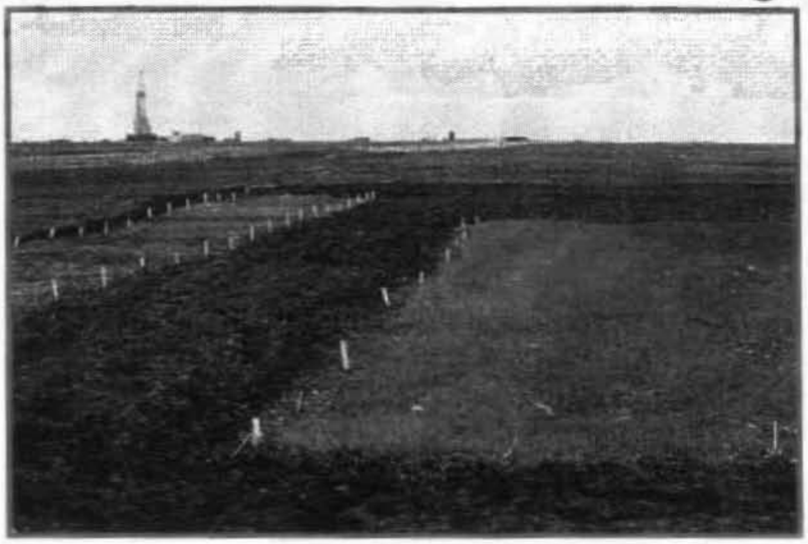

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After 26 growing seasons, we have found that:

- Phosphorus fertilizer was critical in the early establishment of seeded grasses, encourages mosses to recolonize, and stimulates organic matter decomposition in the soil.
- Several species of grass could be established on mesic mineral soils, including: *Arctagrostis latifolia*, *Festuca rubra*, *Poa glauca*, *Deschampsia beeringensis*, and *Puccinellia arctica*.
- *Arctagrostis latifolia*, *Deschampsia beeringensis*, *Festuca rubra*, and *Poa glauca* were recommended for revegetation by Dr. Wm.W. Mitchell, based on these tests.
- *Arctagrostis latifolia*, *Festuca rubra*, and *Poa glauca* have been used most extensively for revegetation across the Alaska North Slope, including production oil fields, the Trans Alaska Pipeline, exploration wells in NPR-A and one in ANWR (Arctic National Wildlife Range).
- *Deschampsia beeringensis* does not occur naturally in the Prudhoe vicinity, and where it has been established along the Spine Road, it grows taller than the natural vegetation and does not blend well with the texture of the tundra. It probably has greater potential for stabilizing sand dunes in river deltas and seashore habitats.
- *Puccinellia arctica* was not included in the original recommendations. It establishes easily over a wide array of habitats. It does not resist the reinvasion of natural tundra species, in contrast to the other grasses. Furthermore, it is unpalatable to geese and caribou, which often graze seedings and slow the development of plant cover. The recommended grasses usually do not establish well in wet habitats, which are quite common to the region.
- If the disturbed habitat is mesic mineral soil, and *Arctagrostis latifolia*, *Festuca rubra*, and *Poa glauca* are seeded, these grasses will establish, but they also have persisted for 26 growing seasons, with little indication of relinquishing their territory to natural tundra.

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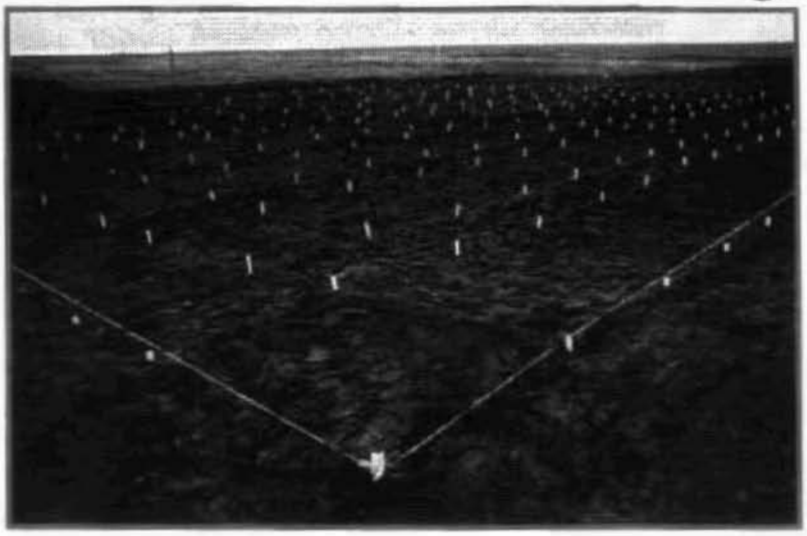

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WINTER HAUL ROADS (A.K.A. PEAT ROADS)

During the 1960s 'dirt' roads were constructed across the tundra to haul equipment to exploration sites. These roads were constructed in August, when the seasonal thaw was near its maximum. Two bulldozers worked in tandem, moving soil from edges to the center of the road. Roads were only used during winter, when the soil was frozen. About 1970, the practice was banned in Alaska.

