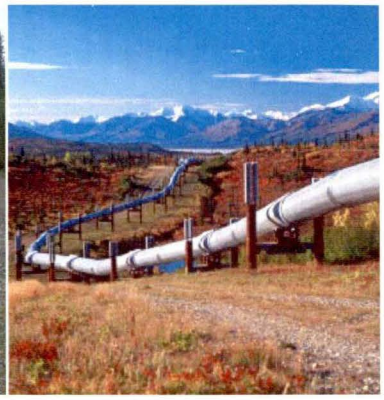




Soils and Vegetation of the Trans-Alaska Pipeline Route: A 1999 Survey

Jay D. McKendrick, Ph.D.
Emeritus Professor of Agronomy
School of Agriculture and Land Resources Management
University of Alaska Fairbanks

UNIVERSITY OF ALASKA FAIRBANKS

Agricultural and Forestry Experiment Station
School of Agriculture and Land Resources Management
University of Alaska Fairbanks

SCHOOL OF AGRICULTURE & LAND RESOURCES MANAGEMENT
AGRICULTURAL & FORESTRY EXPERIMENT STATION

Bulletin 109

January 2002

Soils and Vegetation of the Trans-Alaska Pipeline Route: A 1999 Survey

Jay D. McKendrick, Ph.D.
Emeritus Professor of Agronomy
School of Agriculture and Land Resources Management
University of Alaska Fairbanks

Design, Layout and Editing by:

Peg Banks
Lazy Mountain Research, Palmer, Alaska

Agricultural and Forestry Experiment Station
School of Agriculture and Land Resources Management
University of Alaska Fairbanks

Bulletin 109

January 2002

SOILS AND VEGETATION OF THE TRANS-ALASKA PIPELINE ROUTE: A 1999 Survey

© 2002 Jay D. McKendrick, Ph.D.

Published by:

Agricultural and Forestry Experiment Station,
School of Agriculture and Land Resources Management,
University of Alaska Fairbanks
533 E. Fireweed
Palmer, Alaska 99645

and

BP Exploration (Alaska) Inc.
P.O Box 196612
Anchorage, Alaska 99519-6612
Representing
The Trans Alaska Pipeline System Owner Companies

UAF is an affirmative action/equal opportunity employer and educational institution.

Executive Summary

This report presents the results of a survey of soils and vegetation along the Trans Alaska Pipeline System (TAPS) right-of-way (ROW) from Prudhoe Bay to Valdez, Alaska. This survey, conducted in the summer of 1999, was designed to secure an overall perspective of the soil fertility and general vegetation conditions in the ROW and in the undisturbed habitat immediately adjacent to the ROW. Researchers examined 52 sites along the 800-mile ROW, which crosses three vegetation zones: tundra, alpine, and boreal (includes coastal forest). Soil samples were collected for laboratory analysis of plant nutrients, vascular plant species were inventoried, and photographs were taken at each site. This information can be used to assess the impacts of TAPS on vegetation and the success or failure of revegetation efforts performed during pipeline construction in the 1970s and to make recommendations for revegetation of future disturbed areas in regions similar to the TAPS ROW.

The Federal Agreement and Grant of Right-of-Way for the Trans-Alaska Pipeline System requires that seeding and planting of disturbed areas be conducted as soon as practicable and, if necessary, repeated until vegetation was successful. As a result, areas disturbed during pipeline construction were revegetated by seeding grasses and fertilizing soils and by planting willow cuttings and transplants from natural sources and greenhouse production. Seeding and fertilizing were the most extensively used applications along the route. Transplanted trees and shrubs were used where the pipeline crossed public roads, in order to shield the view of the open ROW from the highway. Native and non-native grasses were seeded. As a result, some weeds were introduced and grasses were established, some of which have persisted.

Success of Revegetation Program

This vegetation survey led to the following general conclusions on the effects and/or success of Alyeska's revegetation program during TAPS construction in the 1970s:

- Vegetation cover produced by seeded grasses as well as plants entering the ROW by natural processes is providing sufficient cover to control soil erosion.
- Attempts to improve the appearance of the ROW by transplanting and seeding vegetation have been successful overall. The vegetation has become established and is persisting. How well it pleases every viewer cannot be assessed.
- According to soil analyses, fertilizer nutrients applied during revegetation have largely returned to background levels. At a few locations, the availability of either phosphorus or potassium may still be higher within the ROW than outside. Even in those situations, the level of these nutrients in the soil was not sufficient for concern.
- In most situations, the vegetation in the ROW appears different from the vegetation off the ROW. However, significant invasion of the ROW by native plans has occurred in the last 19 years. The difference is often more acute because the ROW is periodically mowed to control growth of trees and shrubs. Even so, some of the contrasts in vegetation appearance will likely persist after the ROW is abandoned. Contrasts are expected to diminish in time as the ROW communities achieve balance with the adjacent vegetation, particularly in the boreal zone.

Results of Soil and Nutrient Tests

Differences in soil properties from the TAPS ROW and from adjacent undisturbed areas varied among the sites examined. Where fill had not been added, differences were often small. In permafrost zones, gravel fill usually contrasted markedly to the adjacent soil. Testing revealed the following results:

- Overall, the ROW was more alkaline, rocky, drier, and lower in total carbon and nitrogen, and had higher carbon-to-nitrogen ratios than the adjacent soils.

- Soil analysis data often showed little or no evidence that fertilizer applied during revegetation had carried over.
- ROW soils tended to average slightly higher in available phosphorus and potassium than adjacent soils, but in the alpine zone, only potassium was significantly greater in ROW soils than in the adjacent soils.
- The amount of fertilizer applied in the mid-1970s to revegetate the ROW was neither harmful in the long term nor apparently necessary for natural plant species.

Interpretations of nutrient availabilities are generally based on cropland experience. When applied to the ROW and adjacent soil data, these soils appeared to be largely deficient in nitrogen, phosphorus, and potassium. One exception occurred between milepost 725 and 745, where available soil phosphorus was exceptionally high within and outside the ROW. However, since vegetation was growing where the availability of soil nutrients would be judged deficient for agricultural purposes, there is reason to believe that these agricultural criteria for natural vegetation and revegetation successes should be adjusted downward for future linear projects such as TAPS.

Results of Vegetation Inventory

The appearance of the vegetation in the ROW differs from the adjacent habitat. Several factors are responsible for the distinction between these two habitats:

- Often the ROW substrate contains more stones and is drier than the adjacent soils. This difference was caused because gravel or stony fill was added for a relatively dry and firm foundation for construction equipment and for later operations and maintenance. Where the pipeline was buried, subsoil usually ended up on the surface of the backfilled trench, and this material often contained more rocks than the natural surface soils.
- Where seeded grasses still predominate, the ROW often contrasts with adjacent plant, shrub, and forest communities. Most of the seeded grasses survived to varying degrees, and many remain in the ROW. Throughout the route, *Festuca rubra* (red fescue) and *Poa pratensis* (bluegrass) are the most common of these seeded species. The most consistently obvious effects of this persistence are in the tundra zone, particularly where the pipeline was buried and soil with a significant silt-size component remained at the surface. In those locations, much of the ROW still supports a relatively robust stand of seeded grass. No seeded grass was found outside the ROW.
- Throughout the boreal zone and much of the alpine zone, shrubs and trees have vigorously invaded the ROW. This woody growth would easily overtop the elevated pipeline were it not periodically cut back by the pipeline operators. This continual brushing activity leaves an open swath that contrasts markedly with adjacent shrub and forest communities. Few of these shrubs and trees are actually killed by cutting, and most readily resprout. Even the evergreen trees survive and continue to grow after cutting. Now that these plants are established, if brush-cutting ceased, much of the boreal zone portion of the ROW would be overgrown with trees and brush in less than five years.
- Necessary traffic required along the pipeline on the ROW keeps the road within the ROW mostly free of vegetation. Most exotic weed species have become less significant over time, and none have expanded into undisturbed natural plant communities outside the ROW.

Recommendations for Future Projects

Based on the results of this survey, recommendations for future projects have been made. The authors believe that rehabilitation of disturbed areas such as pipeline rights-of-way should be based on the short-term goal of preventing erosion and the long-term goal of encouraging the site to naturally revegetate. However, making the site quickly green with seeded vegetation often makes reestablishing native species difficult. If the soils are not erodible, limited seeding and fertilizing should be practiced to promote natural recolonization. It is best to stockpile and return topsoil (or another suitable substrate) in the disturbed areas so that native plant species can recolonize. In areas with erodible slopes, measures such as mats and waterbars should be considered. Any seeding should be accomplished only with either native or non-persistent grasses, and fertilizer should be used sparingly or not at all because it can keep out native species, particularly on mesic and dry sites.

Following are specific recommendations:

- In the forested zone, native vegetation will return to disturbed areas as long as suitable soil (loamy and friable) is left in place.
- In the Arctic, some species of seeded grasses keep natural tundra species from recolonizing and should not be used.

- Seeded red fescue and to some extent Kentucky bluegrass have persisted throughout much of the TAPS route. Neither of these grasses is recommended for future revegetation because they impede natural plant colonization. Smooth brome, timothy, and meadow foxtail persisted at some locations and not at others. Replacing these with less aggressive species should be considered in future revegetation projects, because natural revegetation appears to be adequate if suitable soil remains after construction.
- For buried pipeline projects, revegetation would be simplified if the backfilled trench were capped with surface soil (and/or silt-textured material) rather than gravel or subsoil. If a quick plant cover is needed to control soil erosion, the seeding of an annual grass or a low-competition, short-lived perennial such as *Puccinellia borealis* (northern alkaligrass) would better allow natural recolonization to occur than if persisting perennial grasses were seeded.
- Seeding grasses to gravel fill should be avoided. Fertilizing and allowing natural recolonization to occur is a better option for gravel fill in the arctic and boreal zones. A more aggressive approach would be to seed with native legumes such as *Hedysarum mackenzii*, *Hedysarum alpinum* (alpine sweetvetch), *Oxytropis borealis, Artemisia, Castelleja,* and related forb species. *Dryas* is another indigenous plant that naturally colonizes gravel and simultaneously improves soil fertility. There is no commercial source for these species at the present time. Seeds can be hand-harvested for small-scale projects.
- Overfertilization will favor grasses and sometimes weeds over other plant growth forms, because grasses and weeds are adapted to take advantage of additional nutrients. As these plants develop robust stands, they will often out-compete the other species. On wet soils, fertilizers stimulate moss development. Natural wet habitats are often dominated by grasses and sedges, and overfertilizing causes fewer species-composition problems in wet sites than it does on mesic and dry soils.
- Decisions regarding woody plant management in the boreal zone will be necessary, because those plants inevitably become established, regardless of the revegetation treatments used.

About the Author

Jay D. McKendrick, who is originally from southern Idaho, attended the University of Idaho at Moscow and Kansas State University, obtaining degrees in soil science, range management, and plant ecology. After graduation he worked in Kansas City, Missouri, in turfgrass management and urban landscaping. In 1972, he joined the faculty of University of Alaska Agricultural Experiment Station at Palmer, Alaska, as an assistant professor of agronomy, spending most of his tenure with the University researching practical (applied science) aspects of soil-plant-animal relationships. Studies extended widely, from the Kenai Peninsula, to the upper Tanana near the Alaska-Canada border, and the upper Susitna Valley, to Unalakleet, Barrow, NPR-A, and Prudhoe Bay. Long-term recovery of tundra following disturbance has been an important part of his research. Resource development often disturbed or destroyed plant communities. Solving those problems has been the basis for many of his studies and projects. These occurrences were usually associated with energy resource development activities. He has spent nearly three decades on such projects, and is often called upon to consult with industry and government agencies, particularly in the tundra regions of Alaska. His interests, education, and Alaska experiences provided the background for investigating and evaluating soils and vegetation along the Trans Alaska Pipeline System.

Table of Contents

List of Tables

List of Figures

List of Photos

List of Acronyms

Alyeska	Alyeska Pipeline Service Company
C:N	carbon-to-nitrogen
GPS	global positioning system
K	potassium
MP	milepost
N	nitrogen
P	phosphorus
ROW	right-of-way
TAPS	Trans Alaska Pipeline System

1. Purpose and Objectives

The purpose of this document is to present the results of a survey of the soils and vegetation along the Trans Alaska Pipeline System (TAPS) from Prudhoe Bay to Valdez, Alaska. Construction of TAPS began in 1974, and oil began flowing through the system in 1977. The pipeline crosses both state and federal lands, and stipulations in the federal grant of right-of-way and the state lease required erosion control and revegetation of disturbed areas. Areas disturbed during pipeline construction were revegetated by seeding and fertilizing soils and by planting willow cuttings and transplants both from natural sources and from greenhouse production. Seeding and fertilizing were the most extensive application (Hubbard, 1980). Transplanted trees and shrubs were used where the pipeline crossed public roads, in order to shield the view of the open right-of-way (ROW) from the highway (Land Design North, 1979d).

This vegetation survey, performed in the summer of 1999, was designed to secure an overall perspective of the soil fertility and general vegetation conditions in the TAPS ROW and for the undisturbed habitat immediately adjacent to the ROW. The focus of the survey was to identify the surviving plant species in the ROW and determine whether they were introduced or indigenous. Comparing the plant species in the ROW to those outside the ROW was important to identify the most successful natural colonizers, to determine if introduced species had become a problem to natural communities, and to identify both seeded and naturally occurring species that were unsuccessful in colonizing the ROW environment. This information will be useful in assessing the impacts of TAPS on vegetation and the success or failure of revegetation efforts conducted during pipeline construction in the 1970s.

Specific objectives of the survey include the following:

- Summarize revegetation and existing vegetation for the TAPS ROW.
- Provide specific details on vegetation and soils in the ROW and on whether the commercial fertilizers used in revegetation have persisted in soil.
- Identify which of the seeded grass species used in the revegetation program have persisted, and if exotic (introduced) grasses and weed species occur, identify where they are and whether they have invaded the surrounding plant communities.
- Provide general information on revegetation successes and long-term vegetation-management implications for TAPS and future pipelines, roads, etc.

The main text of this report was prepared for general readers who seek a perspective of the soil and vegetation conditions of the TAPS route in general. Alyeska Pipeline Service Company (Alyeska) field personnel and future investigators likely will find useful site-specific information in the appendix, which contains a detailed description of each site examined, along with data and photographs.

2. Literature Review

For the past 20 years there appears to have been no published comprehensive inventory of the vegetation growing throughout the TAPS ROW, with respect to revegetation success or failure. A literature review discovered a series of studies that occurred and were published before and during the construction period. After the pipeline became operational, studies of the vegetation conditions generally ceased, as far as the total route was concerned. The following studies are most prominent:

1969 Dr. Wm. W. Mitchell (1970) conducted a plant ecological survey of the northern section of the proposed route for Alyeska, the operator of TAPS.

1974 Alyeska took 15,000 surface soil samples along the route and prepared a fertilizer guide for revegetation based on laboratory tests (Hubbard, 1980). These data were interpreted according to agricultural production criteria from Ohio (personal communication from Joseph Neubauer to J.D. McKendrick, early 1970s).

1975 Johnson, Quinn, and Brown (1977) investigated revegetation and erosion control practices at selected locations as the pipeline was being built.

1976 A group under contract to Northwest Pipeline for work on the Alaska Natural Gas Transportation System permit toured the TAPS route in a helicopter on June 16, 1976, to inspect various environmental conditions. This author was among that group and reported on revegetation needs, observing that unstable, dry sand along the Tanana River appeared to be the major revegetation problem and that the forest zone portion of the TAPS route would naturally become vegetated with trees and shrubs (McKendrick, 1976, 1978).

1975-78 L.A. Johnson (1981) observed revegetation treatments at 60 sites along the pipeline during construction. Johnson provided summaries and improvement suggestions for a future natural gas transportation pipeline, and these were included in Walker et al. (1987).

1976-77 Webber, Komárková, Walker, and Werbe studied natural vegetation and effects of road construction along a transect from the Yukon River to Prudhoe Bay (Webber et al, 1979). The study resulted in natural vegetation maps for specific locations and geobotanical information along the transect.

1977, 79 A.W. Johnson and S.A. Kubanis inventoried weeds along the TAPS route from the Yukon River north to Prudhoe Bay (Kubanis, 1980; Johnson and Kubanis, 1980). They concluded there was a low potential for weeds to threaten adjacent habitat.

1979 Pamplin (1979) inventoried the acreage affected by construction of TAPS. Twelve vegetation habitat types were identified. Approximately 31,403 acres of habitat were either altered or destroyed by 1976. Material sites constituted the largest acreage (11,828 acres) affected. Construction Section 6 (northernmost) contained the largest acreage (10,900 acres) of impact. Sections 1 and 3 were least impacted, in terms of areal extent. One recommendation was to assess vegetation conditions at five-year intervals to document conditions and progress toward achieving natural vegetation stands on disturbed sites.

1979 Land Design North (1979a, b, c, d) prepared a series of documents for Fluor Northwest, Inc., to evaluate permitting and designing erosion control, restoration, and aesthetics for the Alaska Natural Gas Transportation System. This project culminated in examining the TAPS ROW from Donnelly Dome to Galbraith Lake to evaluate revegetation results and in recommending additional studies.

1979, 80 Native Plants, Inc., (1980a, b, and undated) of Salt Lake City, Utah, examined revegetation re-

sults along the pipeline route, plant succession patterns outside the route, and mycorrhizae on various plant species along the TAPS route from Prudhoe Bay to Delta Junction. These studies were sponsored by Northwest Pipeline for the Alaska Natural Gas Transportation System.

Revegetation recommendations included placing silty soil material on top of the buried pipeline trench and using containerized transplants of indigenous species inoculated with appropriate mycorrhizae.

3. Methods

This survey examined the soil fertility and general vegetation conditions in the ROW and in the undisturbed habitat immediately adjacent to the ROW. Species of vascular plants appearing in these habitats were listed to acquire a perspective of plants present with respect to seeded grasses and natural invaders. Time constraints limited the intensity of sampling of soil and vegetation.

Sites were classified into three groups (tundra, alpine, and boreal) for analytical purposes and to simplify interpretation by pipeline field personnel (Figure 1):

- Limited grouping of data among the three vegetation zones provided workable categories for statistical testing. Sampling of coastal forest habitat included only three locations, which were combined with the boreal forest.
- The three vegetation zones in the survey were a relatively close match to the criteria used by Alyeska in assigning seed mixtures for revegetation practices.
- The classification is uncomplicated and should be understandable to a wide array of readers.

The TAPS revegetation plan was designed with consideration for the occurrence of the three vegetation zones along the route. The literature contains references to locations along TAPS where additional mixed fertilizer was applied and extra phosphorus was used (Land Design North, 1979d and Native Plants Inc., 1980b). Such site-specific information was not available to us before undertaking this survey.

In recent years, emphasis on wetland habitats over mesic and dry habitats has increased. The basis for this shift in emphasis appears to be more political than biological in terms of revegetation needs, and habitat resistance and resilience. Along TAPS, the risk of soil erosion in wetlands is low, due to flat and nearly level topography. Natural vegetation recolonization has a high potential in wetlands, for several obvious reasons. The need to seek preferential accommodations to revegetate wetlands has little biological justification and, therefore, was excluded from this survey.

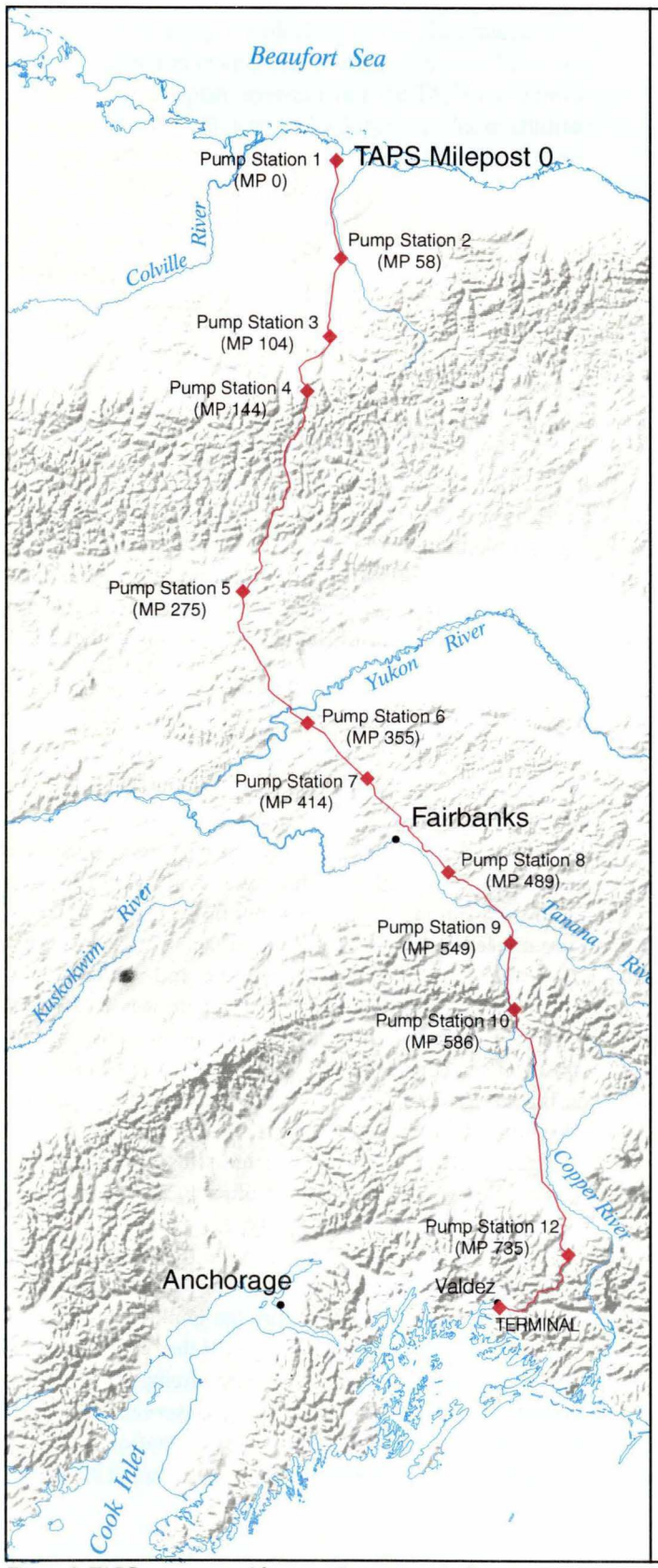
3.1 Time Frame of Field Work

During 1999, we spent a total of 12 days in the field examining and sampling sites: eight days in July and four days in September. Ideally, this type of survey should commence early in the growing season in the portions of the route in Interior Alaska at a time when vegetation is growing and plants are flowering. The survey should extend southward and northward from that initial point. We attempted to follow that plan; however, we did not sample the southernmost sites until September, because other field projects took precedence.

3.2 Site Selection

Completing the survey in a single field season was important for maintaining consistency in personnel and procedures and to acquire an overall perspective. Based on these principles, sufficient time was available to sample about 50 locations during the 1999 field season, and sites were chosen at 15- to 30-mile intervals. Actual locations were selected as we drove the route and found access points within the sampling interval. There was no attempt to stratify sampling according to vegetation zones or construction sections; however, those categories were used during the data analysis. At Atigun Pass, sampling intensity was increased to capture possible effects from rapid changes in elevation. Two selected sites in the Dietrich River valley were close to each other to acquire data for two distinct vegetation and soil types.

All sites except Site 42 were in the ROW and adjacent undisturbed habitat. Site 42 is at the Isabel Camp site, which is on gravel outwash from the Gulkana Glacier on the south side of the Alaska Range. At that location, it appeared that no revegetation had been attempted. In a subsequent visit to the site in 2001, we observed red fescue along the road, and this indicated revegetation had been attempted but success was minimal. We sampled the camp-



Vegetation Survey Sites

SITE NO	TAPS MILEPOST	ZONE	VEGETATION
1	0.25	1	tundra
2	16.00	1	tundra
3	31.00	1	tundra
4	54.40	1	tundra
5	69.00	1	tundra
6	85.00	1	tundra
7	100.00	1	tundra
8	119.70	1	tundra
9	139.60	1	tundra
10	154.00	1	tundra
11	163.40	2	alpine
12	165.10	2	alpine
13	166.00	2	alpine
14	168.50	2	alpine
15	173.70	2	alpine
16	176.50	2	alpine
17	188.00	3	boreal
18	190.00	3	boreal
19	208.30	3	boreal
20	226.00	3	boreal
21	245.40	3	boreal
22	258.30	3	boreal
23	276.00	3	boreal
24	299.70	2	alpine
25	322.60	3	boreal
26	346.90	3	boreal
27	360.20	3	boreal
28	396.00	3	boreal
29	406.00	3	boreal
30	412.30	3	boreal
31	426.30	3	boreal
32	438.70	3	boreal
33	441.80	3	boreal
34	461.00	3	boreal
35	489.20	3	boreal
36	521.10	3	boreal
37	542.00	3	boreal
38	547.70	3	boreal
39	559.40	2	alpine
40	587.50	2	alpine
41	599.00	2	alpine
42	606.50	2	alpine
43	613.40	2	alpine
44	639.80	3	boreal
45	654.80	3	boreal
46	685.15	3	boreal
47	688.90	3	boreal
48	709.70	3	boreal
49	724.60	3	boreal
50	745.20	3	coastal forest*
51	769.00	3	coastal forest*
52	777.50	3	coastal forest*

*Combined with boreal for this study

Figure 1. TAPS route map with vegetation survey site locations.

site and the adjacent undisturbed vegetation, which was undergoing primary succession on the glacial outwash.