One such road was used for tundra revegetation research. Observations over the course of time have revealed that:

1. Wet borrow pits recolonized first with *Eriophorum angustifolium*, *Carex aquatilis*, and *Dupontia fisheri*. Flooded areas were colonized by *Arctophila fulva* and *Hippuris vulgaris*. These habitats colonized within 10-15 years.

2. Surfaces that were well-drained became drier habitats than the adjacent undisturbed tundra. These recolonized more slowly, requiring 25 or more years.

3. Tundra recolonization can be accelerated by attracting wildlife to the site. Several features seem to attract wildlife to disturbances:

   a) Diversity of terrain, which creates a variety of niches.
   b) Thermokarst, which creates pools of water.
   c) Establishing swards of palatable forage plants, i.e. some grass species.

Photo 14. Winter Haul Road between DS-2 and Borough Landfill as it appeared on 27 June 1972. Age 3 years.

Photo 15. Same view of Winter Haul Road 25 July 1994; age 25 years.

Photo 16. Same view of Winter Haul Road 10 September 1997; age 28 years.

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WINTER HAUL ROADS (A.K.A. PEAT ROADS)

Natural vegetation recovery on uppermost surfaces of abandoned winter haul roads differs between the foothills and coastal plain. In the foothills, shrubs, willow (*Salix alaxensis*, *Salix planifolia* ssp. *pulchra* var. *pulchra*, *Salix lanata* ssp. *richardsonii*, and *Salix arctica*) and dwarf birch (*Betula nana*) colonize. On the coastal plain, grasses colonize on the uppermost surfaces (*Puccinellia langeana*, *Festuca baffinensis*, *Trisetum spicatum*, *Arctagrostis latifolia*, *Poa glauca*, *Poa arctica*, *Deschampsia caespitosa*).

The same wet sedge meadow species colonized the wet borrow pits of both roads shown in this sequence, indicating the wettest environments between the two locations are more similar between regions than their dry habitat counterparts.

Photo 17. View of winter haul road in foothill region east of Umiat, Alaska. This road was constructed by British Petroleum in August 1964. Photo was taken 16 July 1991; age 28 years. Natural recolonization is responsible for all vegetation recovery on this site.

Photo 18. View of winter haul road on coastal plain west of Oxbow Road, Prudhoe Bay, Alaska. Road was constructed by British Petroleum in 1969. Photo was taken 9 September 1997; age 28 years. Natural recolonization is responsible for all vegetation recovery on this site.

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LONG-TERM GRAVEL REVEGETATION PROJECT

Gravel fill constitutes the most extensive habitat disturbance on the Alaska North Slope. These pads and roads are dry, in contrast to the natural tundra. Consequently, the plants adapted to the adjacent wetlands are unsuited to the gravel fill. An experiment was begun with the restructuring of a gravel pad in 1989. Treatments included:

- Three thicknesses of gravel: 2-ft, 3-ft, and 5-ft.
- Topsoil (silt loam soil): 0 and 3-inches
- Tillage: none and tilled
- Snow capture: none and 2-ft snow fencing
- Collecting seed from native plants and applying to plots for 3 years: 1990 (880 PLS/ft^2, grass dominated), 1991 (80 PLS/ft^2, forb dominated), 1993 (40 PLS/ft^2 forb dominated), two plots left unseeded.

Findings:

- Grasses established best with topsoil, out competing forbs. Grasses established within two growing seasons and reached sexual maturity within 2-3 years.
- Forbs, particularly legumes established better on gravel than grasses and were competed with by grasses in topsoil treatments. It required 5-7 years for legumes to reach sexual maturity.
- The most aggressive grass, *Puccinellia langeana*, when seeded densely began dying out after about 5 years, giving way to natural colonizers.
- Tillage and snow capture had mixed results. Overall the effects were positive in terms of vegetation cover.
- Mosses established naturally on thinnest lifts and on gravel and topsoil.

Photo 19. Aerial oblique view of gravel vegetation plots → southwest. Photo by David Predeger, July 1991.