At each location, we obtained GPS readings and recorded the TAPS milepost as a reference. Nothing was left in the field to mark these locations, for several reasons. Use of the ROW continues, and that would likely damage markers left in the field. Most of the photos taken include features of the pipeline and/or terrain that should allow future investigators to find these sites with relative ease from milepost and GPS information. Because we were unsure about permit stipulations for the use of field markers, we elected not to use them in case they were disallowed.

3.3 Sampling Soils

Before pipeline construction, Alyeska collected 15,000 soil samples throughout the proposed route (Hubbard, 1980). Laboratory analyses of those soils provided the basis for fertilizer formulations and amounts. Alyeska prepared these fertilizer formulations and applications according to the best available technology of the time. Actually, soil fertility assessment throughout much of the TAPS route was based on fertilizer recommendations for agricultural production in Ohio. Even now, limited references are available for interpreting soil tests with respect to indigenous vegetation requirements throughout much of Alaska. Consequently, fertilizer recommendations and interpretations are still largely interpreted from commercial agricultural production guidelines.

Native Plants, Inc. (1980a, b, and undated) later observed that this rather costly fertilizer practice was probably unnecessary, and furthermore, the soils being fertilized in the TAPS ROW were usually not those originally sampled. The soils that were seeded and fertilized were fill material hauled to the ROW and subsoil on the surface of backfilled trenches, not the originally sampled soils. Given the type of construction, there was no way to identify beforehand what the surface soil would be when the time came to revegetate the ROW.

Based on this information, it seemed appropriate to measure the fertility and general features of the soil in the ROW and compare it to the adjacent soils, which probably more closely represented those on which fertilizer formulae and applications were based. Sampling and laboratory analyses were designed to determine whether there was a fertilizer carryover in the soil of the ROW that might be affecting the vegetation. Trace elements were not examined in this general survey, even though they were included in the pre-construction testing and soil fertilizing done by Alyeska.

At each location, the soil was sampled either under the elevated pipeline or over the buried pipeline and in the adjacent undisturbed habitat. Thickness of the surface organic mat was measured and recorded. The underlying 15 centimeters (6 inches) of mineral soil was sampled. We attempted to acquire about 3/4 to 1 gallon of material, which included rocks. Samples were sealed in plastic bags and labeled, and the collections were placed in a deep freeze as soon as practical to preserve them until they could be prepared for the laboratory.

Before the soil samples were sent to the laboratory, they were thawed and moisture contents were measured on a subsample. These subsamples were dried for 48 hours at 105°C. The loss in weight was divided by the oven-dried net weight to determine percent moisture. Soil moisture data were gathered to compare relative wetness in the ROW and in adjacent habitat. It was assumed there would be a difference, and those differences would influence vegetation development in the ROW in contrast to the undisturbed communities.

3.4 Laboratory Analyses of Soils

Laboratory analyses included:

- Gravel content (percent)
- pH (1:1)
- Available nitrogen, phosphorus, and potassium (ppm)
- Total carbon (C) (percent)
- Total nitrogen (N) (percent)

Gravel content was measured by weight (air-dry). Available nitrogen (ammonium and nitrate N) was extracted with potassium chloride. Available phosphorus (P) was measured on two different extracts, depending on the soil pH. If the pH was 7.0 or greater, a sodium bicarbonate extract was used, while the Bray P-1 extract was used if the pH was less than 7.0. Potassium (K) was extracted with 1.0 N ammonium acetate, and total carbon and nitrogen were measured in a carbon-hydrogen-nitrogen analyzer. Because carbonates were not measured, the total carbon values for alkaline soils included both organic and inorganic carbon. From the total carbon and nitrogen, the carbon-to-nitrogen ratios (C:N) and organic matter percentages were calculated. Organic matter was calculated by dividing the total carbon by 0.45 based on the assumption that the soil organic matter on average consists of 45 percent carbon.

3.5 Inventorying Vegetation

Vascular plant species present both in the ROW and outside the ROW at each sampling location were recorded. This was important because previous investigators specu-

lated that revegetation practices which relied heavily on agronomic grasses were likely to retard natural species from recolonizing the ROW. Native Plants, Inc., (1980) considered the possibility that the absence of certain mycorrhizae may prevent plants from recolonizing open ground in the TAPS ROW. Therefore, it was important to identify plant species in the ROW to learn if any natural species were absent.

3.6 Photographs

Obtaining high-quality photographs of vegetation can efficiently record vegetation aspects and provide references for aspect changes through time. Even though weather conditions were often unsuited to photography, most photos acquired in this study were usable. At each location, duplicates were obtained. One set of images has been placed with BP Exploration (Alaska), Inc., and the other set was retained by Lazy Mountain Research. A third set of images was obtained using a 6"x7", medium-format camera. Those color transparencies are in Lazy Mountain Research's possession.

Photos were taken with the camera on a tripod, and the aperture was set at the minimum for most photos to acquire maximum depth of field and details. A cable release was used to control camera movement. This was especially important for long exposures. When windy conditions prevailed, the shutter speed was set to stop movement, and depth of field was sacrificed accordingly. Records were kept for each photo, and after the film was processed, these images were labeled according to location, subject, and date. The 35 mm images were scanned and files written to two compact disks. One disk set was given to BP Exploration (Alaska), Inc. and one retained by Lazy Mountain Research.

3.7 Data Analysis

Soils and plant data were entered into spreadsheets and eventually transferred into a SYSTAT 10 program file (SPSS, Inc., 2000). Standard t-tests were performed to compare data from the ROW with that from outside. The data set was coded into three vegetation zones (boreal, alpine, and tundra). For certain data, t-tests were performed to compare the ROW and adjacent habitats within these three vegetation zones.

4. Results and Discussion

This survey generated data on both soils and vegetation in and adjacent to the TAPS ROW. Soils data were compared for the ROW and for adjacent habitat throughout the route and in the three vegetation zones (tundra, alpine, and boreal). The frequency of occurrence of vegetation species among study sites was summarized and tested statistically, and the common species were identified by ranking species by their frequency in the ROW. Presence or absence of plant species was the fundamental feature of the vegetation data. However, species importance with respect to cover and population is unavailable from these data, because making such a determination would have required sampling procedures that could not have been accomplished for the full TAPS route in a single season.

Table 1. Comparisons of soil measurement means for the ROW and for adjacent habitat, and t-test significance.

Soil Measurement	Means		t-test Significance
	ROW	Adjacent	
pH	7.54	6.42	0.000
Available N (ppm)	2.76	2.57	0.701
Available P (ppm)	8.20	7.74	0.714
Available K (ppm)	39.3	33.3	0.196
Total C %	1.70	5.51	0.000
Organic Matter %	3.79	12.24	0.000
Total N %	0.056	0.239	0.000
C:N	50.9	20.1	0.013
Organic Mat (cm)	1.4	12.4	0.000
Gravel %	60.3	18.0	0.000
Moisture %	9.2	63.2	0.000

4.1 Soils

Table 1 provides general comparisons between the soil in the ROW and in adjacent undisturbed habitat, while Table 2 compares the soil in the ROW and in adjacent habitat in the three vegetation zones.

4.1.1 Gravel Content

ROW soils averaged 60.3 percent gravel, and those in adjacent habitats averaged 18.0 percent (Table 1). The significant difference in this soil feature was caused by applications of gravel fill and rocky subsoil left on the surface after construction. We noted that rocky soils were quite productive in some locations where silts were mixed with the stones. In the study by Native Plants, Inc. (1980), the presence of silt was the most important soil feature having a positive effect on plant succession, and this feature was the basis for their recommendation that a natural gas pipeline design include provisions for backfilling with soil containing adequate amounts of silt on the surface. Gravel

Table 2. Comparisons of soil measurement means for ROW and for adjacent habitat, and t-test significance among three vegetation zones.

Soil Measurement	Tundra (n=10)			Alpine (n=9)			Boreal and Coastal Forest (n=30)		
	ROW	Adjacent	p	ROW	Adjacent	p	ROW	Adjacent	p
pH	7.86	7.08	0.041	7.66	5.93	0.001	7.25	6.35	0.000
Available N (ppm)	2.7	3.2	0.696	1.4	1.4	1.00	3.2	2.7	0.474
Available P (ppm)	3.2	2.5	0.506	4.3	3.2	0.384	11.0	10.8	0.923
Available K (ppm)	27.2	38.0	0.300	37.8	21.3	0.045	43.4	35.4	0.180
Total Carbon (%)	3.43	11.04	0.057	1.14	3.45	0.062	1.30	4.28	0.000
Organic Matter (%)	7.6	24.5	0.057	2.5	7.7	0.062	2.9	9.5	0.000
Total N (%)	0.073	0.518	0.021	0.040	0.148	0.018	0.550	0.173	0.000
C:N	66.0	24.6	0.054	39.6	19.6	0.201	48.1	26.7	0.149
Organic Mat (cm)	1.8	17.7	0.001	1.3	11.4	0.001	1.3	11.0	0.000
Gravel %	64.9	7.0	0.000	58.5	32.0	0.020	59.2	17.6	0.000
Moisture %	10.1	141.5	0.060	9.4	35.4	0.019	8.8	45.4	0.000

*Photo 1. View of Haines pipeline right-of-way, 4 June 1978, showing poorly vegetated dry sand 22 to 23 years after construction. The silt layer that originally covered the entire site is visible in the background. Limited plant growth (*Calamagrostis purpurascens*) on the sand in the foreground illustrates the importance of soil fines (silt and clay) for supporting vegetation.*

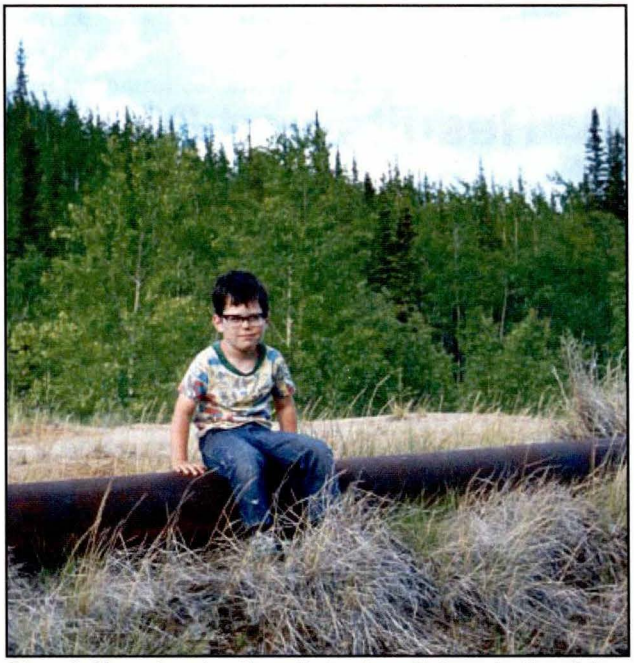


Photo 2. View of mesic, silty soil site along Haines pipeline, 8 June 1978, 22 to 23 years after construction. Soil at this site consists of a thin layer of silt over sand. Calamagrostis purpurascens *is the dominant plant that naturally recolonized at this location, in contrast with the previous photo, where very little grass established. No artificial revegetation was practiced on this right-of-way.*

mixed with only sand, particularly coarse sand, has little capacity to hold and supply water and nutrients to vegetation. Photos 1 and 2 of the Haines pipeline illustrate the different potentials for natural plant recolonization in pure sand and in silty soils in the boreal zone. No artificial revegetation was used along the Haines pipeline, which was built in 1955-56.

In the three vegetation zones, gravel percentages in the ROW and in adjacent soils differed significantly (Table 2). The largest difference was found in the tundra zone, while the smallest occurred in the alpine zone. The greater differences occurred where gravel fill was contrasted to soils dominated by fine particles. Most of the natural tundra soils were formed from loess, which was low in gravel. The alpine soils were thin and rocky, often forming from glacial outwash and on mountains where relatively few soil fines existed. The boreal zone soils formed from a variety of alluvial parent materials, some from glacial outwash and some from unglaciated terrain, such as in the Yukon and lower Tanana drainages.

4.1.2 Moisture Content

Soil moisture in the ROW averaged significantly less (9.2 percent) than the adjacent habitat (63.2 percent) (Table 1). The difference was attributable to additions of fill in the ROW. Alyeska's objective was to create a firm, dry workpad to support equipment. Interestingly, this change in substrate moisture did not prevent seeded and natural vegetation from developing in the ROW.

A survey by Land Design North (1979d) identified soil moisture as an important factor for establishing plants along the ROW and found moist sites producing better growth of seeded grasses than drier sites. Photo 3 shows the benefits of soil moisture for natural revegetation in the boreal zone. In our survey, among the three vegetation zones, ROW soils nearly always contained significantly less moisture than adjacent habitats (Table 2). The largest difference was found in the tundra soils, which have high accumulations of organic matter, organic mat thickness, and permafrost, which prevent vertical drainage within the natural profiles. Usually the fill in the ROW tundra zone consisted of river gravels, which consisted primarily of sand particles in the <2 mm fraction. Fill in other portions of the route sometimes contained a relatively high stone content but often had substantial portions of silt. Although there was often more silt in fill used in the boreal and alpine zones compared to that used on the tundra, the mean moisture content of ROW soils was comparable throughout the route.

Photo 3. View of well vegetated wetland site within the Haines pipeline right-of-way, 9 June 1977, 21 to 22 years following construction. Grass, willow, cottonwood, spruce, and sedge have naturally recolonized at this location. Comparing vegetation in this habitat to those in the previous two photos shows that, with adequate soil moisture and nutrients, natural recolonization in Alaska's boreal zone is sufficiently robust to provide adequate soil cover within 20 years. This pipeline route was neither seeded nor fertilized following construction. Herbicides were used to control brush and trees during the operational life of this pipeline. Woody species in this image invaded after chemical control was discontinued.

4.1.3 pH

The pH of ROW soils averaged significantly higher (7.45) than the adjacent habitat (6.42) throughout the route (Tables 1 and 2). The difference can be attributed to fill added to the ROW where the pipeline was elevated and to subsoil backfill where the pipe was buried. It is expected that the soil reaction would influence the availability of nutrients and in turn the habitat for plant species occurring along the route. Generally, subsurface soils are more alkaline than surface soils, which are influenced by organic matter accumulations and leaching of basic cations. In Alaska soils, the accumulation of organic matter and increase in acidity over time are documented (Viereck, 1966).

Differences in soil pH in the ROW and in adjacent habitats were significant in all three vegetation zones (Table 2). The pH divergence averaged less in the tundra zone (7.86 versus. 7.08, respectively) but was still significant. The most acidic soils were found in the undisturbed habitat of the alpine zone, followed by the undisturbed habitats in the boreal zone.

4.1.4 Available Nutrients (Nitrogen, Phosphorus, and Potassium)

Overall, we found no significant difference in the availabilities of nitrogen, phosphorus, and potassium in soils in the ROW and in adjacent habitats (Table 1). The fact that there was a slight tendency for potassium to be higher in the ROW soils might indicate inherent differences between the subsoils and gravel of the ROW versus the undisturbed soils. In general, there appeared to be no carryover of the commercial fertilizers applied during revegetation.

Available nitrogen and phosphorus were not significantly different in the ROW and in adjacent habitats in any of the three vegetation zones (Table 2). Both nitrogen and phosphorus averaged relatively low levels, except in the boreal zone. The higher averages found in the boreal zone were skewed upward by readings from soils at Sites 49 and 50 (see appendix). The available phosphorus values for the ROW and adjacent habitats at these locations were unusually high, ranging from 50 to 150 parts per million. Because the soils within the ROW and adjacent habitats at both locations were comparable, it appears there is an inherently high level of phosphorus in the soil parent material in the vicinity of TAPS milepost (MP) 725 to 745.

Available soil potassium differed significantly in the ROW and in adjacent habitat in the alpine zone (Table 2). The mean difference favored the ROW soil. This could have been caused by carryover of fertilizer applications or perhaps inherent differences in the soils themselves. Available potassium in the adjacent habitat averaged very low in several boreal zone soils, but in that zone, there also were several high values that raised the mean. Probably the largest factor affecting the statistical analytical results for these data was the fact that there were three times more samples in the boreal zone than in the alpine zone.

Available potassium is inherently more variable than nitrogen or phosphorus. It does not percolate, leach, or volatilize; it is generally a cation on the exchange complex.

4.1.5 Total Carbon and Nitrogen

On average, total soil carbon was significantly higher outside (7.74 percent) the ROW than inside (1.70 percent) (Table 1). This would be expected, considering the nature of the two soils. The values translate to an average organic matter of 1.24 percent in adjacent habitats and 3.79 percent in the ROW soil. It is important to remember the alkaline soils of the ROW contain inorganic carbonates, which were included in this measurement.

Total soil carbon differed significantly in the ROW and

in adjacent habitat in all three vegetation zones (Table 2). In the undisturbed adjacent habitats, tundra soils contained the most carbon (11.04 percent) among the three zones. ROW soils in the tundra zone averaged 3.43 percent carbon, compared to 1.30 percent and 1.14 percent, respectively, for the boreal and alpine zone soils. Tundra soils contain a very large pool of carbon.

Total soil nitrogen averaged 0.239 percent in the adjacent habitat soils and 0.056 percent in the ROW. These means were significantly different (Table 1). All soil nitrogen outside the ROW was from natural sources, but the nitrogen in the ROW included natural nitrogen and perhaps residual nitrogen from the commercial fertilizer applied during revegetation. The proportion from such fertilizers is expected to be minute.

In the three vegetation zones, total soil nitrogen differed significantly between the ROW and in adjacent soils (Table 2). As with soil carbon, total nitrogen of the tundra soils outranked that of the boreal and alpine zones by 3X and 3.5X, respectively.

4.1.6 Carbon-to-Nitrogen Ratios

Throughout the pipeline route, carbon-to-nitrogen (C:N) ratios differed significantly between the ROW and adjacent habitats. The ROW C:N ration averaged 50.9, while natural soils adjacent to the ROW had an average C:N ratio of 20.1 (Table 1). It is generally accepted that C:N ratios above 30 are too large for crop production. Based on that, the high C:N ratio in the ROW soils indicates possible restrictions on plant growth in the form of nitrogen deficiency. However, while we observed limited growth at some locations, we could not attribute the cause to lack of nitrogen.

When the ROW and undisturbed C:N data were compared in each of the three vegetation zones, only ROW ratios of the tundra zone differed significantly from adjacent soils (Table 2). The average ROW soils of the boreal and alpine zones had greater C:N ratios than their adjacent counterparts, but the difference was insignificant according to the t-test. Statistically large differences in C:N in the tundra zone might imply that revegetation of those soils could benefit from higher nitrogen applications. Comparable testing in the field with adequate controls among the three zones would be required to confirm this possibility.

4.1.7 Organic Mat Thickness

At most locations in the ROW, the surface organic mat had begun to form with plant debris, moss, and lichen growth. As expected, there was significantly less organic mat within the ROW (1.4 centimeters) than in adjacent habitats (12.4 centimeters) (Table 1). Organic mat accumulation is a function of plant production and decomposition with time. The formation of an organic mat is a positive sign that soil erosion is not occurring.

When the organic mat thicknesses in the ROW and in adjacent habitats were compared among the three vegetation zones, the ROW was always significantly lowest. The ROW averages among the three zones were, 1.8 centimeters, 1.4 centimeters, and 1.4 centimeters for the tundra, alpine, and boreal environments, respectively. The undisturbed tundra mat averaged 11.7 centimeters, and the alpine and boreal zone mats were 11.4 and 11.0 centimeters, respectively. These large accumulations of organic mat in the undisturbed habitat illustrate the imbalance between plant production and decomposition in the Alaskan environment. More organic matter is produced than decomposed annually, leading to an accumulation on the soil surface. Low temperature accounts for this net accumulation of organic matter.

4.2 Vegetation

The most revealing data from this study are the numbers of plant species found in the ROW. Significant invasion in the ROW has occurred in the 19 years since the Native Plants, Inc. (1980a, b, and undated) conducted its field studies. That data set included 33 species. Because vegetation development in the ROW was limited when Native Plants, Inc., conducted their studies, a number of plants were identified only to genus because of their small size and lack of identifying features, thus limiting the number of species in the data set. Also, the fact that the Native Plants, Inc. inventory was designed to collect cover and population data limited their ability to capture information on plant species that occurred infrequently. Finally, their study did not include the entire pipeline route, and that may have restricted the number of species appearing in their data set.

One of the most striking features of vegetation in the boreal vegetation zone has been the invasion of the TAPS ROW by trees and shrubs. The process began subtly and produced only minor aspect changes for perhaps ten or more years. However in the last ten years, this woody plant growth has become a major factor in the ROW. The accompanying series of photos taken in the upper Dietrich River valley illustrate that process (Photos 4, 5, 6).

Previous reports indicated seeded grasses were interfering with natural recolonization of the ROW by indigenous

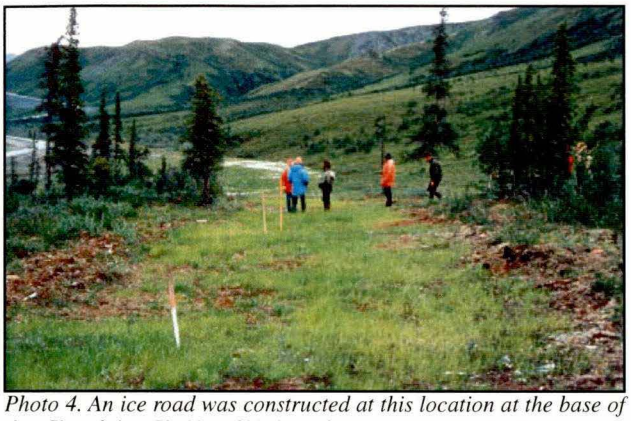


*Photo 4. An ice road was constructed at this location at the base of the Chandalar Shelf (N68° 01' 46.3"; W149° 40' 56.7") to move supplies to the North Slope before the Dalton Highway was constructed. After the ice road route was no longer needed, the clearing was seeded to annual ryegrass (*Lolium multiflorum*) and fertilized. In this view (27 July 1975), the ryegrass is growing in the clearing.*

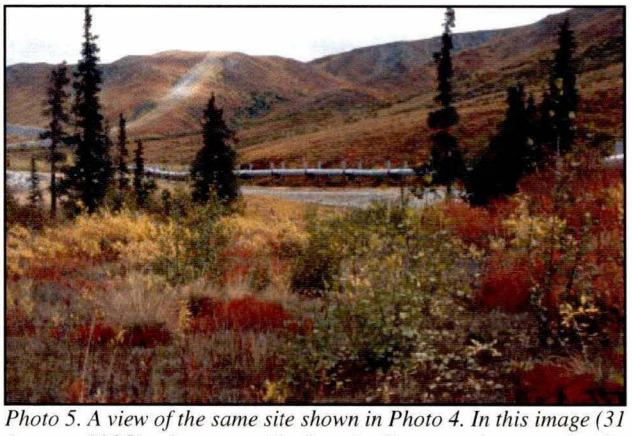


Photo 5. A view of the same site shown in Photo 4. In this image (31 August 1985), the trans-Alaska pipeline can be seen in the background. The clearing that was created for the ice road has been invaded by indigenous plant species, including alder and bluejoint reedgrass. The annual grass has long since died.

Photo 6. The same view of the ice road clearing as shown in Photos 4 and 5. In this view (22 July 1999), alder are the dominant vegetation in the clearing. Spruce trees are 3 to 4 feet in height beneath the alder. Blueberry shrubs are common in the former clearing, as are willow and other woody species.

species (Land Design North 1979a, b, c, d; Native Plants, Inc., 1980a, b). In the southern boreal forest, we found that within 12 years, alder completely overtook coal-mine test pits seeded to non-persisting grass species (McKendrick, 1995). Where seeded grasses established and persisted, shrub and tree invasion was slowed but not entirely prevented. In the current TAPS survey, we found effects from seeded-grass competition on indigenous plants to be most forceful in the tundra vegetation zone, although it was also apparent elsewhere. In 1999, gravel fill in the tundra zone usually supported a sparse stand of seeded *Festuca rubra*, unless the seeding was relatively young and heavily fertilized. Most of the older seeded grasses exhibited poor vigor on the gravel substrate, yet they seemed to occupy territory that ought to have been overtaken by indigenous species suited to gravel substrate. The reasons why the fescue prevailed were not confirmed, but could include competition for moisture and nutrients. Some of this gravel fill was also compacted and most likely poor habitat, such as that observed at TAPS MP 34 (McKendrick and Holmes, 1989).

At the Franklin Bluffs gravel pad, indigenous legumes, primarily *Oxytropis borealis*[1], has gradually invaded the gravel fill on the north, east, and south margins. These stands of *Oxytropis borealis* have become useful sources of seed for gravel revegetation in recent years (McKendrick, 2000). The seeded fescue has not been displaced by the forbs and may even have benefited from the nitrogen provided by them. The same benefits from certain lichen species, legume, and other nitrogen-fixing species could be accruing to seeded grasses and naturally-colonizing plants elsewhere along TAPS.

The survey found 245 species in the ROW and/or adjacent habitats (Table 3). The largest category was forbs, which amounted to more than half (138) the number found. Shrub, grass, sedge/rush, and tree species numbers followed forbs in descending order. One hundred ninety-three vascular plant species were found in the ROW, while the adjacent habitat contained 179 vascular species. All seven tree species encountered occurred in both habitats. Forty-four shrub species occurred in the ROW, and 49 were found outside the ROW. One hundred nine forb species were recorded in the ROW, and 90 occurred in the adjacent communities. Twenty-two grasses occurred in the ROW and 19 in the undisturbed habitat. Eleven sedges and rushes were found in the ROW and 14 outside the ROW.

When average numbers of species per site were com-

[1]*Oxytropis borealis* and *O. vicida* are similar and distinguished in Hultén (1968) by distribution and stipula features. *O. borealis* appeared to be the one we encountered. Our southernmost record for *O. borealis* was on the south side of Atigun Pass.

pared between the ROW and adjacent communities over the whole route, the numbers of species in the ROW sites outranked the undisturbed habitat sites significantly: 24.2 to 17.3 (Table 4). Numbers of tree, forb, and grass species were greater in the ROW, while sedge and rush species of the undisturbed areas were significantly greater outside the ROW than within (Table 4). The average numbers of shrub species per site was slightly greater outside the ROW (7.7 versus 6.9), but the difference was insignificant.

A comparison of plant species in the ROW and in adjacent habitat among the three vegetation zones (tundra, alpine, and boreal) revealed that the numbers of species of trees, forbs, and grasses were always greater within the ROW (Table 5). Species of sedges and rushes in the adjacent communities always outnumber those found in the ROW. Shrub species numbers in the three vegetation zones were always higher outside the ROW, but those means were insignificant according to a t-test.

Table 3. Numbers of vascular plant species observed during 1999 in the ROW and adjacent habitats along the trans-Alaska pipeline corridor. Species were grouped into five growth forms.

Plant Growth Form	ROW	Adjacent	Totals
Trees	7	7	7
Shrubs	44	49	55
Forbs	109	90	138
Grasses	22	19	27
Sedges	11	14	18
TOTALS	193	179	245

Table 4. Comparisons of mean number of species in the ROW and in adjacent habitat, and t-test significance.

Species Categories	Mean Number of Species/Site		p Values of t-test Significance
	ROW	Adjacent	
Total Species	24.2	17.3	0.000
Trees	2.2	1.3	0.000
Shrubs	6.9	7.7	0.082
Forbs	10.3	5.2	0.000
Grasses	4.3	1.6	0.000
Sedges & Rushes	0.5	1.5	0.000

4.2.1 Trees

Every tree species occurring naturally in the region was found in the ROW (Table 6). This is significant, because it illustrates that germinating tree seedlings tolerated the frequently drier ROW soils and that the disturbed soils of the ROW were suitable for natural forest recovery. *Populus balsamifera* (cottonwood) was the most frequently recorded species, occurring in 69.2 percent of the ROW sites. It was found in only 17.3 percent of the adjacent habitats. The second-ranked tree species in the ROW was *Picea glauca* (white spruce). The other tree species in the ROW, in descending order of frequency were: *Populus tremuloides* (quaking aspen), *Betula papyrifera* (paper birch), *Picea mariana* (black spruce), *Larix laricina* (west-

Table 6. Frequency percentages of trees among sites, sorted descending by ROW data.

Tree Species Names	Percent Frequency Among Sites	
	ROW	Adjacen
Populus balsamifera	69.2	17.3
Picea glauca	46.2	40.4
Populus tremuloides	34.6	13.5
Betula papyrifera	32.7	13.5
Picea mariana	28.8	46.2
Larix laricina	3.8	3.8
Picea sitchensis	1.9	5.8

Table 5. Comparisons of average species numbers and t-test probabilities for the ROW and for adjacent habitats in three vegetation zones along TAPS, 1999.

Plant Growth Forms	Tundra (n=10)			Alpine (n=12)			Boreal (n=30)		
	ROW	Adjacent	t-test p	ROW	Adjacent	t-test p	ROW	Adjacent	t-test p
Trees	0	0	n/a	1.2	0.6	0.027	3.3	2.0	0.001
Shrubs	5.6	6.9	0.152	6.8	7.1	0.757	7.4	8.3	0.214
Forbs	9.3	6.0	0.029	9.4	7.4	0.199	11.0	4.0	0.000
Grasses	3.2	1.4	0.004	3.6	2.1	0.040	4.9	1.4	0.000
Sedges & Rushes	1.2	2.6	0.050	0.6	2.1	0.000	0.3	0.9	0.004
All Vascular Species	19.1	17.1	0.296	21.6	19.3	0.273	27.0	16.6	0.000

ern larch), and *Picea sitchensis* (Sitka spruce).

Outside the ROW, the frequency-ranking among tree species differed from that in the ROW (Table 6). *Picea mariana* and *Picea glauca* were the two most frequently recorded species. These were followed in descending order by *Populus balsamifera*, *Populus tremuloides*, *Betula papyrifera, Larix laricina*, and *Picea sitchensis.* This shift from hardwood prominence in the ROW to softwood prominence outside the ROW simply reflects the natural succession for tree species in the boreal zone. The hardwoods are prominent in the younger stands, and the softwoods dominant the older stands. Even though the ROW was a disturbed habitat, niches existed which were suitable to all the species of trees, regardless of their individual proclivity for either serial or climax communities.

Only *Larix laricina* and *Picea sitchensis* occurred in less than 10 percent of the inventoried sites within and outside the ROW. This infrequent occurrence is explained by their limited geographical distribution. *Larix* occurs in Interior Alaska, and its natural range has limited coincidence with the pipeline route (Viereck and Little, 1972). *Picea sitchensis* occurs only in the coastal forest region (Viereck and Little, 1972) where relatively little of the pipeline route occurs.

The fact that all of these tree species produce windborne seeds undoubtedly accounted in part for the spread of these plants onto the ROW. This was especially notable where species ranges were extended latitudinally (Chandalar Shelf) and altitudinally (Yukon Uplands). At those locations, seed sources were not adjacent to the ROW sites which the young trees inhabited.

Research has shown that seed production by white spruce (and presumably other Alaska tree species) varies among years according to weather (Zasada et al., 1978). That study included monitoring germination, which peaked during periods of moisture, indicating the importance of soil moisture for tree establishment. Even when tree seed production is excellent in a given year, seedling establishment will not necessarily be successful. Seedbed conditions and weather are major determinants critical to vascular plant germination and survival. Apparently, alterations of habitat within the ROW were within the natural tolerances for these tree species.

4.2.2 Shrubs

The four shrubs most frequently found in the ROW were the willows *Salix glauca* (diamond willow, glaucous willow, grayleaf willow) and *Salix alaxensis* (Alaska willow, feltleaf willow), followed by *Shepherdia canadensis* (soapberry), and *Vaccinium uliginosum* (bog blueberry) (Table 7). Twenty-one species of shrubs appeared in 10 percent or more of the sites inventoried. Fifteen of those shrub species occurred in 10 percent or more of habitats outside the ROW. Five willow species that occurred at more than 10 percent of sites in the ROW and less than 10 percent of sites outside were: *Salix arbusculoides* (littletree willow), *Salix brachyophylla* ssp. *nyphoclada* (barren-ground willow), *Arctostaphylos uva-ursi* (bearberry), *Salix barclayi* (Barclay willow), and *Salix bebbiana* (Bebb willow). Presumably, these species are significant colonizers that invade new open sites but fail to persist as plant succession proceeds.

The four shrubs most frequently found in the habitat adjacent to the ROW were *Vaccinium vitis-idaea* (mountain cranberry), *Vaccinium uliginosum, Salix planifolia* ssp. *pulchra* (diamondleaf willow), and *Betula nana*[2] (dwarf arctic birch) (Table 7). Twenty-six species of shrubs occurred in the adjacent habitat at 10 percent or more of the sites examined. Among those species, the majority (15) also appeared in the ROW at 10 percent or more of the sites inventoried. This indicated either that much of the adjacent habitat is undergoing secondary succession or that a significant portion of the climax shrub species have the capacity to colonize open ground and remain a part of the climax vegetation. Perhaps both features are part of the vegetation scheme. Regardless of cause and effect, a relatively large number of shrub species appearing in adjacent habitats were able to colonize the ROW. This colonization occurred under conditions of competition from seeded and fertilized grasses as well as in soil that was more alkaline, drier, and more rocky than the natural habitat. The capacity of shrubs to invade causes Alyeska to expend significant efforts in controlling woody plants in the ROW.

4.2.3 Forbs

Forbs composed the largest group of plants found along the TAPS route. The most frequently recorded species was *Epilobium angustifolium* (fireweed), followed by *Equisetum arvense* (meadow horsetail) (Table 8). An introduced weed, *Taraxacum officinale* (dandelion), was the third ranked forb in the ROW. Following in descending order were *Aster sibiricus* (siberian aster), *Astragalus alpinus* (alpine milkvetch), *Epilobium latifolium* (dwarf fireweed), and *Achillea borealis* (yarrow). Each of these species and their reproductive strategies are described below:

[2]*Betala nana* and *B. glandulosa* were undoubtedly confused and are listed as *B. nana* in this survey.

Table 7. Frequency percentages for shrubs among sites, sorted descending by ROW data.

Shrub Species Names	Percent Frequency Among Sites	
	ROW	Adjacent
Salix glauca	69.2	28.8
Salix alaxensis	63.5	17.3
Shepherdia canadensis	42.3	15.4
Vaccinium uliginosum	38.5	63.5
Alnus crispa	36.5	23.1
Salix arbusculoides	28.8	7.7
Salix planifolia ssp. pulchra	28.8	46.2
Salix lanata var richardsonii	26.9	23.1
Salix brachyophylla ssp nyphoclada	26.9	9.6
Potentilla fruticosa	25.0	19.2
Arctostaphylos uva-ursi	23.1	5.8
Empetrum nigrum	21.2	34.6
Salix arctica	21.2	15.4
Arctostaphylos alpina	19.2	34.6
Salix barclayi	19.2	9.6
Betula nana	19.2	46.2
Vaccinium vitis-idaea	17.3	67.3
Salix bebbiana	17.3	1.9
Salix reticulata	17.3	26.9
Ledum groenlandicum	11.5	38.5
Alnus sinuata	11.5	0.0
Salix myrtillifolia	9.6	11.5
Rosa acicularis	9.6	25.0
Dryas octopetala	9.6	13.5
Salix monticola	7.7	0.0
Rubus arcticus	7.7	9.6
Ledum decumbens	7.7	30.8
Arctostaphylos rubra	7.7	11.5
Spirea beauverdiana	5.8	15.4
Salix rotundifolia ?	5.8	3.8
Dryas drummondii	5.8	5.8
Dyras integrifolia	5.8	7.7
Rubus spectabilis	3.8	1.9
Salix ovalifolia	3.8	0.0
Salix scouleriana	3.8	15.4
Eleagnus commutata	1.9	1.9
Salix sitchensis	1.9	1.9
Linnaea borealis	1.9	13.5
Salix hastata ?	1.9	0.0
Cassiope tetragona	1.9	11.5
Salix novae-angliae	1.9	1.9
Andromeda polifolia	1.9	7.7
Juniperus communis	1.9	3.8
Rubus chamaemorus	1.9	26.9
Salix podaphylla ?	1.9	0.0
Rubus idaeus	1.9	0.0
Salix phlebophylla	0.0	3.8
Ribies triste	0.0	3.8
Rhododendron lapponicum	0.0	9.6
Myrica gale	0.0	3.8
Sorbus scopulina	0.0	1.9
Chamaedaphne calyculata	0.0	3.8
Betula nana X B. papyrifera	0.0	5.8
Amelanchier alnifolia	0.0	1.9
Viburnum edule	0.0	11.5

Epilobium angustifolium most likely entered the ROW by seedling establishment where fill material and subsoil were left on the surface following construction. The species produces seeds that are airborne and easily spread to new locations. The combination of airborne seeds and a suitable soil surface to capture them is important for pioneering plants such as *Epilobium angustifolium*. Bare sand, compacted gravel, etc. are poor surfaces for establishing *Epilobium angustifolium* seedlings. Once established, this plant develops an extensive rhizome system, which allows it to expand its territory vegetatively. These rhizomes are fleshy and are presumably storage organs for organic and mineral nutrient reserves. These reserves help the plant survive and perennate vegetatively.

Equisetum arvense spreads into new habitats by spores and vegetative propagation. The underground portions of this plant consist of an extensive rhizome system often deeper than the roots of most forest plants in the boreal zone. These rhizomes are capable of sending new shoots into previously unoccupied ground. Perhaps both spores and vegetative spread were responsible for this plant encroaching on the ROW following construction.

Taraxacum officinale produces seed that is easily airborne. New *Taraxacum officinale* plants in the ROW undoubtedly established from seed, but the origins and pathways of the seed are uncertain. However, the weedy plant is known to occur throughout the portions of the boreal zone where human settlements occur. Seed may have also been included in straw and hay mulches and grass seed mixtures used to revegetate the ROW. Vehicles traveling into the ROW from areas where the plant occurs may have carried the seed to new sites. This plant was not found in undisturbed natural plant communities anywhere along the route. It apparently does not establish in well-stocked stands of natural vegetation. However, once the species establishes, it is tenacious. In contrast to *Epilobium* and *Equisetum*, this species produces a fleshy taproot that extends deep into the soil. To expand its territory, it must establish new seedlings. The taproot is capable of resprouting where the top portion is either cut or broken off. The resulting regrowth is usually a cluster of smaller plants, each of which is readily capable of flowering and producing copious amounts of seed. The species is a problem weed in lawns, gardens, hay fields, etc. in Alaska. Killing it by repeatedly cutting the taproot can prove a long and fruitless process due to its capacity for regrowth. The most effective control of this species has been with repeated applications of chemical herbicide, which kills both the aboveground and underground parts of the plant.

Aster sibiricus produces seeds that are airborne to new

Table 8. Frequency percentages of forbs among sites, sorted descending by ROW data. "E" indicates an exotic species. "I" indicates indigenous species. "W" indicates weed.

Forb Species Names	Origin/ Weed	Percent Frequency Among Sites		Forb Species Names	Origin/ Weed	Percent Frequency Among Sites	
		ROW	Adjacent			ROW	Adjacent
Epilobium angustifolium		76.9	9.6	*Polemonium acutiflorum*		5.8	1.9
Equisetum arvense		44.2	32.7	*Potentilla uniflora*		5.8	0.0
Taraxacum officinale[1]	E/W	40.4	1.9	*Saxifraga cernua*		5.8	0.0
Aster sibiricus		34.6	7.7	*Saxifraga tricuspidata*		5.8	1.9
Astragalus alpinus		34.6	3.8	*Geocaulon lividum*		3.8	19.2
Epilobium latifolium		34.6	9.6	*Astragalus americanus*		3.8	3.8
Achillea borealis		32.7	5.8	*Chenopodium album*	E/W	3.8	0.0
Achillea sibirica		28.8	0.0	*Chenopodium rubrum*	E/W	3.8	0.0
Oxytropis campestris		26.9	3.8	*Equisetum scirpoides*		3.8	7.7
Parnassia palustris		26.9	17.3	*Gentiana algida*		3.8	0.0
Erigeron pulcherrima		25.0	0.0	*Arnica lessingii*		3.8	1.9
Trifolium hybridum	E	23.1	0.0	*Geum macrophyllum*		3.8	0.0
Hedysarum mackenzii		21.2	13.5	*Minuartia macrocarpa*		3.8	1.9
Potentilla hookeriana		21.2	3.8	*Petasites frigidus*		3.8	21.2
Erigeron acris		19.2	1.9	*Polygonum alaskanum*		3.8	3.8
Matricaria matricarioides	E/W	19.2	0.0	*Pyrola asarifolia*		3.8	1.9
Thlaspi arvense	E/W	19.2	0.0	*Pyrola minor*		3.8	3.8
Castelleja elegans		17.3	3.8	*Sagina intermedia*		3.8	0.0
Crepis capillaris	E/W	17.3	0.0	*Sanguisorba officinalis*		3.8	0.0
Stellaria longipes		17.3	5.8	*Saxifraga davurica*		3.8	1.9
Epilobium palustre	I/W	15.4	1.9	*Senecio resedifolius*		3.8	0.0
Oxytropis borealis		15.4	1.9	*Stellaria edwardsii*		3.8	1.9
Oxytropis deflexa		13.5	0.0	*Stellaria laeta*		3.8	1.9
Pyrola grandiflora		13.5	15.4	*Taraxacum lacerum*		3.8	0.0
Artemisia tilesii		11.5	0.0	*Tofieldia coccinia*		3.8	3.8
Cornus canadensis		11.5	15.4	*Tofieldia pusilla*		3.8	3.8
Hedysarum alpinum		11.5	11.5	*Polygonum viviparum*		1.9	15.4
Plantago major var. major	E/W	11.5	0.0	*Saussurea angustifolia*		1.9	11.5
Senecio lugens		11.5	3.8	*Saxifraga hirculus*		1.9	11.5
Solidago multiradiata		11.5	1.9	*Lycopodium annotinum*		1.9	9.6
Gentiana propinqua		9.6	3.8	*Delphinium glaucum*		1.9	7.7
Gentiana glauca		9.6	0.0	*Geum rossii*		1.9	3.8
Pyrola secunda		9.6	5.8	*Luetkea pectinata*		1.9	3.8
Antennaria pulcherrima		9.6	1.9	*Zygadenus elegans*		1.9	3.8
Crepis nana		7.7	0.0	*Cardamine bellidifolia*		1.9	1.9
Draba spp		7.7	1.9	*Cnidium cnidiifolium*		1.9	1.9
Dracocephalum parviflorum	I/W	7.7	0.0	*Saxifraga oppositifolia*		1.9	1.9
Lupinus arcticus		7.7	13.5	*Senecio conterminus*		1.9	1.9
Platanathera hyperborea		7.7	0.0	*Silene acaulis*		1.9	1.9
Polygonum aviculare	E/W	7.7	0.0	*Antennaria rosea*		1.9	0.0
Taraxacum alaskanum		7.7	0.0	*Arabis holboellii*		1.9	0.0
Anemone parviflora		7.7	7.7	*Arnica frigida*		1.9	0.0
Mertensia paniculata		5.8	5.8	*Artemisia arctica*		1.9	0.0
Astragalus eucosmus		5.8	1.9	*Barbarea orthoceras*		1.9	0.0
Cerastium beeringianum		5.8	0.0	*Crepis elegans*		1.9	0.0
Descurainia sophioides		5.8	0.0	*Crepis tectorum*	E/W	1.9	0.0
Galium boreale		5.8	5.8	*Erigeron compositus*		1.9	0.0
Lepidium densiflora	E/W	5.8	0.0	*Fragaria virginiana*		1.9	0.0
Artemisia borealis		5.8	9.6	*Galeopsis bifida*	E/W	1.9	0.0
Pedicularis sudetica		5.8	17.3	*Heracleum lanatum*		1.9	0.0
Plantago major var. peligre	E?/W	5.8	0.0	*Lesquerella arctica*		1.9	0.0
				Melandrium apetalum		1.9	0.0

[1] *Taraxacum officinale* was found outside the ROW only at one location, and that was in a cleared area north of the Nordale Yard. The species was never found in undisturbed habitats.

Table 8 (cont.). Frequency percentages of forbs among sites, sorted descending by ROW data.

Forb Species Names	Origin/ Weed	Percent Frequency Among Sites		Forb Species Names	Origin/ Weed	Percent Frequency Among Sites	
		ROW	Adjacent			ROW	Adjacent
Orchidaceae (?)		1.9	0.0	*Viola epipsila*		0.0	3.8
Oxytropis koyukukensis		1.9	0.0	*Athyrium felix-femina*		0.0	1.9
Papaver macounii		1.9	0.0	*Boschniakia rossica*		0.0	1.9
Potentilla multifida		1.9	0.0	*Botrychium boreale*		0.0	1.9
Rumex acetosa		1.9	0.0	*Boykinia richardsonii*		0.0	1.9
Sanguisorba stipulata		1.9	0.0	*Bupleurum triradiatum*		0.0	1.9
Veronica americana		1.9	0.0	*Cardamine hyperborea*		0.0	1.9
Polygonum bistora subsp. plumosum		0.0	23.1	*Corydalis sempervirens*		0.0	1.9
				Dryopteris dilatata		0.0	1.9
Pedicularis labradorica		0.0	9.6	*Iris setosa*		0.0	1.9
Astragalus umbellatus		0.0	7.7	*Lycopodium selago*		0.0	1.9
Pedicularis verticillata		0.0	7.7	*Minuartia stricta*		0.0	1.9
Pedicularis capitata		0.0	5.8	*Pinguicula vulgaris*		0.0	1.9
Saxifraga punctata		0.0	5.8	*Potentilla gracilis*		0.0	1.9
Anemone richardsonii		0.0	3.8	*Ranunculus bongardi*		0.0	1.9
Potentilla palustris		0.0	3.8	*Saxifraga bronchialis*		0.0	1.9
Saxifraga hieracifolia		0.0	3.8	*Senecio atropurpureus*		0.0	1.9
Thalictrum sparsiflorum		0.0	3.8	*Silene repens*		0.0	1.9
Valeriana capitata		0.0	3.8				

locations. This plant is an indigenous species throughout much of Alaska. It was found frequently on abandoned gravel pads in the National Petroleum Reserve-Alaska (McKendrick, 1991a). Plants most likely established in the ROW by seed. The long, creeping rhizomes produced by the plant allow it to form expanding colonies from a single established plant. As with *Epilobium angustifolium*, after a few plants establish, it is possible for the species to spread vegetatively beyond the point of origin.

Astragalus alpinus, a member of the *Leguminosae* family, produces small hard-coated seeds which often fall close to the parent plant, causing the plants to form colonies. Because of its small size, seed can also saltate across snowy surfaces during wind storms, providing the seedpods project above the snow surface. Animal vectors such as ground squirrels may also move the seed from one location to another. It is often a colonizer on open gravel and rocky sites (McKendrick, 1991a) and also occurs on silty soils. The value of this species on gravel fill and open ground lies in its capacity to fix atmospheric nitrogen and enrich the soil nitrogen supply for itself and other plant species.

Epilobium latifolium and *Epilobium angustifolium* are cousins which share seed production and growth form features. *Epilobium latifolium* was found colonizing more gravel fill sites of the Alaska North Slope than any other species (McKendrick, 1991a). Its geographical range usually extends farther north than *Epilobium angustifolium*. In this study, *Epilobium angustifolium* was found from 16 miles south of Pump Station 1 (Site 2) to the southernmost site (Site 52) at MP 777.5. *Epilobium latifolium* was found from Pump Station 1 (Site 1) to MP 707 (Site 48). This species most likely entered the ROW as seedlings.

Achillea borealis and *Achillea sibirica* are members of the *Compositae* (*Asteraceae*) family, along with *Taraxacum officinale* and *Aster sibiricus*. Seed of *Achillea* do not have as much pappus to carry them in the wind as do the asters and dandelion species, but they have some capacity to be wind-transported to new locations. These species probably entered the ROW as seedlings. Both species of *Achillea* arise from underground rootstock that allows these plants to expand their territories beyond their point of origin. *Achillea borealis* has a larger geographical distribution in Alaska than *Achillea sibirica*. In this survey, *Achillea sibirica* ranged from MP 31 (Site 3) to MP 542 (Site 37). *Achillea borealis* ranged from MP 258.25 (Site 22) to MP 777.5 (Site 52). *Achillea borealis* was found at three sites outside the ROW, while *Achillea sibirica* was found only in the ROW.

Outside the ROW, *Equisetum arvense* was the most common forb, followed by *Polygonum bistorta* subsp. *plumosum* (meadow bistort) and *Petasites frigidus* (arctic sweet coltsfoot) (Table 8). Thirty forb species appeared at 10 percent of more of the sites in the ROW. Outside the ROW only 14 species appeared at 10 percent or more of the sites inventoried. Among the forbs most frequently occurring in habitats outside the ROW were six species that also occurred in the ROW at more than 10 percent of the sites: *Equisetum arvense, Parnassia palustris* (northern grass-of-

Parnassus), *Pyrola grandiflora* (large-flower wintergreen), *Cornus canadensis* (bunchberry), *Hedysarum alpinum* (alpine sweetvetch), and *Hedysarum mackenzii.* Habitat tolerances for these six species are evidently broad, allowing them to colonize and persist as communities age. The first four have underground rhizomes, while the last two are solitary plants that fix nitrogen. The persistence of the plants with underground stems is understandable because they spread vegetatively. The solitary growth forms must persist either through individual longevity aided by N-fixation, or by establishing seedlings.

4.2.4 Grasses

Twenty-seven grass species were recorded in this survey (Table 9): 22 in the ROW and 19 in the adjacent habitat. The most frequently occurring grass in the ROW was *Festuca rubra* (red fescue), which was found in nearly 90 percent of the locations examined. This grass is clearly a significant species along the TAPS ROW, since it often appeared to dominate the cover, particularly north of the Brooks Range and on fill. *Poa pratensis* (bluegrass), *Agropyron* spp. (wheatgrass), and *Alopecurus pratensis* (meadow foxtail) were the three species following *Festuca rubra* in frequency of occurrence. Twelve species of grass occurred at 10 percent or more of the sites examined. The four above were followed by eight species, in descending order: *Bromus inermis* (smooth brome), *Calamagrostis canadensis* (bluejoint), *Arctagrostis latifolia* (polargrass), *Hordeum jubatum* (foxtail barley), *Puccinellia borealis* (northern alkaligrass), *Agrostis scabra* (ticklegrass), *Festuca altaica,* and *Trisetum spicatum* (downy oatgrass). Three of the top 12 grasses were species with origins outside Alaska (Table 9). Two of the 12 (*Hordeum jubatum* and *Agrostis scabra*) might be considered weedy species, and they are indigenous to Alaska.