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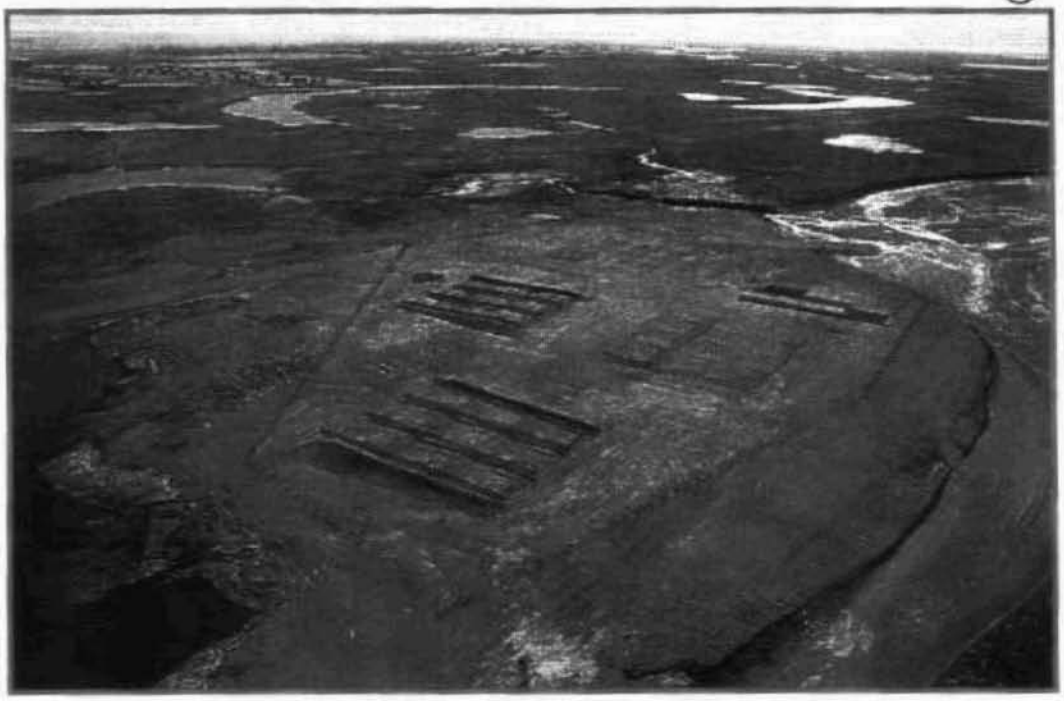

LONG-TERM GRAVEL REVEGETATION PROJECT

Photo 20. View of barren gravel fill plot, Block 1, Rep III, 2-ft lift, no-topsoil, no-till. Upper center plot seeded approximately 1 month prior to this photo (23 July 1991).

Photo 21. View of same plot shown in Photo 20. Age of the first-seeded plot eight growing seasons (28 July 1997). Foreground plot seeded 1991. Brown cast due to moss natural colonization.

Photo 22. View of barren gravel fill plot, Block 1, Rep III, 5-ft lift, no-topsoil, no-till. Upper center plot seeded approximately 1 month prior to this photo (23 July 1991).

Photo 23. View of same plot shown in Photo 22. Age of the first-seeded plot eight growing seasons (28 July 1997). Foreground plot seeded 1991. Note absence of moss on this lift and abundance of legume establishment, in contrast with photo 21, same treatment at 2-ft lift.

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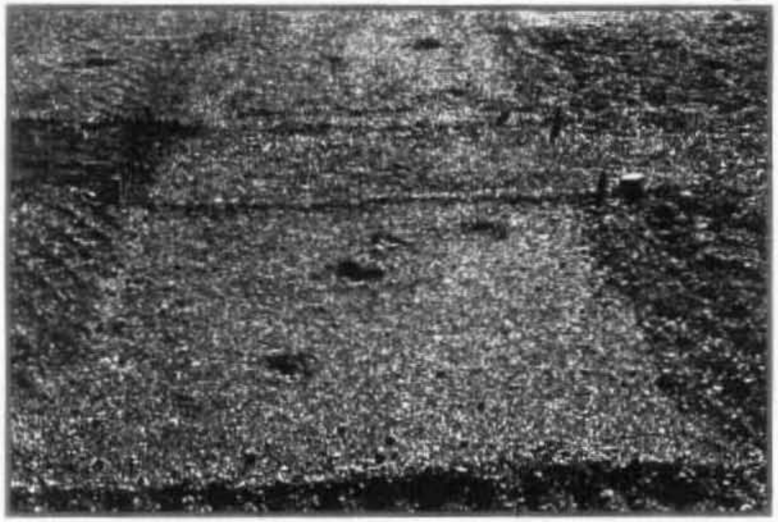

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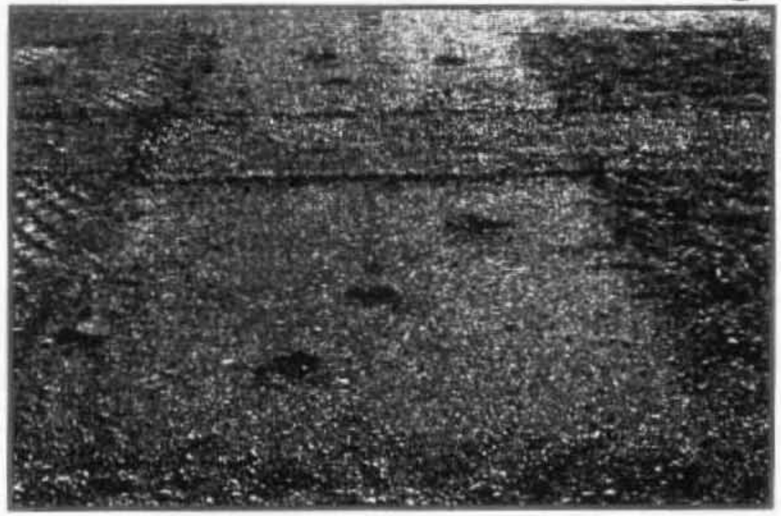

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