Table 9. Frequency percentages of grasses among sites, sorted descending by ROW data. "E" indicates an exotic species. "I" indicates indigenous species. "W" indicates weed.

Grass Species Names	Origin	Percent Frequency Among Sites	
		ROW	Adjacent
Festuca rubra		88.5	1.9
Poa pratensis	E	46.2	0.0
Agropyron spp.		40.4	7.7
Alopecurus pratensis	E	30.8	0.0
Bromus inermis	E	30.8	0.0
Calamagrostis canadensis		28.8	25.0
Arctagrostis latifolia		25.0	23.1
Hordeum jubatum	I/W	23.1	0.0
Puccinellia borealis		19.2	0.0
Agrostis scabra	I/W	17.3	1.9
Festuca altaica		17.3	36.5
Trisetum spicatum		17.3	9.6
Poa arctica		9.6	13.5
Phleum pratense	E	7.7	0.0
Deschampsia caespitosa		5.8	0.0
Bromus pumpellianus		5.8	3.8
Calamagrostis purpurascens		3.8	1.9
Festuca baffinensis		3.8	1.9
Poa glauca		3.8	1.9
Calamagrostis lapponica		1.9	5.8
Beckmannia erucaeformis	E	1.9	0.0
Dupontia fisheri		0.0	3.8
Hierochloe alpina		0.0	5.8
Poa paucispicula		0.0	5.8
Poa alpina		0.0	1.9
Arctophila fulva		0.0	3.8

Only five grass species occurred in 10 percent or more of the habitats adjacent to the ROW (Table 9). These grasses, in descending order of frequency, were *Festuca altaica, Calamagrostis canadensis, Arctagrostis latifolia, Poa arctica,* and *Trisetum spicatum.*

It is important to note that introduced grasses were not found outside the ROW. This fact indicates that those species were not spreading beyond the disturbed area that was seeded and fertilized. It was encouraging to see a number of indigenous grass species invading the ROW; however, it was uncommon to find an indigenous grass species predominating in the ROW. There were exceptions, such as in Atigun Canyon at Site 9, where *Agropyron* spp. was at least equal in cover with *Festuca rubra.* Earlier observations of the Haines pipeline route (McKendrick, 1978) indicated indigenous grass (*Calamagrostis purpurascens* [purple reedgrass]) was able to dominate if artificial revegetation was not used. Native Plants, Inc. (1980b) reported that portions of the TAPS ROW that were not seeded became vegetated with native shrubs and that seeded grasses remained vigorous where extra fertilizer applications were made.

Native Plants, Inc. (1980a) observed that it mattered little whether a species was indigenous or naturalized, if the plant served its intended purpose. As far as revegetation with grasses is concerned, the advantages are:

- The seed and the technology for using them are readily available.
- Grasses are excellent for holding soil against erosion.
- Grasses can form barriers to prevent weedy species and other undesired plants from encroaching on a site.
- Lush grasses are quite palatable to some wildlife

grazers, such as caribou, mountain goat, Dall sheep, and geese.

Disadvantages are:

- They may be exotic and considered undesirable in some locations.
- If indigenous recolonization is desired, certain grass species may form a barrier to the indigenous species eventually desired.
- As grass seedlings reach maturity, their palatability to grazers declines.
- In the boreal zone, grasses produce a contrasting aspect to the natural forest.
- Grasses are not a predominating plant life form throughout the TAPS corridor. Instead, trees, shrubs, and sedges dominate.

As far as the TAPS ROW is concerned, it now appears that seeding and fertilizing with grass may have been needed only in locations where risk of soil erosion was particularly high. Leaving the rest of the ROW to recolonize naturally would have resulted in adequate plant cover to be both aesthetically acceptable and suited to wildlife needs. Had such an approach been followed, it could have encouraged the invasion of woody species sooner and caused Alyeska to begin brush control earlier. A more detailed account of grass species along the TAPS ROW can be found in McKendrick (2001a).

4.2.5 Sedges and Rushes

A total of 18 species of sedges and rushes were found in this survey (Table 10). Fourteen species occurred in adjacent habitats and 11 within the ROW. Four species occurred in at least 10 percent of the locations outside the ROW. In descending order of frequency, these were: *Carex aquatilis* (water sedge), *Carex bigelowii* (Bigelow sedge), *Carex lugens,* and *Eriophorum vaginatum (tussock cottongrass).* Only one of these, the sedge *Carex lugens*, was recorded in at least 10 percent or more of the locations within the ROW. One rush (*Juncus* spp.) also occurred in at least 10 percent of the sites within the ROW. Soil dryness is believed to be a major factor in preventing sedges from entering the ROW. Undoubtedly, competition from other species (seeded grasses as well as other growth forms) was also a factor affecting sedge and rush colonization of the ROW. We have observed elsewhere that sedges have been able to invade and establish wet sedge tundra sites which had been seeded to *Puccinellia borealis* (McKendrick, 1991b and 2001b). The current investigation showed that seeded grasses dominated the ROW in the tundra zone, and the adjacent tundra was predominately sedge species. The grass species seeded in the TAPS ROW have persisted in test plots in the Prudhoe Bay oil field for nearly 30 years, indicating their tenacity and capacity to prevent sedge invasion.

Table 10. Frequency percentages for sedges and rushes among sites, sorted descending by ROW data.

Sedge and Rush Species	Percent Frequency Among Sites	
	ROW	Adjacent
Carex lugens	21.2	23.1
Juncus spp.	11.5	0.0
Eriophorum vaginatum	3.8	19.2
Carex glacialis	1.9	0.0
Carex microglochin	1.9	1.9
Carex rotundata	1.9	3.8
Carex rupestris	1.9	0.0
Carex spp.	1.9	7.7
Eleocharis acicularis	1.9	5.8
Eriophorum angustifolium	1.9	9.6
Eriophorum scheuchzeri	1.9	0.0
Carex aquatilis	0.0	34.6
Carex atrofusca	0.0	5.8
Carex bigelowii	0.0	25.0
Carex misandra	0.0	3.8
Carex rhynchophysa	0.0	1.9
Carex tenuiflora ?	0.0	5.8
Luzula spp.	0.0	5.8

4.2.6 Other Considerations

Species Found Only In the ROW

Sixty-seven species of vascular plants were found in the ROW and not in the adjacent habitat (Table 11). The largest group was the forbs, with 49 species. Forbs were followed by grasses (8), shrubs (6) and sedges/rushes (4). Most of these species were indigenous and usually occur in natural habitats along the route. Appearance on this list resulted from at least three possibilities: 1) they occurred so infrequently in the undisturbed communities we were unable to discover them, 2) they ordinarily occur in naturally disturbed habitats not represented in the adjacent undisturbed communities, or 3) they are exotic species that do not invade natural plant communities.

Species Found Only Outside the ROW

Fifty-three species of vascular plants were found only in habitats outside the ROW (Table 12). Forbs constituted the largest group, with 30 species. Forbs were followed by shrubs (9), sedges and rushes (8), and grasses (6). These were all indigenous species. Possible explanations for their absence from ROW sites are: 1) they were intolerant of the drier conditions of the ROW, 2) they could not compete

Table 11. List of vascular plant species recorded only in the ROW.

Shrubs		Forbs	Forbs (cont.)	
Alnus sinuata[1]		*Achillea sibirica*	*Lesquerella arctica*	
Rubus idaeus		*Antennaria rosea*	*Matricaria matricarioides*	
Salix hastata ?		*Arabis holboellii*	*Melandrium apetalum*	
Salix monticola		*Arnica frigida*	*Orchidaceae (?)*	
Salix ovalifolia		*Artemisia arctica*	*Oxytropis deflexa*	
Salix podaphylla ?		*Artemisia tilesii*	*Oxytropis koyukukensis*	
Total Shrub Species	**6**	*Barbarea orthoceras*	*Papaver macounii*	
		Cerastium beeringianum	*Plantago major var. major*	
Grasses		*Chenopodium album*	*Plantago major var. peligre*	
Alopecurus pratensis		*Chenopodium rubrum*	*Platanathera hyperborea*	
Beckmannia erucaeformis		*Crepis capillaris*	*Polygonum aviculare*	
Bromus inermis		*Crepis elegans*	*Potentilla multifida*	
Deschampsia caespitosa		*Crepis nana*	*Potentilla uniflora*	
Hordeum jubatum		*Crepis tectorum*	*Rumex acetosa*	
Phleum pratense		*Descurainia sophioides*	*Sagina intermedia*	
Poa pratensis		*Dracocephalum parviflorum*	*Sanguisorba officinalis*	
Puccinellia borealis		*Erigeron compositus*	*Sanguisorba stipulata*	
Total Grass Species	**8**	*Erigeron pulcherrima*	*Saxifraga cernua*	
		Fragaria virginiana	*Senecio resedifolius*	
Sedges and Rushes		*Galeopsis bifida*	*Taraxacum alaskanum*	
Carex glacialis		*Gentiana algida*	*Taraxacum lacerum*	
Carex rupestris		*Gentiana glauca*	*Thlaspi arvense*	
Eriophorum scheuchzeri		*Geum macrophyllum*	*Trifolium hybridum*	
Juncus spp.		*Heracleum lanatum*	*Veronica americana*	
Total Sedges and Rushes	**4**	*Lepidium densiflora*	Total Forb species	49
			Total Vascular Species	**67**

[1]This species was probably not always identified correctly.

Table 12. List of vascular plant species recorded only in communities adjacent to the ROW.

Shrubs		Sedges and Rushes		Forbs (cont.)	
Amelanchier alnifolia		*Carex aquatilis*		*Lycopodium selago*	
Betula glandulosa X B. papyrifera		*Carex atrofusca*		*Minuartia stricta*	
Chamaedaphne calyculata		*Carex bigelowii*		*Pedicularis capitata*	
Myrica gale		*Carex misandra*		*Pedicularis labradorica*	
Rhododendron lapponicum		*Carex rhynchophysa*		*Pedicularis verticillata*	
Ribies triste		*Carex tenuiflora ?*		*Pinguicula vulgaris*	
Salix phlebophylla		*Luzula spp.*		*Polygonum bistora*	
Sorbus scopulina		**Total Sedges and Rushes**	**8**	*subsp. plumosum*	
Viburnum edule				*Potentilla gracilis*	
Total Shrub Species	**9**	**Forbs**		*Potentilla palustris*	
		Anemone richardsonii		*Ranunculus bongardi*	
Grasses		*Astragalus umbellatus*		*Saxifraga bronchialis*	
Arctophila fulva		*Athyrium felix-femina*		*Saxifraga hieracifolia*	
Dupontia fisheri		*Boschniakia rossica*		*Saxifraga punctata*	
Hierochloe alpina		*Botrychium boreale*		*Senecio atropurpureus*	
Phleum commutatum		*Boykinia richardsonii*		*Silene repens*	
Poa alpina		*Bupleurum triradiatum*		*Thalictrum sparsiflorum*	
Poa paucispicula		*Cardamine hyperborea*		*Valeriana capitata*	
Total Grass Species	**6**	*Corydalis sempervirens*		*Viola epipsila*	
		Dryopteris dilatata		**Total Forb Species**	**30**
		Iris setosa			
				Total Vascular Species	**53**

Table 13. List of exotic species and weeds, percent frequency among sites, and north-south geographic range of occurrence along TAPS 1999.

Weeds and Exotic Species Names	Origin and Weed Class		% Frequency Among Sites		Range of Occurrence Milepost (Site No.)			
	Exotic	Weed	ROW	Adjacent	Northernmost		Southernmost	
Forbs								
Taraxacum officinale[1]	•	•	40.4	1.9	173.7	(15)	777.5	(52)
Trifolium hybridum	•		23.1	0.0	396	(28)	777.5	(52)
Matricaria matricarioides	•	•	19.2	0.0	226	(20)	685.15	(46)
Thlaspi arvense	•	•	19.2	0.0	258.25	(22)	654.8	(45)
Crepis capillaris	•	•	17.3	0.0	276	(23)	745.2	(50)
Epilobium palustre		•	15.4	1.9	115.7	(8)	769	(51)
Plantago major var. *major*	•	•	11.5	0.0	226	(20)	777.5	(52)
Dracocephalum parviflorum		•	7.7	0.0	412.3	(30)	777.5	(52)
Polygonum aviculare	•	•	7.7	0.0	360.2	(27)	489.2	(35)
Lepidium densiflora	•	•	5.8	0.0	685.15	(46)	724.6	(49)
Plantago major var. *peligre*	•	•	5.8	0.0	396	(28)	441.8	(33)
Chenopodium album	•	•	3.8	0.0	542	(37)	547.7	(38)
Chenopodium rubrum	•	•	3.8	0.0	547.7	(37)	685.15	(46)
Crepis tectorum	•	•	1.9	0.0	547.7	(37)	547.7	(38)
Galeopsis bifida	•	•	1.9	0.0	777.5	(52)	777.5	(52)
Grasses								
Poa pratensis	•		46.2	0.0	16	(2)	777.5	(52)
Alopecurus pratensis	•		30.8	0.0	165.1	(12)	769	(51)
Bromus inermis	•		30.8	0.0	254.4	(21)	421.3	(30)
Hordeum jubatum		•	23.1	0.0	190	(18)	709	(48)
Agrostis scabra		•	17.3	1.9	276	(23)	777.5	(52)
Phleum pratense	•		7.7	0.0	406	(29)	777.5	(52)
Beckmannia erucaeformis	•		1.9	0.0	412.3	(30)	412.3	(30)
TOTALS	**18**	**16**						

[1] *Taraxacum officinale* was found outside the ROW only at one location, and that was in a cleared area north of the Nordale Yard. The species was never found in undisturbed habitats.

with the seeded grasses, or 3) perhaps essential soil microbes were absent from the ROW. Many of these species are usually found in plant communities in advanced stages of plant succession. There the soil usually has a relatively thick layer of organic matter at the surface, consisting of humus and moss. That organic layer holds moisture and provides a habitat much wetter than the ROW. The absence of those conditions within the ROW may have been a leading factor preventing these species from invading the ROW.

Weeds and Exotic Species

Weeds and exotic species are present in the ROW, and Table 13 provides a summary of the species we found and the range of occurrences for each. The definition of a "weed" is a plant growing where it is not wanted. Depending on revegetation objectives, plants that could be considered weeds in one location might be quite desirable in others. For instance, Hultén (1968) stated that *Poa pratensis* (Kentucky bluegrass) is a weed in Alaska. Kentucky bluegrass is a common turf species and was seeded to revegetate the TAPS ROW. Those involved with the Native Plants, Inc. studies (1980a, b, and undated) were more tolerant than Hultén in their assessment, allowing exotic plants a place in the scheme of revegetation as long as the species met the objectives. Thus, our classification of weeds in Table 13 includes both exotic species that are usually considered undesirable and some indigenous species that either seem to have little aesthetic value or which can be troublesome to manage.

Common dandelion (*Taraxacum officinale*) had the widest range among the weeds, beginning on the Chandalar Shelf and extending to our southernmost site. Among the exotic species, *Poa pratensis* had the largest range, beginning 16 miles south of Pump Station 1 and extending to our southernmost site. The exotic clover *Trifolium hybridum* was the second most frequently observed forb (Table 13). This legume was introduced with hay mulch during revegetation, and it is likely some of the other exotic species entered the ROW under similar circumstances.

At least two species mentioned in the Native Plants, Inc., (1980b) survey — *Sisymbrium altissimum* and *Capsella bursa-pastoris* — were not found in our survey.

Natural Recolonization

All trees and shrubs, and most of the forbs, entered the ROW naturally as volunteers. Except for the clover *Trifolium hybridum* and perhaps the weedy species, these plants originated from natural habitats. The clover seed was probably included in hay mulches used during revegetation. It is interesting that two sweetclover species (*Melilotus alba* and *Melilotus officinalis*) commonly found along Alaska roadsides were not found in this survey. (In July, 2000 and August, 2001, the species *Melilotus alba* was observed in the ROW north of Fairbanks, near Globe Creek.) Sweetclover is a biennial and may not develop every year. Because of the importance of nitrogen-fixing plants for improving soil fertility, Native Plants, Inc. (1980a) questions why legumes were not included in the Alyeska seed mixtures. In this survey, we observed that numerous nitrogen-fixing vascular plant species have naturally entered the ROW and that nitrogen-fixing lichen (*Stereocaulon* spp. and *Peltigera* spp) have established at many locations.

Pioneering and early colonizing plant species often establish seedlings most easily on freshly disturbed, open mineral soil. Species adapted to advanced stages of succession are capable of establishing seedlings in moss, under light-limited canopies, and in other situations intolerable to pioneering species. Black spruce is capable of establishing at both ends of the succession spectrum. It was found in the ROW as seedlings on fill, and it can establish beneath the forest canopy of shrubs and softwood trees.

It appears that microhabitat conditions soon after a disturbance are important in determining which species establish and persist. Throughout the ROW, grasses were seeded to the open ground, yet the vegetation resulting is not uniform. In the Arctic, tall willow established along the margins of gravel fill, and seeded grasses predominate in the central portion of the fill and over the buried pipeline. Assuming willow seed was uniformly available to the entire ROW, then it follows that some other factor prevented willow from establishing uniformly across the ROW disturbance. Several environmental factors differed between the margins and the central portion of the ROW. Some of those factors are probably soil moisture, soil compaction, exposure to wind, and competition from seeded grasses. The factors responsible for the predominance of willow along the margins are not readily apparent, but it is likely that competition from seeded grasses may have been important. A similar linear pattern of willow development occurred along the edges of the Dalton Highway in the tundra zone, indicating that the side slopes of gravel fill are a common habitat feature for willow development. The slopes of gravel fill at drilling sites in the National Petroleum Reserve-Alaska produced quite different plant cover than horizontal surfaces, even though both habitats were given identical seed and fertilizer treatments (McKendrick et al., 1992).

Two erect willows common to the northern portions of the TAPS corridor are *Salix lanata* var. *richardsonii*, and *Salix planifolia* ssp. *pulchra*. These shrubs develop two distinct growth patterns depending upon habitat. In tundra away from streams, they produce low to moderate canopy heights in the range of one to two feet in height and occur as scattered individuals. When they occur near streams, they form dense thickets four to six feet in height, similar to those found along margins of the Dalton Highway and TAPS ROW. Presumably, there are similar environmental factors in these habitats controlling willow development.

Native Plants, Inc. (1980a and undated) made a point of examining mycorrhizae associated with indigenous species along portions of the TAPS route and issued advice regarding use of containerized forbs and shrubs to revegetate the proposed natural gas pipeline. Phase II of their study was to identify the plants to use. Because reports for Phase II were not found, we are unable to compare those findings with current conditions in the TAPS ROW. However, among the plant species occurring within the region but absent from the ROW, there may be species for which mycorrhizae may have a particular purpose. If any native species were prevented from recolonizing the ROW because of mycorrhizal limitations, the significance of that fact cannot be determined. However, except where erosion risks are extreme, natural recolonization of the TAPS corridor seems adequate, based on the large number of indigenous species that have invaded the ROW and on observations of natural recolonization along the Haines pipeline and the margins of roads built before artificial revegetation was used.

Vegetation Inventory and Monitoring

This survey did not include TAPS material sites, which constituted major acreage impacted by construction (Pamplin, 1979). It would be worthwhile and advantageous to document vegetation conditions at the TAPS material sites. A few locations have been used by the Alaska Department of Transportation to provide materials for maintenance and upgrades to the Dalton Highway. A few were sources of stones for revetment to protect the pipeline. Many have become well vegetated, in spite of having little or no soil (Photos 7, 8, and 9). It is quite likely that such a survey would reveal positive progress toward natural plant community establishment, particularly in the boreal zone and where seeded grasses were largely unsuccessful.

Photo 7. Material site at base of Slope Mountain and seeded grass in the foreground. Even though most of the Slope Mountain material site has little soil cover, vegetation has established in several habitats at this location.

Photo 8. Rock quarry photographed 6 July 1996 (N67° 23' 54"; W150° 05' 16") near Wiseman, AK. On the left side of the image, stones have been recently removed. On the right side, alder and lower growing plants have colonized the surface of this material site during the approximately 20 years since the site was used for TAPS construction. This illustrates the ability of indigenous plants to colonize stony material sites in the boreal zone. In the background, a large barren gash appears on the mountain slope. This resulted from a recent natural landslide, illustrating that the presence of vegetation cover is no guarantee against powerful natural erosion forces.

Photo 9. View of material site (23 July 1997) recolonized in 20 years predominantly by shrubs and trees. This location (N 66 21' 31"; W 150 27' 32") is approximately 2 miles south of the crossing of the South Fork of the Koyukuk River. Soil was replaced in the basin, and it was seeded to grasses. Species of seeded grasses persisting in openings beneath the canopy include: Bromus inermis, Alopecurus pratensis, *and* Festuca rubra. *Other plants which had colonized naturally were: willows, cottonwood, alder, spruce, birch, fireweed, moss, lichens, and the common weed, dandelion. The rocky slope in the foreground has siberian aster,* Antennaria rosea, Artemisia tilesii, *aspen, and birch colonizing among the stones.*

5. Conclusions and Recommendations

This survey of the soils and vegetation along the TAPS ROW can be used to formulate conclusions about the results of the revegetation program for TAPS and about the current condition of the vegetation on the ROW compared to habitats outside the ROW. These conclusions relate to erosion control, aesthetics, soil, and plant species. In addition, recommendations are possible for revegetation of disturbed areas resulting from future pipeline construction.

5.1 Erosion Control and Aesthetics

The plant cover and topographic restructuring along the TAPS ROW have successfully avoided erosion problems from the placement and operation of the pipeline. Types of erosion reported by Johnson et al. (1977) were not observed in this survey. Vegetation produced by seeded grasses and plants entering the ROW by natural processes is providing sufficient cover to control soil erosion. Erosion that cannot be controlled by plant cover was observed in Atigun Canyon (Photo 10).

Aesthetics is a subjective consideration, because what is pleasing to one may be offensive to another. In my opinion, Alyeska's attempts to improve the appearance of the ROW by transplanting and seeding vegetation have been successful overall. The vegetation became established and is persisting. How well it pleases every viewer cannot be assessed.

Wildlife use of the ROW varies from location to location, just as in undisturbed habitats. Observations of wildlife use along the ROW were a subordinate part of this inventory. Obvious points were:

- Second-growth shrubs and trees were prominent in the boreal zone of the ROW, and they consisted of species commonly browsed by moose. Stubble, fecal pellets, and tracks in the ROW indicated browsing animals (hare and moose) were feeding on this growth.
- The preponderance of grazing by caribou and Dall sheep on the seeded grasses in the tundra and alpine zones that was so common immediately following revegetation has diminished and disappeared. However, caribou use the ROW in natural ways. These animals no longer congregate on seeded areas the way they did when plants were becoming established.
- Where the pipe is buried in the tundra, arctic ground squirrels are attracted to the habitat, where they develop dens. The squirrels attract predators, such as grizzly bears and foxes.

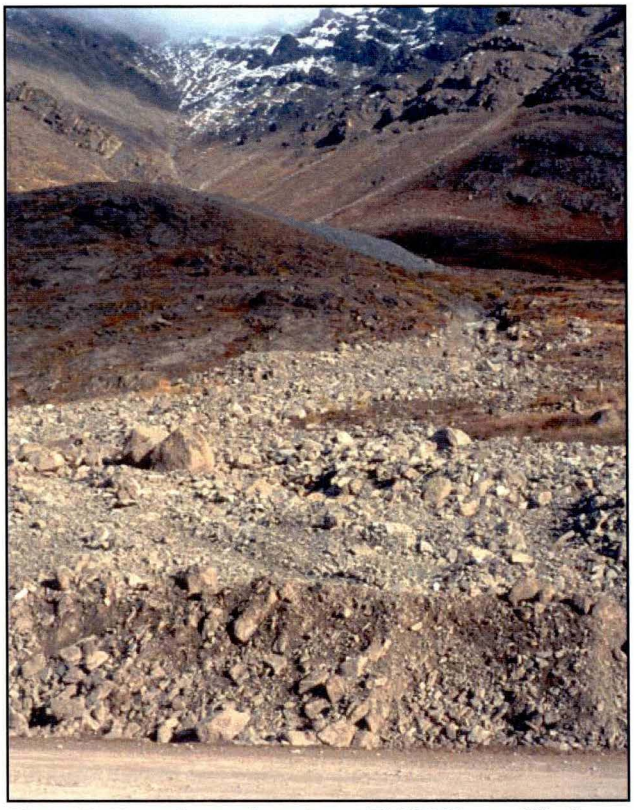


Photo 10. View of natural erosion at TAPS Milepost 152. Storms produced heavy precipitation in the adjacent mountains. Runoff flooded down the valley and carried mud and rock debris, closing the Dalton Highway at this location. The flood carried boulders across the highway and under the elevated pipeline. This type of erosion was anticipated (Mitchell, 1970), and the pipeline route was selected to avoid alluvial fans, where this geomorphic process was likely to occur.

5.2 Soil Substrate

Most of the ROW contained some form of workpad used during construction and for subsequent operations and maintenance. This workpad was designed to support equipment; consequently, firmness and dryness were required. Rocky and gravel materials were used to create this workpad. Composition of fill varied according to what was locally available. Overall, the ROW soil samples contained more stones and less moisture than the adjacent undisturbed soils.

According to soil analyses, fertilizers applied during revegetation could not be differentiated from background levels. At a few locations, the availability of phosphorus and/or potassium may still be higher in the ROW than outside. Even in those situations, the elevated levels of these nutrients in the soil are not sufficient for concern.

As judged by agricultural standards, the availability of the three major nutrients (nitrogen, phosphorus, and potassium) were low overall throughout the ROW and adjacent soils. In spite of these apparent deficiencies, the indigenous plant species appeared to be growing normally. This indicates a need to adjust downward the criteria for assessing nutrient availabilities in soils with respect to revegetation with indigenous plant species in Alaska and elsewhere. At the time the pipeline ROW was assessed for fertilizer needs (before construction), only agricultural standards were available, and Alyeska relied on them for fertilizer formulation and application rates. Those standards were probably suitable for agronomic grasses, but excessive for natural tundra, shrub, and forest plants. At that time, considerations of seeded plants were assumed to be more critical than those of indigenous plants.

Total soil carbon was less in the substrate within the ROW than adjacent to the ROW. This was expected, because the soil on the surface was either fill hauled to the site or subsoil. Both of these are generally lower in carbon than natural surface soils.

Total soil nitrogen was less in the substrate within the ROW than adjacent to the ROW, for the same reasons total carbon was low. The C:N ratio was higher in the ROW substrate than in the undisturbed soils. The average C:N ratio for undisturbed soils was below the threshold of 30, which is considered important for soils to adequately supply nitrogen to vascular plants and soil microbes.

The soil left on the surface following construction was seldom the same as that present at the surface before construction. This appeared to be the situation even in the section south of Slope Mountain which was constructed from an ice/snow pad. It appeared that material removed while drilling for placement of vertical support members may have been deposited on the ROW surface in the ice road construction section. Where soil in the ROW was similar to that adjacent to the ROW, vegetation growth was usually more akin to the surrounding vegetation than where soil differed markedly from the adjacent habitat.

The presence of soil fines (silts and clays) is most desirable for supporting vegetation, because they will hold and supply moisture and nutrients to the vegetation.

5.2.1 Gravel Substrate

Coarse gravel, sand, and rocky rubble generally are poor substrates for vegetation, especially seeded grasses. Forbs and shrubs are the natural colonizer species on gravel, and in this survey, several of those species were observed invading and establishing voluntarily on gravel fill along the TAPS ROW. In contrast, the seeded grasses on gravel fill sometimes appeared to have stagnated after their initial establishment.

5.2.2 Controlling Unwanted Vegetation

The major vegetation management problem along TAPS currently is controlling the growth of shrubs and trees which have invaded the ROW extensively in the boreal zone. Alyeska has taken the position that they will not use chemical controls. This forces them to rely on mechanically cutting these plants either by laborers or with brush hogs. Mowing does not usually kill the woody plants, and they readily sprout from the stumps. The process of cutting brush and trees will remain part of ROW maintenance indefinitely.

5.3 Plant Species

Both exotic and indigenous weeds occur along the ROW from the Chandalar Shelf southward; however, none were found outside the disturbed portion of the ROW. A weed control program for the TAPS ROW is impractical at this time. The number of weedy species is relatively low and consists of the same plants that are considered weeds by homeowners and farmers in Alaska (dandelion, plantain, knotweed, pineapple weed, etc.). Although plant density was not assessed in this inventory, no dominance of weed species was observed. There appears to be no threat of exotic species invading indigenous vegetation along the ROW. At some locations, dandelions were quite prominent.

Other than weeds, the introduced species of most significance were the species of grasses seeded for revegetation

and the alsike clover that was introduced to the ROW, most likely with hay mulches. Attempts to compare current observations with those by predecessors suggest this clover has assumed increasing importance over time. Native Plants, Inc. (1980a, b) was somewhat critical of the TAPS revegetation plan for relying only on grasses and overlooking legumes (clover).

The grasses most frequently observed along the route were creeping red fescue and Kentucky bluegrass. The fescue was found from Pump Station 1 south and often dominated the ROW, particularly in the tundra zone where the pipeline was buried. Fescue survived on gravel fill in the tundra zone, but those plants are no longer vigorous. The fescue is technically of Alaska origin; however, its dominance in revegetated portions of TAPS ROW is uncommon compared to its natural occurrences in adjacent habitats.

Other grasses with origins outside Alaska that are present along the ROW included timothy, bromegrass, and meadow foxtail. These grasses were seeded in the boreal and/or alpine zones and have prevailed on sites with silty soil and adequate moisture. Two seeded grasses that have not persisted were annual ryegrass and redtop.

Native Plants, Inc., (undated) listed plant species to consider for revegetation of a proposed natural gas pipeline. The following native plant species with corresponding frequencies (which would be most comparable to our data), were reported along TAPS in 1980:

- *Epilobium angustifolium* (fireweed): 7.4
- *Alnus crispa* (green alder): 7.3
- *Salix glauca* (diamond, glaucous, or grayleaf willow): 4.8
- *Betula papyrifera* (paper birch): 3.0
- *Equisetum* spp.: 3.0
- *Calamagrostis canadensis* (bluejoint grass): 2.8
- *Poa arctica* (arctic bluegrass): 1.0

It is instructive to compare this list with plant data in our 1999 survey. Several of these species, such as fireweed, horsetail, alder, grayleaf willow, and paper birch, have frequently colonized the ROW. Arctic bluegrass colonized in only about 10 percent of the sites examined. Bluejoint reedgrass was even less successful than arctic bluegrass and colonized only about 4 percent of sites. During the past 19 years, considerable changes have occurred in the vegetation on the ROW. The earliest colonizers on the ROW consisted mostly of plants whose seeds are dispersed by wind. Now the ROW is populated by a large number of species, many of which do not produce wind-dispersed seeds. This demonstrates that natural colonization is quite effective in vegetating open habitats, and artificial revegetation is probably not as critical as it was once believed.

5.4 Considerations for Other Construction Projects

5.4.1 Revegetation Objectives

Revegetation objectives must be compatible with what can be reasonably achieved. The standard objective is to control soil erosion, and for the TAPS ROW, aesthetics and wildlife habitats were also considered. The greatest effort appeared to be seeding grasses and fertilizing the entire route, presumably to meet these three objectives. Based on this survey and statements of previous investigators, it now appears the need for extensive seed and fertilizer applications was relatively minor. Where erosion was a major threat, seeding and fertilizing were probably useful activities, but for most of the ROW, it was not necessary. If natural plant recolonization was desired to meet wildlife and aesthetic needs, then extensive seeding and fertilizing have been counterproductive. It must be remembered that sensitive political conditions prevailed and technical documentation available to Alyeska and to government agencies was limited during permitting, design, and construction of TAPS. The industry and government agencies were very aware the project was being carefully watched, and it was preferable to forestall criticism rather than to be found wanting. Consequently, it was important to use any and all techniques to meet environmental standards.

5.4.2 Soil Fertility Considerations

Soil fertility assessment of the TAPS route initially was based on agricultural criteria, for the lack of a better standard, and there is still no revegetation fertilizer standard beyond individual experience and agricultural benchmarks. However, it is clear from the performance of natural vegetation that fertilizer is usually not needed if either the original soil or a suitable substitute is left in place. If soil is no longer available, and gravel fill, sand, subsoil, and the like are left following construction, then some fertilizer will probably be needed. Sampling soil before construction does not provide information about the conditions after construction. For the most part, soil should be sampled after the construction has been completed. Double-ditching[3] to save the surface soil will go a long way toward solving revegetation problems and may avoid the need to do anything more.

[3]Double-ditching involves removing upper soil layers separately from the rest of excavated material. This makes it possible to put surface soil on top after the trench is backfilled.

Overfertilization will favor grasses and sometimes weeds over other plants, because grasses and weeds are adapted to take advantage of additional nutrients. As grasses and weeds develop robust stands, they will often out-compete the other species. Limiting fertilizer may help reduce aggressive grass and weed competitors. In wet soils, fertilizers stimulate moss development. Wet habitats are often dominated by grasses and sedges, and overfertilizing causes fewer problems there than it does on mesic and dry soils.

5.4.3 Plant Material Considerations

The current trend for revegetation of wildlands is to select species from among the natural array present. The idea is to minimize the need for maintenance (fertilizer, mulching, watering, etc.) and provide a community that resembles the adjacent vegetation. For the boreal zone of Alaska, that presents a problem for pipeline rights-of-way. The natural tendency is for trees and shrubs to reinvade the clearing. This happened along the Haines pipeline, where soil conditions were favorable. The military needed to keep the pipeline route open for inspections and repair, and resorted to chemical controls. Alyeska faces the same problem of having to control woody plants in order to keep the ROW open for inspections and maintenance. Alyeska is using mechanical cutting.

Use of transplants and container-grown trees and shrubs has been suggested (Native Plants, Inc., 1980b), and Alyeska used willow cuttings with some success. However, an easier approach would be to leave a soil suited to natural tree and shrub establishment, and let those plants invade on their own. That means limiting fertilizer applications that would encourage grasses and forbs, avoiding seeding aggressive grasses, and ensuring that a friable silty soil remains after construction is completed.

A right-of-way where the pipe is buried and no permanent workpad or fill is used would naturally revegetate with species adjacent to the site. If there was no need to keep the right-of-way clear, then replacing soil and letting natural recolonization occur would appear adequate for most of the route. Where erosion control is needed, seeding native grasses would be the most desirable approach. The current choices would be *Calamagrostis canadensis* (bluejoint grass), *Arctagrostis latifolia* (polargrass), *and Puccinellia borealis* (northern alkaligrass). If persistence is desired, *Festuca rubra* (red fescue) would be an obvious selection. However, the use of this grass species would be counterproductive to the desired goal of "restoration... until natural vegetation communities have clearly established..." (Pamplin, 1979).

Erosion risk for gravel is greatest from stream meanders, and vegetation offers little protection from that process. Consequently, the purpose of vegetating gravel is primarily to improve appearance and provide wildlife habitat.

If gravel fill was used in the boreal zone, fertilizing and allowing natural recolonization to occur is a preferred option. A more aggressive approach would be to seed with native legumes such as *Hedysarum mackenzii, Hedysarum alpinum* (alpine sweetvetch), *Oxytropis borealis,* and related species. Applying grass seed to gravel is counterproductive, because it only creates competition for forbs and shrubs, which are superior plant forms on gravel. If gravel fill is used distant from natural gravel habitats, considerable time may be required for natural recolonization to occur, particularly for legumes, whose seeds are not readily moved far from mother plants. *Dryas* (mountain-avens) is another indigenous plant that naturally colonizes gravel and simultaneously improves soil fertility.

In the Arctic, legumes and other species suited to vegetating gravel fill grow best on gravel substrates. Those adapted to the Arctic seldom survive elsewhere. Consequently, developing seed for vegetating gravel fill in the Arctic must be done in the Arctic. There are no commercial sources for seeds of these native species at the present time, and prospects of such developing in the future are unlikely because of economic and agronomic limitations. Demand for these kinds of seeds would be too unreliable for a commercial grower to invest time and materials. There was demand for seed for about three years in the mid-1970s. Since then, seed needs in Alaska have been very limited. Should a natural gas pipeline be built in the next five to seven years, that would generate another short-term market for seed. No seed grower could survive financially under that time frame for marketing. The agronomic limitations center on the ability to cultivate plants for seed production.

6. References

Hubbard, G. 1980. Revegetation-restoration for the Trans-Alaska Pipeline System. Pages 113-125 *In:* C.L. Jackson and M.A. Schuster (eds.). Proceedings: High-Altitude Revegetation Workshop No. 4. Colorado State University, Fort Collins.

Hultén, E. 1968. Flora of Alaska and neighboring territories a manual of vascular plants. Stanford University Press. Stanford. 1008 pp.

Johnson, A.W., and S.A. Kubanis. 1980. The vegetation of disturbed sites along the Yukon River to Prudhoe Bay haul road. Pages 16-29 *In:* C.L. Jackson and M.A. Schuster (eds.). Proceedings: High-Altitude Revegetation Workshop No. 4. Colorado State University, Fort Collins.

Johnson, L.A. 1981. Revegetation and selected terrain disturbances along the Trans-Alaska Pipeline, 1975-1979. Cold Regions Research and Engineering Laboratory, Hanover, NH. CRREL Report 81-12. 115 pp.

Johnson, L.A., W. Quinn, and J. Brown. 1977. Revegetation and erosion control observations along the Trans-Alaska Pipeline, 1975 summer construction season. Cold Regions Research and Engineering Laboratory, Hanover, NH. SR-77-8. 36 pp.

Kubanis, S.A. 1980. Recolonization by native and introduced species along the Yukon River – Prudhoe Bay haul road, Alaska. M.S. thesis, San Diego State University, CA.

Land Design North. 1979a. Task 1, Evaluation of federal and Alaska state regulations and guidelines for erosion control restoration and aesthetics with discussion on standard ECR&A practices. Fluor Northwest, Inc., Fairbanks, AK. 42 pp.

Land Design North. 1979b. Task 2, Appraisal of ECR&A compliance options and recommendations for integrating ECR&A planning with overall project planning. Fluor Northwest, Inc., Fairbanks, AK. 65 pp + diagram.

Land Design North. 1979c. Task 3, Review of past Northwest Alaskan revegetation studies & recommendations for additional research. Fluor Northwest, Inc., Fairbanks, AK. 23 pp + diagram.

Land Design North. 1979d. Task 4, TAPS revegetation reconnaissance summary & findings of field assessment. Fluor Northwest, Inc., Fairbanks, AK. 21 pp.

McKendrick, J.D. 1976. Observations and suggestions concerning vegetation disturbances, reestablishment and management — site selections for Northwest Pipeline Corporation's proposed gasline route from Prudhoe Bay to the Alaskan-Canadian border. A preliminary report. 3 pp. (copy in author's possession)

McKendrick, J.D. 1978. Revegetation of disturbed sand dunes near Northway, Alaska, a first year progress report of research. Northwest Alaskan Pipeline Company, Anchorage, AK. 69 pp.

McKendrick, J.D. 1991a. Colonizing tundra plants to vegetate abandoned grave pads in arctic Alaska. *Advances in Ecology* 1:209-223.

McKendrick , J.D. 1991b. Arctic tundra rehabilitation – observations of progress and benefits to Alaska. *Agroborealis* 23(1):29-40.

McKendrick, J.D. 1995. Vegetation recovery after 12 years at three test pits on the Diamond Alaska Coal Company lease southcentral, Alaska. Riverside Technology, Fort Collins, CO. 25 pp.

McKendrick, J.D. 2000. Seeding gravel fill along Badami pipeline 1999 report of progress: Kadleroshilik river crossing. BP Exploration (Alaska) Inc., Anchorage, AK. 6 pp.

McKendrick, J.D. 2001a. Inventory of Grasses Along the Trans-Alaska Pipeline — 1999. *Agroborealis* 33(1):4-15.

McKendrick, J.D. 2001b. Boreal alkaligrass (*Puccinellia borealis)*, is this the one? *Agroborealis* 33(1):16-20.

McKendrick, J.D., and K.W. Holmes. 1989. Plant species on dredge tailings of interior and gavel pads of arctic Alaska. Pages 157-165 *In*: S. Bandopadhyay and F.J. Skudrzyk (eds.) Mining in the Arctic. Proceedings of the 1st International Symposium on Mining

in the Arctic, Fairbanks, AK, 17-19 July 1989. A.A. Balkema, Rotterdam, Netherlands.

McKendrick, J.D., P.C. Scorup, W.E. Fiscus, and G. Turner. 1992. Lessons from the Tunalik Wellsite No. 1 — National Petroleum Reserve in Alaska. *Agroborealis* 24(1):33-40.

Mitchell, W.W. 1970. A scientific tour of the pipeline route. *Agroborealis* 2(1):4-5 .

Native Plants, Inc. 1980a. Revegetation assessment for the proposed Alaska Natural Gas Transportation System. Vol. I, Review of literature on previous revegetation studies and projects. Fluor Northwest, Inc./Northwest Pipeline Company, Irvine, CA. 45 pp.

Native Plants, Inc. 1980b. Revegetation assessment for the proposed Alaska Natural Gas Transportation System. Vol. II, Field assessment of TAPS revegetation Prudhoe Bay to Delta Junction. Fluor Northwest, Inc./Northwest Pipeline Co., Irvine, CA. 218 pp.

Native Plants, Inc. (undated). Phase II revegetation studies in disturbed habitats adjacent to the proposed Alaska Natural Gas Transportation System. Fluor Northwest, Inc./Northwest Pipeline Company, Irvine, CA. 94 pp.

Neubauer, J. 1970. Personal communication with J.D. McKendrick at Alyeska Pipeline Service Co. offices, Anchorage, AK.

Pamplin, W.L. 1979. Construction-related impacts of the trans-Alaska pipeline system on terrestrial wildlife habitats. U.S. Department of the Interior, Joint State/ Federal Fish and Wildlife Advisory Team. Special report No. 24. Anchorage, AK. 69 pp + appendices.

SPSS, Inc. 2000. SYSTAT® 10. Chicago, IL.

Viereck, L.A.. 1966. Plant succession and soil development on gravel outwash of the Muldrow Glacier, Alaska. *Ecological Monographs* 36:181-1999

Viereck, L.A., and E.L. Little. 1972. Alaska trees and shrubs, U.S. Department of Agriculture, Forest Service Handbook No. 410. 265 pp.

Walker, D.A., D. Cates, J. Brown, and C. Racine. 1987. Disturbance and recovery of arctic Alaskan tundra terrain: a review of recent investigations. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. CRREL Report 87-11. 63 pp.

Webber, P.J., V. Komárková, D.A. Walker, and E. Werbe. 1979. Geobotanical studies along a latitudinal gradient between the Yukon River and Prudhoe Bay, Alaska. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Hanover, NH. Internal report 585. 366 pp.

Welsh, S.L. 1974. Anderson's flora of Alaska and adjacent parts of Canada. Brigham University Press. 724 pp.

Zasada, J. C., M.J. Foote, F.J. Deneke, and R.H. Parkerson. 1978. Case history of an excellent white spruce cone and seed crop in the Interior Alaska: cone and seed production, germination, and seedling survival. U.S. Department of Agriculture, Forest Service General Technical Report PNW-65. Portland, OR. 53 pp.

7. Acknowledgments

Design and layout of the appendix document was done by Peg Banks. Neither she nor I fully appreciated the details and hours this document would require, but it will be one in which we can take lasting satisfaction. Appreciation is expressed to Steve McKendrick, who collected most of the soil samples, recorded organic mat thicknesses, and took site notes and GPS data for this project. Dan McKendrick assisted with a portion of the field aspects. Conce Rock helped finish the field study in September 1999, after the summer hires returned to college. Ray Jakubczak and Anne Brown were important in seeing that this project came about. Marko Radonich and Chipper Loggie were instrumental in contractual arrangements for funding support, which came from BP Exploration (Alaska), Inc. and the other pipeline owners. J.D. (Dave) Norton was a source of encouragement and was active in arranging an informative summer tour of the TAPS route in 2000; although not part of the soil and plant data gathering, it contributed greatly to synthesizing those data for this publication. Peter Nagel was most helpful in arranging access to the TAPS ROW and Alyeska Pipeline Service Company facilities. Jim Lukin was the key figure in the final publication step as well as a significant reviewer. Other reviewers include: Dr. Bonita Nieland (professor emeritus, University of Alaska Fairbanks), Anne Brown (LD Corporation), Ray Jakubczak (BP Exploration Alaska). Dr. Allen Mitchell, Jr., Director of the Alaska Agricultural and Forestry Experiment Station, facilitated the joint publication arrangements between the industry and the University of Alaska Fairbanks, which provided some matching funds to assist with printing expenses. Soil laboratory analyses were purchased from the Alaska Agricultural and Forestry Experiment Station in Palmer.

8. Species List

TREES

Betula papyrifera	Paper birch
Larix laricina	Tamarack, western larch
Picea glauca	White spruce
Picea mariana	Black spruce
Picea sitchensis	Sitka spruce
Populus balsamifera	Balsam poplar, cottonwood
Populus tremuloides	Aspen, quaking aspen

SHRUBS

Alnus crispa	Green alder
Alnus sinuata	Sitka alder
Amelanchier alnifolia	Northern serviceberry, Saskatoon serviceberry
Andromeda polifolia	Bog rosemary
Arctostaphylos alpina	Alpine bearberry
Arctostaphylos rubra	Red-fruit bearberry
Arctostaphylos uva-ursi	Bearberry, kinnikinnick
Betula nana X B. papyrifera	
Betula nana	Dwarf arctic birch
Cassiope tetragona	Mountain heather
Chamaedaphne calyculata	Leatherleaf
Dryas drummondii	Drummond mountain-avens
Dryas octopetala	White mountain-avens
Dryas integrifolia	Entire-leaf mountain-avens
Eleagnus commutata	Silverberry
Empetrum nigrum	Crowberry
Juniperus communis	Common juniper
Ledum decumbens	Northern Labrador tea
Ledum groenlandicum	Labrador tea
Linnaea borealis	Twin-flower
Myrica gale	Sweet gale
Potentilla fruiticosa	Shrubby cinquefoil, yellow rose, tundra rose
Rhododendron lapponicum	Lapland rosebay
Ribes triste	American red currant
Rosa acicularis	Prickly rose
Rubus arcticus	Nagoonberry, Kneshenaka
Rubus chamaemorus	Cloudberry
Rubus idaeus	Red raspberry
Rubus spectabilis	Salmonberry
Salix alaxensis	Alaska willow, feltleaf willow
Salix arbusculoides	Littletree willow
Salix arctica	Arctic willow

SHRUBS (CONT.)

Salix barclayi	Barclay willow
Salix bebbiana	Bebb willow
Salix brachyophylla ssp nyphoclada	Barren-ground willow
Salix glauca	Diamond willow, glaucous willow, grayleaf willow
Salix hastata (?) undergreen	Halberd willow
Salix lanata var richardsonii	Lanate willow, Richardson willow
Salix monticola	Park willow
Salix myrtillifolia	Low blueberry willow
Salix novae-angliae	New England willow
Salix ovalifolia	Roundleaf willow, ovalleaf willow
Salix phlebophylla	Skeletonleaf willow
Salix planifolia ssp. pulchra	Diamondleaf willow
Salix podaphylla (S. monticola)	Park willow
Salix reticulata	Netted willow, netleaf willow
Salix rotundifolia	Least willow
Salix sitchensis	Sitka willow
Salix scouleriana	Scouler willow
Shepherdia canadensis	Soapberry
Sorbus scopulina	Western mountain ash
Spirea beauverdiana	Beauverd spirea
Vaccinium uliginosum	Bog blueberry
Vaccinium vitis-idaea	Mountain cranberry
Viburnum edule	Highbush cranberry

FORBS

Achillea borealis	
Achillea sibirica	Siberian yarrow
Anemone parviflora	Northern anemone
Anemone richardsonii	Yellow anemone
Antennaria pulcherrima	
Antennaria rosea	
Arabis holboellii	Holboell rockcress
Arnica frigida	
Arnica lessingii	
Artemisia arctica	
Artemisia borealis	
Artemisia tilesii	
Aster sibiricus	Siberian aster
Astragalus alpinus	Alpine milkvetch
Astragalus americanus	American milkvetch
Astragalus eucosmus	Elegant milkvetch
Astragalus umbellatus	Tundra milkvetch
Athyrium filix-femina	Lady fern
Barbarea orthoceras	Wintercress
Boschniakia rossica	Ground-cone, poque
Botrychium boreale	Northern grapefern
Boykinia richardsonii	Richardson boykinia
Bupleurum triradiatum	Thorough-wort
Cardamine bellidifolia	Alpine bittercress
Cardamine hyperborea	Richardson bittercress
Castelleja elegans	Indian paintbrush

FORBS (CONT.)

Cerastium beeringianum	Bering chickweed
Chenopodium album	Lamb's quarters
Chenopodium rubrum	
Cnidium cnidiifolium	
Cornus canadensis	Bunchberry
Corydylis sempervirens	Pink corydalis
Crepis capillaris	Slender hawk's-beard
Crepis elegans	Elegant hawk's-beard
Crepis nana	Dwarf hawk's-beard
Crepis tectorum	
Delphinium glaucum	Glaucous larkspur
Descurainia sophioides	Northern tansy mustard
Draba spp	
Dracocephalum parviflorum	Dragonhead
Dryopteris dilatata	Oak-fern
Epilobium angustifolium	Fireweed
Epilobium latifolium	Dwarf fireweed
Epilobium palustre	Swamp willow-herb
Equisetum arvense	Meadow horsetail
Equisetum scirpoides	Dwarf scouring-rush
Erigeron acris	Fleabane daisy
Erigeron compositus	
Erigeron pulcherrima	
Fragaria virginiana	Wild strawberry
Galium boreale	Northern bedstraw
Gentiana algida	Whitish gentian
Gentiana glauca	Glaucous gentian
Gentiana propinqua	
Geocaulon lividum	
Geum macrophyllum	Large-leaf avens
Geum rossii	Ross avens
Hedysarum alpinum	Alpine sweetvetch
Hedysarum mackenzii	
Heracleum lanatum	Cow parsnip
Iris setosa	Wild iris, flag
Lepidium densiflora	Common peppergrass
Lesquerella arctica	Arctic bladderpod
Luetkea pectinata	Luetkea
Lupinus arcticus	Arctic lupine
Lycopodium annotinum	Stiff clubmoss
Lycopodium selago	Fir clubmoss
Matricaria matricarioides	Pineapple weed
Melandrium apetalum	
Mertensia paniculata	Tall bluebell
Minuartia macrocarpa	Long-podded sandwort
Minuartia stricta	Rock sandwort
Orchidaceae	
Oxytropis borealis	
Oxytropis campestris	Field oxytrope
Oxytropis deflexa	Deflexed oxytrope
Oxytropis koyukukensis	
Papaver macounii	Macoun poppy
Parnassia palustris	Northern grass-of-Parnassus

FORBS (CONT.)

Pedicularis capitata	Capitate lousewort
Pedicularis labradorica	Labrador lousewort
Pedicularis sudetica	
Pedicularis verticillata	Whorled lousewort
Petasites frigidus	Arctic sweet coltsfoot
Pinguicula vulgaris	Bog violet, common butterwort
Plantago major var. major	Common plantain
Plantago major var. peligre	Common plaintain
Platanthera hyperborea	Bog orchid
Polemonium acutiflorum	Jacobs-ladder
Polygonum alaskanum	Wild rhubarb
Polygonum aviculare	Knotweed
Polygonum bistorta subsp. plumosum	Meadow bistort
Polygonum viviparum	Alpine bistort
Potentilla gracilis	Slender cinquefoil
Potentilla hookeriana	Hooker cinquefoil
Potentilla multifida	
Potentilla palustris	Marsh cinquefoil
Potentilla uniflora	One-flower cinquefoil
Pyrola asarifolia	Liverleaf wintergreen
Pyrola grandiflora	Large-flower wintergreen
Pyrola minor	Lesser wintergreen
Pyrola secunda	One-sided wintergreen
Ranunculus bongardi	
Rumex acetosa	Green sorrel
Sagina intermedia	Snow pearlwort
Sanguisorba officinalis	Officinal burnet
Sanguisorba stipulata	Sitka burnet
Saussurea angustifolia	
Saxifraga bronchialis	Spotted saxifrage
Saxifraga cernua	Nodding saxifrage
Saxifraga davurica	
Saxifraga hieracifolia	Hawkweed-leaf saxifrage
Saxifraga hirculus	Yellow marsh saxifrage
Saxifraga oppositifolia	Purple mountain saxifrage
Saxifraga punctata	Brook saxifrage
Saxifraga tricuspidata	Three-tooth saxifrage
Senecio atropurpureus	
Senecio conterminus	
Senecio lugens	
Senecio resedifolius	
Silene acaulis	Moss campion
Silene repens	Pink campion
Solidago multiradiata	Northern goldenrod
Stellaria edwardsii	
Stellaria laeta	
Stellaria longipes	Long-stalked starwort
Taraxacum alaskanum	
Taraxacum lacerum	
Taraxacum officinale	Common dandelion
Thlaspi arvense	Pennycress
Thalictrum sparsiflorum	Few-flower meadowrue

FORBS (CONT.)

Tofieldia coccinia	Northern asphodel
Tofieldia pusilla	Scotch asphodel, false asphode
Trifolium hybridum	Alsike clover
Valeriana capitata	Capitate valerian
Veronica americana	Speedwell
Viola epipsila	Marsh violet
Zygadenus elegans	Death camas

GRAMINOIDS

Grasses:

Agropyron spp.	Wheatgrass
Agrostis scabra	Ticklegrass
Alopecurus pratensis	Meadow foxtail
Arctagrostis latifolia	Polargrass
Arctophila fulva	Pendant grass
Bechmannia erucaeformis	
Bromus inermis	Smooth brome
Bromus pumpellianus	Arctic brome, pumpelly brome
Calamagrostis canadensis	Bluejoint
Calamagrostis lapponica	Lapland reedgrass
Calamagrostis purpurascens	Purple reedgrass
Deschampsia caespitosa	Tufted hairgrass
Dupontia fisheri	Dupontia
Festuca altaica	
Festuca baffinensis	Baffin fescue
Festuca rubra	Red fescue
Heirochloe alpina	Alpine holygrass
Hordeum jubatum	Foxtail barley
Phleum commutatum	
Phleum pratense	Timothy
Poa alpina	Alpine bluegrass
Poa arctica	Arctic bluegrass
Poa glauca	Glaucous bluegrass
Poa paucispicula	
Poa pratensis	Bluegrass
Puccinellia borealis	Northern alkaligrass
Trisetum spicatum	Downy oatgrass

Sedges and Rushes:

Carex aquatilis	Water sedge
Carex atrofusca	Dark brown sedge
Carex bigelowii	Bigelow sedge
Carex glacialis	Glacier sedge
Carex lugens	
Carex microglochin	
Carex misandra	Short-leaf sedge
Carex rhynchophysa	
Carex rotundata	
Carex rupestris	Rock sedge
Carex spp.?	
Carex tenuiflora ?	
Eleocharis acicularis	Needle spikerush

Sedges and Rushes (cont.):	
Eriophorum angustifolium	Tall cottongrass
Eriophorum scheuchzeri	White cottongrass
Eriophorum vaginatum	Tussock cottongrass
Juncus spp.	Rush
Luzula spp.	Woodrush

Appendix:
Detailed Site Descriptions

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #1

Date Examined:	8 September 1999
Location:	N70°15' 14.5"; W148°37' 42.8"; TAPS M.P. 0.25.
Pipeline:	Elevated
Slope:	Level
Drainage:	Inside - moderate; Outside - perched over permafrost
Vegetation:	Coastal tundra (wet sedge meadow)

Site No. 1 is in a lake basin drained for Pump Station No. 1. The elevated pipeline is along the east side of the ROW, and the roadway is on the west. Access to this site is from the visitor gazebo south along the pipeline. The ROW is vegetated beneath the pipeline primarily with seeded grasses, 'Alyeska' polargrass being conspicuous. The roadway is largely barren gravel. Both ROW and adjacent habitats are undergoing plant successional changes, the ROW because of gravel fill placement, and the adjacent because the drained lake basin is becoming colonized. These habitats were entirely barren following pipeline construction. The lake basin provides an object lesson in the capacity of tundra plants to naturally recolonize drained lake basins within 25-30 years. Many VIP tours stop at Pump Station 1 because of its obvious significance. Pointing out the natural recovery of tundra to visitors in the summer would be advantageous; however, this is not mentioned in the materials provided to visitors.

Gravel content of the workpad (about 59%) was considerably greater than the lake basin soil (about 8%). The workpad (30.2% soil moisture) was drier than the adjacent soil (138.4%). Soil reaction was alkaline both inside (pH 7.99) and outside (pH 7.70) the ROW. Total C content of the ROW was almost 5% and that of the lake basin was 16%. Some of this C was undoubtedly inorganic carbonates, which are prevalent in the Prudhoe Bay soils west and south of the Sagavanirktok River delta. C values translated to soil organic matter estimates of 10% and 36%, respectively, for the ROW and adjacent habitats. Total soil N was 0.12% and 0.98% for the ROW and lake basin soils. The C:N ratios were 38 for the ROW and 16.4 for the adjacent soils. The ROW C:N ratio is wider than desired, but that of the lake basin soil is well within the desirable range for vascular plants. Total C and N were both comparatively higher than for soils farther south.

Available soil N was low in ROW (2 ppm) and in the adjacent soils (3 ppm). Available soil P was also low, typical of alkaline soils in the Prudhoe area. Available P in the ROW was 3 ppm and in the basin 7 ppm. Available soil K for the ROW was 23 ppm and that of the adjacent soil 56 ppm. The adjacent soil available K is higher than average soil K values generally found in unfertilized soils of the region. There was no evidence that fertilizer applied during revegetation had persisted in the ROW soil. Organic mat development beneath the pipeline consisted primarily of plant litter. There was no measurable organic mat in the lake basin, at this location, primarily because that site was flooded.

Seventeen vascular plant species were found at this location, thirteen within the ROW and four in the adjacent lake basin. There were three shrubs, five forbs, six grasses and three sedge/Juncus at this location. No species were common to both habitats; this disparity of species is directly related to differences in habitat

Photo 1-1. Southward along east side of elevated pipeline over drained lake basin at Pump Station 1. Gravel fill placed in the ROW is largely vegetated with seeded grasses, except in the wheel tracks of the road. The plants to the left established naturally in the lake basin.

Photo 2-2. Northwest from ROW across lake basin drained to construct Pump Station 1. This portion has been naturally vegetated with Eriophorum angustifolium, Dupontia fisheri, *and* Arctophila fulva.

Site No. 1 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	58.9	8.4
Moisture %	30.2	138.4
Total C %	4.6	16.1
Total N %	0.12	0.98
C:N ratio	38	16.4
Organic matter %	10.1	35.8
pH	7.99	7.70
NH_4-N (ppm)	Not detectable	1
NO_3-N (ppm)	2	2
P (ppm)	3	7
K (ppm)	23	56
Organic mat thickness (cm)	0-1	1

moisture. The adjacent lake basin was partially flooded, and the ROW had a thin gravel pad. No shrubs or forbs were found in the lake basin habitat.

The three shrubs found at the site are common willows of this locale. Other willow species in the vicinity have not yet colonized the workpad. No willow were found in the lake basin habitat because of its wetness.

The five forbs at this location were species often found on gravel fill on the North Slope, *Epilobium latifolium* being one of the most common. *Astragalus alpinus* is a legume that is particularly valuable for fixing N. None of these forbs occurred in the adjacent lake basin.

Four grasses within the ROW included two that had been seeded (*Arctagrostis latifolia* and *Festuca rubra*) and two that occurred naturally in the vicinity. Indigenous *Deschampsia caespitosa* and *Poa arctica* occurred on the gravel fill. *Arctophila fulva* and *Dupontia fisheri* occurred in the adjacent partially flooded habitat. Both of these are known for their ability to invade disturbed and open soils.

Three species within the sedge/rush class occurred at this location. *Juncus* spp. occurred on the gravel fill under the pipeline but not in the adjacent habitat. *Carex aquatilis* and *Eriophorum angustifolium* occurred in the adjacent lake basin. These are two common species of the region and characterize the wet sedge meadow tundra type.

Waterfowl, caribou, Arctic fox, small mammals, and numerous small birds commonly occur in this habitat. Winter use by wildlife is very limited.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 1.

Species Names	*Inside*	*Outside*
Shrubs		
Salix arctica	•	
Salix lanata var richardsonii	•	
Salix ovalifolia	•	
Total Shrubs	3	
Forbs		
Astragalus alpinus	•	
Epilobium latifolium	•	
Melandrium apetalum	•	
Parnassia palustris	•	
Stellaria longipes	•	
Total Forbs	5	
Grasses		
Arctagrostis latifolia	•	
Arctophila fulva		•
Deschampsia caespitosa	•	
Dupontia fisheri		•
Festuca rubra	•	
Poa arctica	•	
Total Grasses	4	2
Sedges		
Carex aquatilis		•
Eriophorum angustifolium		•
Juncus spp.	•	
Total Sedges	1	2
Total Vascular Species	***13***	***4***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #2

Date Examined:	27 July 1999
Location:	N70°02' 23.7"; W148°38' 13.7"; TAPS M.P. 16.
Pipeline:	Buried
Slope:	Level
Drainage:	Inside - well-drained gravel fill; Outside - perched over permafrost
Vegetation:	Coastal tundra (wet sedge meadow)

Site No. 2 is south of Deadhorse and west of the braided channel of the Sagavanirktok River and the Dalton Highway. Access to the site is via a spur road or from the point where the pipeline crosses the Dalton Highway.

Gravel was used to construct the workpad, which is drier than the adjacent soil. Gravel content of the ROW was 76.6%, typical for river gravel in this region. Gravel content of the adjacent tundra soil was 22.7%. Soil moisture within the ROW was 6.2, and that of the adjacent tundra soil was 72.8%. Soil reaction is alkaline and similar both inside (pH 8.16) and outside (pH 7.98) the ROW. This is due to the highly limestone-influenced loess carried from the braided river channel east of the ROW. Total C within the ROW was 3.4% and outside the ROW 6.3%. Both of these were affected by carbonates and overestimate the organic C within the soils. Calculated organic matter percentages were 7.6% and 14.0% for the ROW and adjacent habitat, respectively. The C in the ROW is relatively low for tundra soils.

Total soil N was quite low in the gravel fill of the ROW (0.04%). Total N in the adjacent soil was 0.25%. The C:N ratio of the gravel fill was 85, well above the 30 considered desirable for agricultural soils. In the natural soil, the C:N ratio was adequate at 25.2. Available soil N was 3 ppm in the ROW and 2 ppm in the adjacent soil. Available soil P was 2 ppm for the gravel fill and 1 ppm for the adjacent soil; both values were low, suggesting that available P could be controlling plant growth. Available K was 17 ppm within the ROW and 22 ppm in the adjacent soil. These values are also relatively low, indicating that available K may also be limiting plant growth. There was no evidence that fertilizers applied during revegetation had persisted. The organic mat within the ROW varied from none to 6 cm. The thickest accumulation consisted of litter from the seeded grasses. The organic mat of the adjacent wet sedge tundra was 25 cm thick and consisted of partially decomposed organic matter produced by the tundra vegetation.

The natural vegetation is wet sedge meadow. About 80% of the ROW is bare gravel due to recent excavation and traffic. Plants occur only on the margins of the ROW fill, which were not disturbed by the recent disruptions from pipeline maintenance. Seeded grasses were growing vigorously on the slopes of the fill and appeared to be responding to fertilizer applications. In spite of the limited amount of plant cover on the ROW, a greater number of plant species occur within the ROW than in the adjacent wet sedge tundra. Competition from seeded grasses and habitat changes are responsible for the difference in vegetation between these two habitats.

Twenty-four vascular plant species were recorded at this location. Nineteen were found within the ROW and 11 in the adjacent tundra. Two shrub species, one forb, one grass, and two sedges were common to both habitats. Five species of shrubs

Photo 2-1. Southward along east side of buried pipe. This site has been recently worked upon, leaving barren gravel fill. The edge of the ROW that was undisturbed is supporting seeded and indigenous grasses.

Photo 2-2. Wet sedge tundra on west side of ROW.

Site No. 2 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	76.6	22.7
Moisture %	6.2	72.8
Total C %	3.4	6.3
Total N %	0.04	0.25
C:N ratio	85	25.2
Organic matter %	7.6	14
pH	8.16	7.98
NH_4-N (ppm)	Not detectable	1
NO_3-N (ppm)	3	1
P (ppm)	2	1
K (ppm)	17	22
Organic mat thickness (cm)	0 - 6	25

were identified. Four were found within the ROW community, and three in the adjacent tundra. Only two shrubs, *Salix arctica* and *Salix lanata* var. *richardsonii*, were common to both habitats. These are the most common willow species in the vicinity. *Salix reticulata* was found only in the natural tundra habitat. This is a common mat-forming shrub that grows on moist surfaces of organic soils, a habitat not found on the ROW gravel fill.

Eight forb species were recorded at this site. Six species occurred within the ROW and three in the adjacent tundra. Only *Parnassia palustris* was common to both habitats, occurring at the toe of the gravel fill margin slopes where moisture was presumably greater. *Cardamine hyperborea* and *Saxifraga hirculus* were found only outside the ROW. These species are typically denizens of wet tundra habitats and are probably unable to survive on dry gravel fill. *Equisetum arvense* was found on the margins of the gravel fill. It was not recorded within the adjacent tundra habitat. Whether we missed this species in our inventory was unclear. *Equisetum* does occur in the region and is often conspicuous on slopes of the moist foothill tundra, where it creates a yellow-green aspect within the vegetation cover. The species spreads by spores and underground rhizomes. It occurred at this location in the more moist microhabitats of the gravel fill

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 2.

Species Names	Inside	Outside
Shrubs		
Salix arctica	•	•
Salix brachyophylla ssp nyphoclada	•	
Salix glauca	•	
Salix lanata var richardsonii	•	•
Salix reticulata		•
Total Shrubs	4	3
Forbs		
Artemisia borealis	•	
Cardamine hyperborea		•
Descurainia sophioides	•	
Epilobium latifolium	•	
Epilobium angustifolium	•	
Equisetum arvense	•	
Parnassia palustris	•	•
Saxifraga hirculus		•
Total Forbs	6	3
Grasses		
Arctagrostis latifolia	•	•
Deschampsia caespitosa	•	
Dupontia fisheri		•
Festuca rubra	•	
Poa pratensis	•	
Trisetum spicatum	•	
Total Grasses	5	2
Sedges		
Carex aquatilis		•
Carex rotundata	•	•
Eriophorum scheuchzeri	•	
Eriophorum angustifolium	•	•
Juncus spp.	•	
Total Sedges	4	3
Total Vascular Species	**19**	**11**

margins. *Descurainia sophioides* is a biennial that periodically dominates open habitats in the region. In 1989, seed of this species was collected about 1 mi south of this site for use in gravel vegetation experiments at Prudhoe Bay and to seed the Sequoia No. 1 and Badami No. 1 drilling sites (McKendrick, et al., 1992; McKendrick, 2000). This species is indigenous to Alaska and the North Slope and can flourish only in disturbed sites. It is replaced by perennial plants during secondary succession. The other forbs within the ROW at this location (*Artemisia borealis, Epilobium angustifolium*, and *Epilobium latifolium*) are typical colonizers of gravel fill (McKendrick, 1991). Except for *D. sophioides,* all the forbs occurred in the more moist microhabitats. *Descurainia* was found atop the gravel fill over the buried pipeline.

Six grass species were found at this location. Five were found within the ROW and two in the adjacent habitat. Only one grass species, *Arctagrostis latifolia,* was common to both habitats. Grasses introduced during revegetation include *Arctagrostis latifolia, Festuca rubra* and *Poa pratensis*. *F. rubra* occurs in the vicinity along streams, but not in the normal wet-sedge meadow habitat. *A. latifolia* occurs in the adjacent habitat, but specimens within the ROW appeared to be the commercially available cultivar rather than the local ecotype. *P. pratensis* does not occur in the region naturally, and survives only in sheltered habitats, primarily on the east-facing slope of the workpad and in depressions. Hultén (1968) stated that *Poa pratensis* (Kentucky bluegrass) is a weed in Alaska. Kentucky bluegrass is a common turf species and was seeded to revegetate the TAPS ROW.

We recorded *P. pratensis* at 24 locations during this survey. This location was our northernmost sighting. All records were within the ROW; the species was not found in undisturbed habitats. It rarely occurs within the Prudhoe oilfield, as a remnant of revegetation experiments. The variety "Primo" (Sweden) may survive better than "Nugget" (Alaska) at this latitude. *Deschampsia caespitosa* is a natural component of the vegetation along the Sagavanirktok River. Reports prepared by Native Plants, Inc. (1980) indicate that *D. caespitosa* was a replacement species used in seeding portions of the ROW in the Arctic. It is not known if that grass was actually seeded at this location or were from natural sources. *Deschampsia caespitosa* is a natural component of the plant community along the nearby Sagavanirktok River. *Trisetum spicatum* is also a naturally-occurring grass along the Sagavanirktok River. Its appearance at this location may have resulted from seed carried to the site with gravel fill, and/or from seed blown from the river, which is upwind from this site. The indigenous grasses at this location are typical of mesic to dry habitats where silt has accumulated over gravel along stream margins.

Five sedge species were recorded at this location. Two were common to both habitats (*Carex rotundata* and *Eriophorum angustifolium*). Both were confined to the more moist portions of the margins of the gravel fill. One sedge and one rush species were found exclusively within the ROW (*Eriophorum scheuchzeri* and *Juncus* spp.) These often occur in disturbed wet habitats. At this location, they were confined to the more moist margins of the gravel fill. *Carex aquatilis* was found only in the adjacent habitat.

Wildlife in this area include caribou, fox, grizzly bear, lemming, and waterfowl. We have observed a moose near this location at other times. No wildlife were present at the site during our survey.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #3

Date Examined:	27 July 1999
Location:	N69°49' 59.1"; W148°45' 27.1"; TAPS M.P. 31.
Pipeline:	Buried
Slope:	Level
Drainage:	Inside - well-drained gravel fill; Outside - fair over permafrost
Vegetation:	Mixed tussock and wet sedge tundra

Site No. 3 is south of Deadhorse, west of the braided channel of the Sagavanirktok River and east of the Dalton Highway near the Franklin Bluffs. The site can be accessed from a spur road. The buried pipeline is on the east side of the ROW, and the road on the west. Nearby natural vegetation is a mixture of wet and moist tundra sedges with a significant short willow component.

Gravel was used to construct the workpad, which is drier than the adjacent soil. Gravel content of the fill was about 74%. No gravel was found in the adjacent soil. Soil reaction is alkaline both inside and outside the ROW (pH 8.11 and 8.05). Soil moisture in the ROW soil was only 3.4%. Moisture content outside the ROW was 23.7%, relatively low for tundra soils. Total C within the ROW was 2.52% and outside 5.48%. The ROW soil was unusually high in C, which indicates that surface soil was probably mixed with the surface backfill over the pipeline. A significant portion of the C in both soils is likely calcium carbonate. The organic matter percentages of the ROW and natural soil were calculated to be 5.6% and 12.2%, respectively. Total soil N was 0.07% inside the ROW and 0.12 % outside. These translated to C:N ratios of 36.0 for the ROW soil and 45.7 for the adjacent tundra soil. Very likely these values are inflated by the carbonate C. Available soil N was 2 ppm inside the ROW and 1 ppm outside. These are low values, but typical of many of the sites in this survey. Available P inside the ROW was 4 ppm and outside 2 ppm. These levels are consistent with available P found in Prudhoe Bay soils. The higher value for the ROW soil may indicate some persistence of P fertilizer applied during revegetation. However, it is more likely that there is no real difference in available P between the ROW and natural tundra. Available K for the ROW soil was 18 ppm and that of the tundra was 17 ppm. These values are lower than those typically found in Prudhoe Bay soils, and for agricultural production would be considered deficient. Plant growth at this location may have been limited by both P and K. However, no stress indicators were observed in the plants. Based on the laboratory data, there appeared to have been no significant carryover of fertilizer applied to this site. The organic mat within the ROW ranged from 0.5 to 6 cm. This was mainly litter from seeded grasses. Outside the ROW, the organic mat was 7.5 cm in thickness and consisted of partially decomposed organic matter.

The natural vegetation is a combination of species from wet sedge meadow and tussock tundra, with a prominent amount of low-growing willow which provides a shrub aspect to the site. The shrub canopy above sedges is typical of tussock tundra in the region. The predominant willows are *S. planifolia* ssp *pulchra* and *S. lanata* var. *richardsonii*. The former is favored by acidic soils, and the latter by alkaline soils, as at this location. About 20% of the ROW is bare gravel due to traffic, and poor habitat for vascular plant species. Seeded grasses dominate the ROW, with shrubs and forbs largely confined to margins. This

Photo 3-1. Southward view along buried section of pipeline near Franklin Bluffs. Seeded grasses dominate center, and tall willows line the margin.

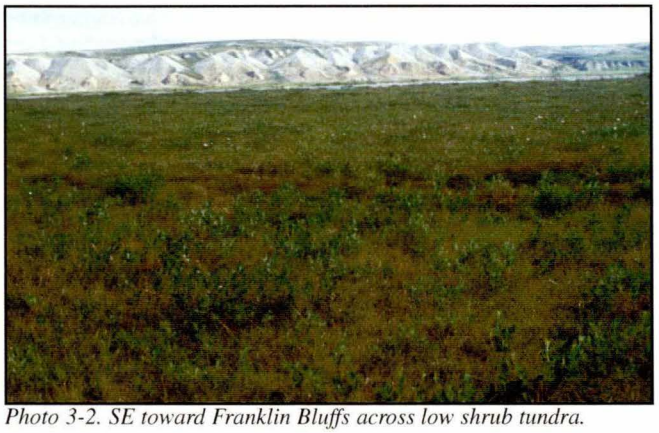


Photo 3-2. SE toward Franklin Bluffs across low shrub tundra.

Site No. 3 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	73.9	0
Moisture %	3.4	23.7
Total C %	2.52	5.48
Total N %	0.07	0.12
pH	8.11	8.05
C:N ratio	36	45.7
Organic matter %	5.6	12.2
NH_4-N (ppm)	1	Not detectable
NO_3-N (ppm)	1	1
P (ppm)	4	2
K (ppm)	18	17
Organic mat thickness (cm)	0.5 - 6	7.5

distribution of plant species suggests that competition from seeded grasses is probably hindering natural plant invasion into the ROW. The predominance of willow along the margin indicates that where moisture is more available, these species are able to invade in spite of the seeded grasses. The numbers of plant species between the undisturbed and ROW habitats are comparable, but their overall compositions differ. There are more forbs and grasses and fewer shrubs and sedges in the ROW habitat. Seeding and habitat changes are responsible for these differences.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 3.

Species Names	Inside	Outside
Shrubs		
Arctostaphylos alpina		•
Dryas integrifolia		•
Salix glauca	•	
Salix reticulata	•	•
Salix alaxensis	•	
Salix brachyophylla ssp nyphoclada	•	•
Salix lanata var richardsonii	•	•
Salix arctica		•
Vaccinium uliginosum		•
Total Shrubs	5	7
Forbs		
Achillea sibirica	•	
Artemisia arctica	•	
Artemisia borealis	•	
Artemisia telesii	•	
Aster sibiricus	•	
Astragalus alpinus	•	
Castelleja elegans	•	
Epilobium latifolium	•	•
Equisetum scirpoides		•
Hedysarum alpinum		•
Hedysarum mackenzii	•	•
Oxytropis campestris	•	
Oxytropis borealis	•	•
Parnassia palustris		•
Pedicularis sudetica		•
Polygonum viviparum		•
Potentilla uniflora	•	
Saxifraga oppositifolia		•
Silene acaulis	•	
Total Forbs	13	9
Grasses		
Agropyron spp.	•	
Arctagrostis latifolia		•
Bromus pumpellianus	•	•
Calamagrostis purpurascens	•	
Deschampsia caespitosa	•	
Festuca rubra	•	
Poa pratensis	•	
Trisetum spicatum	•	
Total Grasses	7	2
Sedges		
Carex aquatilis		•
Carex rotundata		•
Eriophorum angustifolium		•
Juncus spp.	•	
Total Sedges	1	3
Total Vascular Species	**25**	**21**

Forty vascular plant species were recorded at this location. Twenty-five were found in the ROW, and 21 in the adjacent tundra community. Only seven species were common to both habitats (three shrubs, three forbs, and one grass).

Nine shrub species were found at this location. Five species were recorded within the ROW and seven in the adjacent tundra. Three shrubs were common to both habitats (*Salix reticulata, Salix brachyophylla* ssp. *nyphoclada,* and *Salix lanata* var. *richardsonii*). *Salix reticulata* usually occupies moist soils and was confined to the moist niches and fine textured soils of the ROW at this location. *Salix brachyophylla* ssp. *nyphoclada* is a common colonizer along streams, on glacial outwash, and some tallus slopes. Its presence within the ROW was confined to the margins of the disturbance. *Salix lanata* var. *richardsonii* is one of the most common low willows of the tundra with alkaline soils. It colonizes along stream channels and the Dalton Highway in this vicinity. These pioneering plants reach a greater stature than their counterparts in the undisturbed tundra. We measured heights of willows in both habitats. The tallest willow at the margin of the ROW was 163 cm (64") and in the undisturbed tundra, the tallest willows were 66 cm (26"). Two shrubs (*Salix glauca* and *Salix alaxensis*) were unique to the ROW. Both of these species are found in the vicinity along the Sagavanirktok River. Four shrub species (*Arctostaphylos alpina, Dryas integrifolia, Salix arctica,* and *Vaccinium uliginosum*) were unique to the adjacent habitat. That group is an interesting mixture of plants. The *Arctostaphylos* and *Vaccinium* are typical of moist tundra of the foothills and often found in the alpine zone. They are part of the complex of heath species typical of acidic soils. *Dryas* commonly occurs on the raise rims of polygons and is considered an important N fixing plant. *Salix arctica* occurs throughout the Prudhoe Bay Oil Field and is apparently tolerant of alkaline soils.

Nineteen forbs were recorded at this location. Thirteen were found within the ROW and nine in the adjacent tundra community. Only three species (*Epilobium latifolium, Hedysarum mackenzii,* and *Oxytropis borealis*) were common to both habitats. The first is a common colonizer on open gravel along streams in this region. Its seed are small and easily carried by wind. The latter two (*H. mackenzii* and *O. borealis*[1]) are legumes and important colonizers on gravel fill. These two plants produce small seeds that can be carried by wind short distances from the mother plant, and because of that, they tend to form colonies as they gradually invade open gravel habitats. Both species, especially *Oxytropis*, have invaded the Franklin Bluffs Camp pad and along margins of spur dikes into the Sagavanirktok River from TAPS. These stands are sites from which we collected seed for establishing vegetation on the gravel fill of the Badami Pipeline. Nine forbs at this location were found only within the ROW. Six forbs were found only within the undisturbed adjacent tundra community. Those found only within the ROW are commonly found colonizing open ground. Those found only within the tundra were species typically found on moist soils, especially soils with an organic mat at the surface.

Eight grass species were found at this location. Seven species were recorded within the ROW, and two in the adjacent tundra.

[1]*Hedysarum mackenzii* was recorded as *Hedysarum boreale*, and *Oxytropis borealis* was recorded as *Oxytropis viscida* in the Native Plants, Inc. (1980b) report of revegetation along TAPS.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #3
Date Examined:	27 July 1999
Location:	N69°49' 59.1"; W148°45' 27.1"; TAPS M.P. 31.
Pipeline:	Buried
Slope:	Level
Drainage:	Inside - well-drained gravel fill; Outside - fair over permafrost
Vegetation:	Mixed tussock and wet sedge tundra

Continued

Only one (*Bromus pumpellianus*) was common to both habitats. This grass is usually found on mounds in the tundra and on deeper soil within the braided river channel. This is a rhizomatous grass and a close relative of *Bromus inermis*, which was seeded in the boreal zone of the TAPS. A hybrid between *B. inermis* and *B. pumpellianus* was developed by the Alaska Agricultural & Forestry Experiment Station. However, that variety was not included in revegetation mixtures used by Alyeska Pipeline Service Company, likely because of limited seed availability. Grasses introduced during revegetation include *Festuca rubra* and *Poa pratensis*. *F. rubra* occurs in the vicinity along streams, but not in the normal wet-sedge meadow habitat. Where *F. rubra* occurs naturally, it is usually as scattered clumps, as opposed to the dense sod common in the ROW. *P. pratensis* does not occur in the region naturally, and survives only in sheltered habitats at this location. Most of the indigenous grasses within the ROW (*Agropyron* spp, *Bromus pumpellianus, Calamagrostis purpurascens, Deschampsia caespitosa,* and *Trisetum spicatum*) originated from the disturbed soils associated with the nearby river channel. One grass species (*Arctagrostis latifolia*) was unique to the adjacent tundra. It is unclear why this grass was not invading the ROW at this location. The species may have been overlooked in our survey.

There were four sedges and rushes found at this location. One was found in the ROW and three in the adjacent tundra. None were common to both habitats. The rush *Juncus* spp. was found only within the ROW. Three sedges were found only in the adjacent tundra. Two species of *Juncus* were collected by Native Plants, Inc. (1980b) in their survey of vegetation of the ROW. Neither of those species was recorded within the ROW in the Native Plants, Inc. data. We found *Juncus* within the ROW at six locations in this inventory.

Wildlife use at this location consists primarily of caribou, migratory waterfowl, fox, grizzly bear, muskox, and occasionally moose. Ground squirrel have created many dens over the buried pipe, quite evident from an aerial perspective. A ground squirrel can be seen in Photo 1. Hawk and sometimes owl are observed along the Dalton Highway in this vicinity during the summer months.

This page deliberately left blank

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #4
Date Examined:	27 July 1999
Location:	N69°30' 26.5"; W148°33' 45.7"; TAPS M.P. 54.37.
Pipeline:	Elevated
Slope:	Level
Drainage:	Inside - well-drained gravel fill; Outside - perched over permafrost
Vegetation:	Wet sedge tundra

Site No. 4 is located at the junction of the pipeline workpad and an abandoned construction pad that was used to haul gravel from the nearby Sagavanirktok River. The site is south of Franklin Bluffs, west of the river channel, and east of the Dalton Highway. It is accessed by the first gravel spur road north of Pump Station 2. The elevated pipeline is on the east side of the ROW, and the roadway on the west. Between the pipeline and river are mounds which may be stabilized dunes. Adjacent vegetation consisted of a mosaic of wet sedge meadow with tussock tundra and shrubs on the elevated topographic features. The shrub height of this community was much lower than at Site No. 3. The mounds support bunchgrasses and shrubs which are uncommon in the wet surrounding habitat. Seeded grasses dominate the ROW, with shrubs and forbs largely confined to margins. Growth of seeded grasses on the gravel fill within the ROW was declining in vigor and appeared to be gradually dying (Photos 1 and 2). About 40% of the ROW is bare gravel due to traffic and dry conditions. Patches of legumes (*Oxytropis* and *Hedysarum* spp) occur on the gravel fill, and are natural colonizers on gravel in this region.

Gravel content of the ROW was about 80%. No gravel was found in the adjacent soil. Soil moisture of the ROW soil was very low, about 2%. There was 154% moisture in the adjacent tundra soil. The pH within the ROW was 8.16 and outside 7.93. Total C within the ROW substrate was 3.5% and outside 11.5%. These values translated to about 8% organic matter for the gravel and 25% for the tundra soil. Because the soils were both alkaline and contained carbonate C, these estimates are probably biased upward. Total N was 0.07% (relatively low) in the ROW gravel and 0.61% in the tundra soil. The C:N ratios for these soils were 49.4 for the gravel fill and 18.7 for the tundra soil. The wide C:N ratio of the gravel fill was too great to adequately supply N to vascular plants from soil organic matter. The C:N ratio for the tundra soil was within the range that should adequately meet vascular plant N needs. The organic mat ranged from none to 2 cm within the ROW. In the adjacent tundra, the organic mat was 22 cm and consisted of partially decomposed organic matter, plant litter, moss and lichen (*Cetraria cucullata*). The organic mat within the ROW was mostly vascular plant litter; however, there were moss and lichens (*Peltigera* and *Cetraria*) on the surface of the gravel fill.

There was 2 ppm available soil N within the ROW and 7 ppm in the adjacent tundra soil. The gravel fill was particularly low in available N. Available P in the gravel fill was 5 ppm and 4 ppm in the tundra soil. These values are typical of what we usually find for soils in the Prudhoe Bay vicinity. They are low, and vegetation would respond to P fertilizer applications. Fertilizer applications are not suggested, however. Available K in the ROW was 20 ppm, and it was 22 ppm in the adjacent tundra soil. Both measurements are relatively low. Based on the soil test data, there

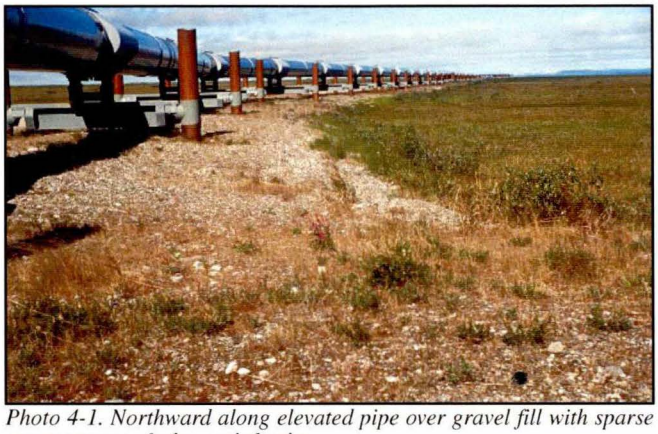


Photo 4-1. Northward along elevated pipe over gravel fill with sparse cover grasses, forbs, and shrubs.

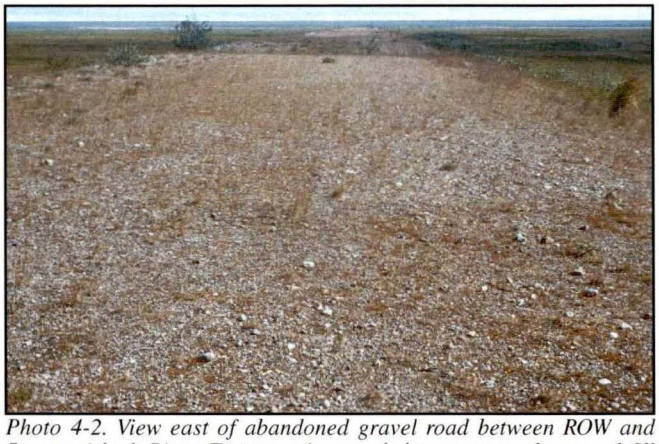


Photo 4-2. View east of abandoned gravel road between ROW and Sagavanirktok River. Festuca rubra *seeded to vegetate the gravel fill dominates this habitat.*

Site No. 4 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	80.1	0
Moisture %	2.4	154.4
Total C %	3.5	11.5
Total N %	0.07	0.61
C:N ratio	49.4	18.8
Organic matter %	7.7	25.4
pH	8.16	7.93
NH_4-N (ppm)	1	6
NO_3-N (ppm)	1	1
P (ppm)	5	4
K (ppm)	20	22
Organic mat thickness (cm)	0-2	22

Photo 4-3. SE toward Brooks Range across sedge meadow next to ROW.

was no carryover of fertilizer from the revegetation program.

Thirty-four vascular plant species were found at this location. Twenty-one occurred within the ROW, and 16 in the adjacent tundra. The vegetation consisted of 11 shrubs, 16 forbs, two grasses and 5 sedges. Only one species (*Carex lugens*) was common to both habitats.

Five shrub species were recorded within the ROW. Eight shrub species were recorded in the adjacent habitat. Two species (*Dryas integrifolia* and *Salix lanata* var. *richardsoni*) were common to both habitats. *Salix brachyophylla* ssp. *nyphoclada*, *Salix arctica,* and *Salix alaxensis* were unique to the ROW. These species are known as common colonizers of gravel fill in the Arctic. Six shrubs were unique to the tundra habitat (*Andromeda polifolia, Arctostaphylos alpina, Cassiope tetragona, Rhododendron lapponicum, Salix reticulata*, and *Vaccinium uliginosum*). All of these shrubs are typically found on moist or wet soils that are usually capped with an organic mat and/or mosses. Since such habitat did not occur in the ROW, these species were absent there.

Sixteen forbs were found at this location. Twelve occurred within the ROW and four in the adjacent habitat. None were common to both habitats. Those occurring within the ROW were species often found colonizing gravel fill. Five were N-fixing legumes. All four of the forb species in the adjacent tundra are usually found in moist habitats and on soil with a relatively high organic matter content. The gravel fill of the ROW is largely uninhabitable for these species.

Only two grass species were recorded at this site, both found only within the ROW. *Festuca rubra* was applied during revegetation and was the predominate species on the horizontal surface of the ROW. *F. rubra* can be found in places along the streams in the Alaska Arctic. However, it usually occurs as scattered clumps and not as solid stands as in the situation at this and other locations along the TAPS corridor. *Arctagrostis latifolia* was possibly introduced to this site with revegetation seed applications. It occurred primarily on the lower margins of the ROW gravel fill. The species occurs naturally in the area on mounds, so specimens at this location may also have invaded naturally from the surrounding habitat.

Five sedge species were recorded at this location. Two were found in the ROW, and four occurred in the adjacent tundra. One species (*Carex lugens*) was common to both habitats. *Carex rupestris* was found only in the ROW habitat. *Carex aquatilis, Carex misandra,* and an unidentified *Carex* species were found only within the adjacent tundra. Difference in habitat moistness was largely responsible for the lack of sedges within the ROW. Those that were found occurred in moist micro sites.

Caribou, fox, grizzly bear, muskox, and occasionally moose are common wildlife of this area. Ground squirrel burrow into the gravel fill at some locations, but prefer the more silty gravel where the pipeline is buried. Migratory waterfowl use the vicinity to a limited extent during migration.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 4.

Species Names	Inside	Outside
Shrubs		
Andromeda polifolia		•
Arctostaphylos alpina		•
Cassiope tetragona		•
Dryas integrifolia	•	•
Rhododendron lapponicum		•
Salix brachyophylla ssp nyphoclada	•	
Salix arctica	•	
Salix alaxensis	•	
Salix reticulata		•
Salix lanata var richardsonii	•	•
Vaccinium uliginosum		•
Total Shrubs	5	8
Forbs		
Artemisia borealis	•	
Aster sibiricus	•	
Astragalus alpinus	•	
Epilobium latifolium	•	
Equisetum arvense	•	
Hedysarum mackenzii	•	
Oxytropis borealis	•	
Oxytropis campestris	•	
Oxytropis deflexa	•	
Polygonum viviparum		•
Saussurea angustifolia	•	
Saxifraga hirculus		•
Senecio resedifolius	•	
Silene acaulis		•
Stellaria longipes	•	
Tofieldia pusilla		•
Total Forbs	12	4
Grasses		
Arctagrostis latifolia	•	
Festuca rubra	•	
Total Grasses	2	0
Sedges		
Carex aquatilis		•
Carex lugens	•	•
Carex rupestris	•	
Carex misandra		•
Carex spp.?		•
Total Sedges	2	4
Total Vascular Species	***21***	***16***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #5

Date Examined:	27 July 1999
Location:	N69°19' 03.3"; W148°43' 09.7"; TAPS M.P. 69.
Pipeline:	Buried
Slope:	Level to gentle general slope
Drainage:	Inside - well-drained gravel fill; Outside - perched over permafrost
Vegetation:	Moist tussock sedge/shrub tundra, string bog

Site No. 5 is located in the Sagavanirktok drainage above Sagwon. The natural vegetation is predominantly moist tussock sedge meadow with a scattered willow shrub component. The natural landscape is uneven due to surface creep and wrinkling on the gentle slope. This produces a variation in plant species, with the elevated microtopography dominated by dry tundra species, and low areas by either moist or wet tundra species.

The pipeline workpad was 65% gravel and much drier than the adjacent undisturbed soil, which contained no gravel (11% moisture vs. 57%) . Soil reaction was alkaline both inside (7.91) and outside (7.70) the ROW. Total C was higher outside the ROW (7.54% vs. 4.80%), but the difference was not as great as in many other pipeline locations examined. A significant portion of the C in both soils is likely calcium carbonate. There was more total N in the undisturbed soil than in the ROW (0.42% vs. 0.16%). There was more available N in ROW substrate than in the undisturbed soil. Available P was identical in both habitats. Available K in the ROW was more than twice that of the undisturbed, indicating either that fertilizer applied during revegetation has persisted, or that inherent available K was much higher in the gravel fill used for the ROW. The organic mat in the ROW consisted primarily of grass and forb litter in combination with a few mosses.

This is the northernmost location where we found both *Salix planifolia* ssp. *pulchra* and *Salix lanata* var *richardsonii* in the natural and ROW communities. It is also the northernmost location where we observed *Shepherdia canadensis* colonizing in the ROW. *Shepherdia* was not found in the adjacent undisturbed community.

A dense stand of seeded *Festuca rubra* grass dominated the ROW over the buried pipe. The willow herb *Epilobium latifolium* and *Aster sibiricus* were commonly mixed with the seeded grass over the pipe. Tall willows, primarily *Salix alaxensis*, lined the ROW margins. Little vegetation occurred in the traveled portion of the ROW. The numbers of plant species in the ROW and the undisturbed were identical; however, composition differed between those two habitats. There were more forbs in the ROW habitat, compared to that of the undisturbed. Six species of legumes were found at this location. Five were found only on the ROW and one found only in the undisturbed community. There were no sedges in the ROW, and five in the undisturbed. There was one more shrub in the ROW than in the natural community, but shrub composition differed between the two habitats. Forty percent of the shrubs in the natural community were not found in the ROW, and fifty percent of the shrubs found on the ROW were not present in the adjacent undisturbed vegetation. Seeding grasses and habitat changes are responsible for these differences.

Festuca rubra was the surviving seeded grass, occupying most of the ROW except for the road portion. It is clearly holding ground at the expense of other species. *Festuca rubra* does not

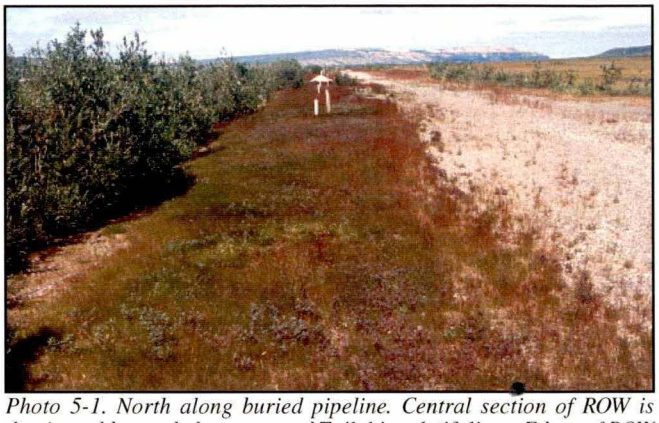


Photo 5-1. North along buried pipeline. Central section of ROW is dominated by seeded grasses and Epilobium latifolium. *Edges of ROW are dominated by tall willows (*Salix alaxensis *and* Salix lanata *var.* richardsonii*).*

Photo 5-2. North across moist sedge-shrub tundra.

Site No. 5 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	65.2	0
Moisture %	10.6	57.2
Total C %	4.80	7.54
Total N %	0.16	0.42
C:N ratio	30	18
Organic matter %	10.7	16.8
pH	7.91	7.70
NH_4-N (ppm)	Not detectable	1
NO_3-N (ppm)	9	Not detectable
P (ppm)	2	2
K (ppm)	43	19
Organic mat thickness (cm)	3	27

occur in the adjacent undisturbed habitat. *Arctagrostis latifolia* was included in some of the revegetation mixtures, but only the natural ecotype was found in the undisturbed vegetation at this site, indicating either that the seeded *Arctagrostis* failed to establish or that it was not part of the seed mixture in this location.

These differences in composition resulted from the disturbance which created an opening for secondary plant succession, and from revegetation which introduced a grass that is a strong competitor. Invasion by indigenous plant species signals that secondary succession is occurring on the ROW.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 5.

Species Names	*Inside*	*Outside*
Shrubs		
Andromeda polifolia		•
Arctostaphylos alpina		•
Dryas integrifolia	•	•
Potentilla fruiticosa	•	
Rhododendron lapponicum		•
Salix alaxensis	•	
Salix arctica	•	•
Salix brachyophylla ssp nyphoclada	•	
Salix glauca	•	
Salix lanata var richardsonii	•	•
Salix planifolia ssp. pulchra	•	•
Salix reticulata	•	•
Shepherdia canadensis	•	
Vaccinium uliginosum		•
Total Shrubs	10	9
Forbs		
Artemisia telesii	•	
Aster sibiricus	•	
Astragalus alpinus	•	
Crepis nana	•	
Epilobium latifolium	•	
Equisetum arvense	•	•
Gentiana propinqua	•	
Hedysarum mackenzii	•	
Lupinus arcticus		•
Oxytropis borealis	•	
Oxytropis campestris	•	
Oxytropis deflexa	•	
Parnassia palustris		•
Pedicularis sudetica	•	•
Pinguicula vulgaris		•
Polygonum viviparum		•
Tofieldia coccinia		•
Tofieldia pusilla		•
Total Forbs	12	8
Grasses		
Arctagrostis latifolia		•
Festuca rubra	•	
Total Grasses	1	1
Sedges		
Carex aquatilis		•
Carex atrofusca		•
Carex bigelowii		•
Carex misandra		•
Eleocharis acicularis		•
Total Sedges	0	5
Total Vascular Species	***23***	***23***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #6
Date Examined:	27 July 1999
Location:	N69°05' 53.1"; W148°49' 29.3"; TAPS M.P. 85.4.
Pipeline:	Elevated
Slope:	Moderate to steep
Drainage:	Inside - well-drained gravel fill; Outside - perched over permafrost
Vegetation:	Moist tussock sedge/shrub tundra

Site No. 6 is located in the Sagavanirktok drainage south of Happy Valley at Dan Creek. The pipeline workpad was 61% gravel, and much drier than the adjacent undisturbed soil which contained no gravel. Soil reaction was alkaline inside and acidic outside the ROW. Total C was ten times greater outside the ROW. A significant portion of the C in the gravel fill of the ROW was likely calcium carbonate. There was more total N in the undisturbed soil than in the ROW. The C:N ratio inside the ROW was more than seven times the desired balance for adequately supplying vascular plants. Available N inside the ROW and outside were comparable. Two-thirds of the ROW substrate N was in the nitrate form, while all of the available N in the undisturbed soil was ammonium. That is typical for alkaline and acidic soils. Available P in the gravel fill was 8 ppm, and elevated above normal background levels, indicating a possible carryover of fertilizer from revegetation. Available P in the undisturbed soil was below detection limits. Available K in the ROW was not different from that in the undisturbed soil. The organic mat in the ROW consisted primarily of grass and forb litter in combination with a few mosses and a foliose lichen.

The natural vegetation is predominantly moist tussock sedge meadow, with a scattered willow and dwarf birch shrub component. At this location, horsetail and coltsfoot were significant members of the vascular plant community. The natural landscape is rolling and subject to lateral drainage, but the thick accumulation of moss holds water on the slopes, producing a relatively wet habitat. This wetness in combination with the acidic soil base encourages formation of the heath shrubs (dwarf birch, crowberry, blueberry, mountain cranberry). Nine shrub species were found in the undisturbed and six in the ROW. *Salix planifolia* ssp. *pulchra* was present in the undisturbed vegetation as well as colonizing in the ROW margins. *Salix lanata* var *richardsonii* was absent from both communities. *Shepherdia canadensis* and *Salix alaxensis* were colonizing in the ROW, but not found in the adjacent undisturbed community.

A dense stand of seeded *Festuca rubra* grass dominated the ROW under the elevated pipe. *Festuca rubra* was not part of the original vegetation at this location. *Arctagrostis latifolia* was present in the ROW and adjacent undisturbed stand. This grass may have originated from seed applications as well as natural colonization. It is present in the natural plant complex. Willow shrubs were commonly mixed with the seeded grass under the pipe. There was an occasional tall willow along the ROW margins, but no dense stands as commonly observed farther north. Little vegetation occurred in the portion of the ROW where vehicles traveled. The numbers of plant species in the ROW and the undisturbed were similar; however, the species composition differed markedly between habitats. There were more forbs in the ROW habitat. Only two forb species common to both habitats

Photo 6-1. North along elevated pipe. Gravel fill within ROW is dominated by seeded grasses and shrubs, Salix *and* Shepherdia.

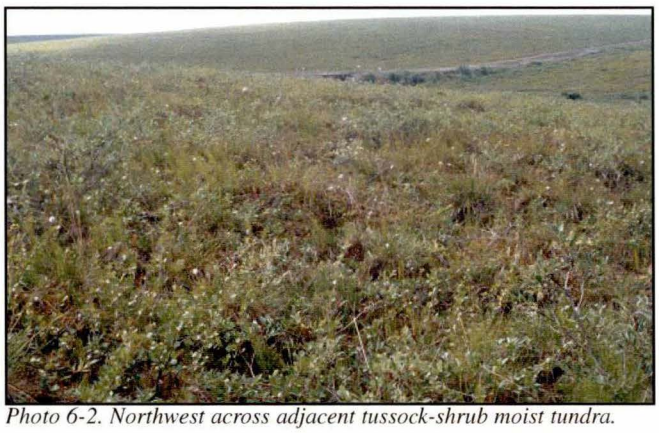


Photo 6-2. Northwest across adjacent tussock-shrub moist tundra.

Site No. 6 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	61.0	0
Moisture %	2.8	101.5
Total C %	2.16	10.67
Total N %	0.01	0.48
C:N ratio	216	22.2
Organic matter %	4.8	23.7
pH	8.29	5.88
NH_4-N (ppm)	1	4
NO_3-N (ppm)	2	Not detectable
P (ppm)	8	Not detectable
K (ppm)	29	33
Organic mat thickness (cm)	0-2	13

(*Equisetum arvense* and *Pedicularis sudetica*). Eleven forbs in the ROW and six forbs outside were unique to their respective habitats, indicating a wide divergence in site conditions. There were no sedges in the ROW and three in the undisturbed. There was one more shrub in the ROW than in the natural community, but shrub composition differed between the two habitats. Forty percent of the shrubs in the natural community were not found in the ROW, and fifty percent of the shrubs found on the ROW were not present in the adjacent undisturbed vegetation. Substrate differences and seeding were believed largely responsible for the vegetation differences.

Festuca rubra and *Arctagrostis latifolia* were the seeded grasses in the ROW. *Festuca rubra* was the most prominent grass in the ROW, occupying most of the area under the pipeline and on either side, except the road portion. Three sedges were recorded at this location, only in the undisturbed habitat. Although the species occurs farther north, this was our northernmost record for *Eriophorum vaginatum* in this survey. The species is a key component of moist tundra. We found it at 10 locations. It was invading the ROW at two sites. Our southernmost record was at Site #39 near Donnelly Dome.

Wildlife were not sighted at this location. Ground squirrel, caribou, musk ox, wolf, fox, and moose are the most likely mammals found in this area.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 6.

Species Names	Inside	Outside
Shrubs		
Arctostaphylos alpina		•
Betula nana		•
Cassiope tetragona		•
Empterum nigrum	•	•
Ledum decumbens		•
Salix alaxensis	•	
Salix glauca	•	•
Salix planifolia ssp. pulchra	•	•
Shepherdia canadensis	•	
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea		•
Total Shrubs	6	9
Forbs		
Aster sibiricus	•	
Astragalus alpinus	•	
Epilobium angustifolium	•	
Epilobium latifolium	•	
Equisetum arvense	•	•
Gentiana propinqua	•	
Hedysarum mackenzii	•	
Oxytropis borealis	•	
Oxytropis campestris	•	
Pedicularis sudetica	•	•
Petasites frigidus		•
Polygonum bistora subsp. plumosum		•
Pyrola grandiflora		•
Saussurea angustifolia		•
Saxifraga hirculus		•
Saxifraga punctata		•
Saxifraga tricuspidata	•	
Stellaria longipes	•	
Total Forbs	12	8
Grasses		
Arctagrostis latifolia	•	•
Festuca rubra	•	
Total Grasses	2	1
Sedges		
Carex aquatilis		•
Carex atrofusca		•
Eriophorum vaginatum		•
Total Sedges	0	3
Total Vascular Species	***20***	***21***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #7

Date Examined:	27 July 1999
Location:	N68°53' 52.4"; W148°52' 34.0"; TAPS M.P. 100.
Pipeline:	Elevated
Slope:	Gentle to moderate
Drainage:	Inside - well-drained gravel fill; Outside - perched over permafrost
Vegetation:	Moist tussock sedge tundra

Site No. 7 is located in the Sagavanirktok drainage north of Pump Station 3 and Slope Mountain. The Sagavanirktok River and Dalton Highway are east of the pipeline at this location. Just south of TAPS M.P. 100, there is a gravel road by which access to this site is possible from the Dalton Highway. The pipeline is positioned on the west side of the ROW, while the largely barren roadway is on the east. Seeded grass and naturally colonizing forbs provide nearly complete cover to the ROW except in the roadway. The natural vegetation is moist tussock tundra. Shrubs do not dominate the upper canopy of the adjacent vegetation. The natural landscape is rolling and subject to lateral drainage, but the thick accumulation of moss holds water on the slopes, producing a relatively wet habitat. This wetness along with the acidic soil base encourages formation of heath shrubs (Labrador tea, dwarf birch, crowberry, cloudberry, blueberry, and mountain cranberry).

Gravel fill was placed at this site. The pipeline workpad contained 80% gravel. There was no measurable gravel in the adjacent soil. Gravel fill of the ROW contained about 4% moisture while the adjacent tundra soil contained about 671% moisture. Soil reaction was alkaline (pH 8.03) inside and acidic (pH 5.47) outside the ROW. Total C was twelve times greater outside the ROW (40.32%) than within the ROW (3.23%). These values translated into 7.2% organic matter for the ROW gravel fill and 40.3% for the undisturbed soil. A significant portion of the C in the gravel fill of ROW was likely calcium carbonate, which inflated the organic matter estimate and unknown amount. Total soil N within the ROW was relatively low (0.05%). Outside the ROW, total soil N was 1.71%. The C:N ratios for the ROW gravel fill and moist tundra soil were 64.6 and 23.6, respectively. Clearly the ROW soil was imbalanced as far as total N and C were concerned.

There was 1 ppm available N in the ROW soil, and 5 ppm in the adjacent soil. All of the ROW substrate N was in the nitrate form, while 60% of the available N in the undisturbed soil was ammonium. That is typical for alkaline and acidic soils, respectively. Available P in the gravel fill was 3 ppm, slightly higher but not atypical for alkaline substrates in this region. Available P in the undisturbed soil was 6 ppm, typical for these soils. Available K in the ROW was 28 ppm and similar to the values found farther north, but available K in the undisturbed soil was 114 ppm, much above normal levels of these soils. Apparently, natural K levels were inherently greater than for other soils in the region. Fertilizers applied during revegetation were no longer apparent in the ROW soil tests. The organic mat in the ROW consisted primarily of grass and forb litter in combination with a few mosses and a crustose lichen. The organic mat in the adjacent tundra community consisted of decomposing organic matter, capped with sphagnum moss and lichens.

Photo 7-1. North along elevated pipeline. Gravel fill within ROW is well vegetated, except in roadway. Seeded grass and indigenous forbs predominate.

Photo 7-2. Adjacent moist tussock tundra.

Site No. 7 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	80.0	0
Moisture %	3.6	670.8
Total C %	3.23	40.32
Total N %	0.05	1.71
C:N ratio	64.6	23.6
Organic matter %	7.2	89.6
pH	8.03	5.47
NH_4-N (ppm)	Not detectable	3
NO_3-N (ppm)	1	2
P (ppm)	3	6
K (ppm)	28	114
Organic mat thickness (cm)	0.5 - 3	29.2

Twenty-six vascular plant species were recorded at this location . Fourteen occurred within the ROW, and 12 were found in the adjacent moist tundra. None of the species recorded at this location were common to both habitats. Differences in soil conditions, mainly wetness was probably responsible for the lack of commonality of the species between the two habitats.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 7.

Species Names	Inside	Outside
Shrubs		
Arctostaphylos alpina		•
Betula nana		•
Cassiope tetragona		•
Empterum nigrum		•
Ledum decumbens		•
Rubus chamaemorus		•
Salix brachyophylla ssp nyphoclada	•	
Salix lanata var richardsonii	•	
Salix planifolia ssp. pulchra		•
Shepherdia canadensis	•	
Vaccinium uliginosum		•
Vaccinium vitis-idaea		•
Total Shrubs	3	9
Forbs		
Aster sibiricus	•	
Astragalus alpinus	•	
Astragalus eucosmus	•	
Epilobium latifolium	•	
Equisetum arvense	•	
Gentiana glauca	•	
Hedysarum mackenzii	•	
Oxytropis borealis	•	
Polemonium acutiflorum	•	
Polygonum bistora subsp. plumosum		•
Total Forbs	9	1
Grasses		
Arctagrostis latifolia	•	
Festuca rubra	•	
Total Grasses	2	0
Sedges		
Carex aquatilis		•
Eriophorum vaginatum		•
Total Sedges	0	2
Total Vascular Species	***14***	***12***

There were 12 shrubs at this location. Three species were found within the ROW, and nine in the adjacent tundra. The three ROW shrubs (*Salix brachyophylla* ssp. *nyphoclada*, *Salix lanata* var. *richardsonii,* and *Shepherdia canadensis*) are species that commonly invade open habitats. *Shepherdia* is a member of the *Elaeagnaceae* family and has N-fixing capacity, making it desirable for improving soil fertility. The two willow species were most likely able to enter this site from windborne seed. It is unclear how *Shepherdia* arrived to the site. The nine shrub species found in the adjacent tundra are all typical of this type of tundra. They represent the heath component of tussock tundra and usually occur prominently on acidic soils.

Ten forb species were found at this location. Nine occurred within the ROW and one was found in the adjacent habitat. None were common to both habitats. Unlike ROW sites north of here, these forbs were mixed throughout the community rather than confined to the margins. The ROW forbs consisted of species usually associated with disturbed habitats. Four of the nine were legumes with capacity to fix N. The species represented both those with easily windborne seeds as well as those that generally fall close to the mother plant. It is not known how these plants were introduced to the site; possibly they were brought by wind, by animals, carried with the gravel fill, or carried on vehicles from other locations along the ROW. *Polygonum bistorta* subsp. *plumosum* was the only forb found in the adjacent habitat. This is a common species in the moist tundra. It was never found within the ROW in our survey.

Only two grass species (*Arctagrostis latifolia* and *Festuca rubra*) were found at this site, and both occurred exclusively within the ROW. Both were introduced to the location during revegetation. A dense stand of seeded *F. rubra* grass dominated the ROW under the elevated pipe and the area beyond the road. *A. latifolia* was found much less abundantly and seemed to prefer the sloping margins of the gravel fill to the horizontal surface.

Nine shrub species were found in the undisturbed and three in the ROW. All of these shrubs were unique to each of their respective habitats. That was true for all vascular species at this location. There were no common plant species between the two habitats.

Two sedges (*Carex aquatilis* and *Eriophorum vaginatum*) were found at this location, both confined to the undisturbed tundra. These species were probably not colonizing the ROW because it was too dry, and the sedges prefer wetter soils.

Wildlife common to this location include caribou, moose, grizzly bear, wolf, fox, muskox, and small mammals. Sightings and signs of wildlife were not observed at the time we inspected this site.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #8
Date Examined:	27 July 1999
Location:	N68°40' 33.9"; W149°10' 33.8"; TAPS M.P. 115.7.
Pipeline:	Elevated
Slope:	Gentle
Drainage:	Inside - perched over permafrost; Outside - perched over permafrost
Vegetation:	Moist tussock sedge/shrub tundra

Site No. 8 is located in the Kuparuk River drainage north of Pump Station 3 and south of Slope Mountain. The gravel of this work pad appeared to have been placed relatively recently and did not occur beneath the pipeline. The natural vegetation is predominantly moist tussock sedge meadow with a scattered willow and dwarf birch shrub component. At this location, the shrubs are more prominent in the undisturbed habitat than at Site No. 7, but sedges dominate the aspect.

The ROW beneath the pipeline was 19% gravel, and the soil outside the ROW was 18% gravel. These are presumably from similar parent material and would be expected to be equivalent in physical and chemical factors. Soil moisture within the ROW was less (21%) than that outside the ROW (49%). This is a glacial moraine with a natural rock component. We did not sample the workpad, which was river gravel. Soil reaction was similarly acidic both inside (pH 5.82) and outside (pH 5.73) the ROW, illustrating relatively little change in soil conditions from construction at this location. Total C was slightly less than twice that outside the ROW (1.87% vs 3.71%). That difference may reflect a mixing of subsurface material deposited at the surface during VSM installation. These values translate to 4.2% and 8.0% organic matter. Total soil N was 0.05% within the ROW and 0.13% in the adjacent tundra. There was a wider C:N ratio (37.4 vs 27.8) in the disturbed soil. Because the soils were both acidic, these organic matter and C:N ratios were not biased by carbonate C.

Available N inside the ROW was 2 ppm, half that of the undisturbed soil (4 ppm). Both values are low, but typical of levels encountered in this investigation. Available P was 2 ppm in the disturbed soil and 1 ppm in the undisturbed soil. These values are low, and may indicate P may be limiting plant growth. Available K was 19 ppm in the ROW and 31 ppm in the undisturbed area. Both of these values are low and typical of soils in the region. There appears to have been no long-term carryover from fertilizer applied during construction at this site. The organic mat in the ROW (up to about 2cm) consisted primarily of grass litter in combination with moss and lichen. *Thamnolia* was one prominent lichen species in the organic mat within the ROW. The organic mat of the adjacent tundra (22.3cm) consisted of mosses, *Cetraria cucullata* and *Dactylina arctica.*

Twenty-one species were recorded at this location. There were vascular 16 species within the ROW and 10 in the natural community. Four of the vascular plant species were common to both habitats. Nine shrub species were found at this site. Six species occurred in each of the two habitats. Three species (*Betula nana, Rubus chamaemorus* and *Salix planifolia* ssp. *pulchra*) were common to both. Three willow (*Salix glauca, Salix lanata* var. *richardsonii,* and *Salix rotundifolia*) were found only in the ROW. Three shrubs (*Ledum decumbens, Salix phlebophylla,* and *Vaccinium vitis-idaea*) were found only in the undisturbed habitat.

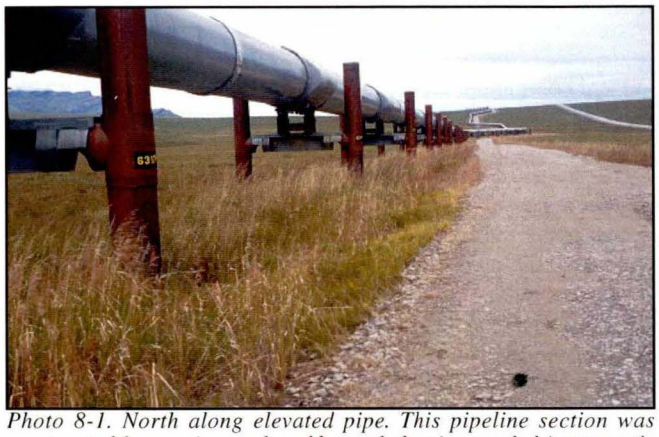


Photo 8-1. North along elevated pipe. This pipeline section was constructed from an ice road, and beneath the pipe, seeded Arctagrostis latifolia *and* Equisetum arvense *predominate. Gravel fill of roadway is largely barren.*

Photo 8-2. Northward across adjacent low shrub tussock tundra.

Site No. 8 soil data inside and outside TAPS right-of-way.

Characteristic	Inside	Outside
Gravel %	19.0	18.2
Moisture %	21.4	48.7
Total C %	1.87	3.61
Total N %	0.05	0.13
C:N ratio	37.4	27.8
Organic matter %	4.2	8
pH	5.82	5.73
NH_4-N (ppm)	1	3
NO_3-N (ppm)	1	1
P (ppm)	2	1
K (ppm)	19	31
Organic mat thickness (cm)	1.9	20.3

There seemed to be a fairly dense stand of seeded grasses in the ROW, and this may have been affecting the invasion by native species. Fertilization is also known to shift the species composition of tundra in favor of graminoids, which may have been a factor at this location.

Five forb species were recorded at this location. Four forb species occurred in the ROW, and one (*Polygonum bistorta* subsp. *plumosum*) in the adjacent tundra. No forb species was common to both habitats. The forbs recorded for the ROW were species typical of disturbed habitats. Leguminosae and Compositae family members were conspicuously absent from this site. They are expected to eventually colonize on the gravel fill of the roadway.

Three grass species were found at this site. One species, *Poa arctica*, was common to both habitats. Judging from the stature and leaf color and texture of the *Arctagrostis latifolia* within the ROW at this site, it appears this is the commercially available ecotype and probably introduced with the revegetation program. *Festuca rubra* was clearly introduced by seeding. The predominance of grass resulted from the combined effects of seeding and fertilizer applications. It is possible that without those treatments, the vegetation would have been more similar between the two habitats.

Four sedges/rushes were found at this location. One, *Eriophorum vaginatum*, was common to both habitats. Three occurred within the ROW (*Carex lugens, Eriophorum vaginatum,* and *Juncus* spp.) *Carex aquatilis* was found only in the adjacent tundra.

Wildlife that use this area include caribou, wolf, and small mammals. No signs of wildlife were observed during this survey.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 8.

Species Names	*Inside*	*Outside*
Shrubs		
Betula nana	•	•
Ledum decumbens		•
Rubus chamaemorus	•	•
Salix glauca	•	
Salix lanata var richardsonii	•	
Salix phlebophylla		•
Salix planifolia ssp. pulchra	•	•
Salix rotundifolia	•	
Vaccinium vitis-idaea		•
Total Shrubs	6	6
Forbs		
Astragalus alpinus?	•	
Epilobium palustre	•	
Equisetum arvense	•	
Polemonium acutiflorum	•	
Polygonum bistora subsp. plumosum		•
Stellaria longipes	•	
Total Forbs	5	1
Grasses		
Arctagrostis latifolia	•	
Festuca rubra	•	
Poa arctica	•	•
Total Grasses	3	1
Sedges		
Carex aquatilis		•
Carex lugens	•	
Eriophorum vaginatum	•	•
Juncus spp.	•	
Total Sedges	3	2
Total Vascular Species	***17***	***10***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #9

Date Examined:	28 July 1999
Location:	N68°28' 49.3"; W149°25' 07.5"; TAPS M.P. 139.6.
Pipeline:	Elevated
Slope:	Moderate
Drainage:	Inside - well-drained gravel fill; Outside - perched over permafrost
Vegetation:	Moist tussock sedge/shrub tundra

Site No. 9 is located in the Atigun River drainage north of Pump Station 4 and east of Galbraith Lake. This location is in a glacial valley, with relatively steep slopes to the east and the valley basin toward the west. Access to this site is via a gravel road that leaves the Dalton Highway between TAPS M.P. 135 and M.P. 140. Once the pipeline ROW is reached, the site is south along the roadway. The ROW is east of the Dalton Highway, between the highway and the toe of the mountain slope. The elevated pipeline is on the east side of the ROW, and the roadway is on the west. Rocky fill was used to construct the pipeline workpad. The natural vegetation is moist tussock sedge meadow with a willow and dwarf birch shrub component. The natural landscape is sloping and subject to lateral drainage, but the thick accumulation of moss holds water on the slopes, producing a relatively wet habitat. At this location, the shrubs are relatively prominent, but the tussock sedge predominates. The absence of typical heath shrub species is notable.

The ROW beneath the pipeline contained 73% gravel, and the soil outside the ROW was about 7% gravel. The soil moisture within the ROW contained about 8% moisture, and that of the adjacent tundra contained 122% moisture. Soil reaction was acidic (pH 6.23) in the undisturbed area and alkaline (pH 8.03) in the ROW. The gravel fill was a mixture of coarse, angular stones, representative of glacial outwash.

Total soil C was 6.49% in the ROW fill and 7.09% in the adjacent soil. These values translated to 14.4% and 15.8 % organic matter. The alkaline soil of the ROW probably contained carbonates that would have inflated the C and organic matter values for that soil. The total N in the ROW was 0.08% and for the natural soil 0.42%, relatively low for both soils. The C:N ratio for the ROW was 81.1 and for the tundra soil 16.9. The

Site No. 9 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	73.3	6.6
Moisture %	7.6	122.3
Total C %	6.49	7.09
Total N %	0.08	0.42
C:N ratio	81.1	16.9
Organic matter %	14.4	15.8
pH	8.03	6.23
NH_4-N (ppm)	Not detectable	3
NO_3-N (ppm)	1	2
P (ppm)	1	1
K (ppm)	34	46
Organic mat thickness (cm)	0 - 2.5	26.7

Photo 9-1. South along elevated pipe. Rocky fill at this site is dominated by naturally-established Agropyron *spp. and seeded* Festuca rubra.

Photo 9-2. Eastward toward mountain slope. Foreground dominated by low shrub-tussock tundra.

wide C:N ratio would suggest there was not enough N in the ROW to adequately supply both microbial and vascular plant requirements.

Available N inside the ROW was 1 ppm, and that for the adjacent tundra soil was 5 ppm. Both values are relatively low, but the ROW was particularly limited in available N. Available soil P was 1 ppm in both soils. This element was also possibly limiting plant growth. Available K was 34 ppm in the ROW and 46 ppm in the undisturbed area. Both of these values are typical of soils in the region. There appears to have been no long-term carryover from the fertilizer applied during construction at this location. The organic mat in the ROW consisted primarily of grass litter in combination with moss and crustose lichen. Much of the ROW surface was bare stones.

Thirty-six vascular plant species were identified at this location. Fifteen occurred within ROW and 26 in the natural community. Four of these were common to both habitats. Differences between the two substrate environments was a significant factor affecting total vegetation cover and species composition.

Twelve shrub species were found at this location. Six occurred within the ROW and nine in the adjacent tundra. Three of the shrubs (*Salix brachyophylla* ssp *nyphoclada*, *Salix lanata* var *richardsonii*, and *Salix planifolia* ssp. *pulchra*) were common to both habitats. *Potentilla fruticosa, Salix alaxensis,* and *Salix arctica* were unique to the ROW. *Arctostaphylos alpina, Betula nana, Rhododendron lapponicum, Salix phlebophylla, Salix reticulata,* and *Vaccinium uliginosum* were found only in the undisturbed tundra. Shrubs exclusive to the ROW were generally those species we usually found colonizing new habitats. Those exclusively in the undisturbed tundra are species usually associated with climax tundra communities. Habitat dryness and perhaps competition from grass species were factors affecting the species composition of the ROW.

Nineteen forb species were recorded at this location. Seven occurred within the ROW and 14 in the adjacent tundra. This was a bit unusual, because often the forb species of the ROW outnumbered those of the adjacent habitats. Only one species (*Saussurea angustifolia*) occurred in both habitats.

Three grass species were recorded at this location. Two occurred exclusively within the ROW, and one occurred only in the adjacent tundra. *Arctagrostis latifolia* was found only in the undisturbed tundra. *Agropyron* spp. and *Festuca rubra* were confined to the ROW fill material. The *Agropyron* appeared to dominate the aspect, perhaps in part because of its stature. Fertilizer applications undoubtedly aided the natural *Agropyron* establishment. *Festuca rubra* had been introduced by revegetation practices.

Only two sedges were found at this location, *Carex aquatilis* and *Eriophorum vaginatum*. Both species occurred exclusively in the undisturbed tundra. The habitat within the ROW was probably too dry for these species.

Wildlife common to this area include Dall sheep and caribou. Wolves also occur in the area. No wildlife signs or sightings were recorded at this site during our inventory.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 9.

Species Names	Inside	Outside
Shrubs		
Arctostaphylos alpina		•
Betula nana		•
Potentilla fruiticosa	•	
Rhododendron lapponicum		•
Salix alaxensis	•	
Salix arctica	•	
Salix brachyophylla ssp nyphoclada	•	•
Salix lanata var richardsonii	•	•
Salix phlebophylla		•
Salix planifolia ssp. pulchra	•	•
Salix reticulata		•
Vaccinium uliginosum		•
Total Shrubs	6	9
Forbs		
Astragalus umbellatus		•
Bupleurum triradiatum		•
Cnidium cnidiifolium		•
Epilobium latifolium	•	
Gentiana propinqua	•	
Oxytropis borealis	•	
Oxytropis campestris	•	•
Oxytropis koyukukensis	•	
Pedicularis capitata		•
Pedicularis sudetica		•
Polygonum bistora subsp. plumosum		•
Polygonum viviparum		•
Pyrola grandiflora		•
Saussurea angustifolia	•	•
Saxifraga hieracifolia		•
Saxifraga hirculus		•
Saxifraga punctata		•
Senecio atropurpureus		•
Taraxacum lacerum	•	
Total Forbs	7	14
Grasses		
Agropyron spp.	•	
Arctagrostis latifolia		•
Festuca rubra	•	
Total Grasses	2	1
Sedges		
Carex aquatilis		•
Eriophorum vaginatum		•
Total Sedges	0	2
Total Vascular Species	***15***	***26***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #10

Date Examined:	23 July 1999
Location:	N68°17' 15.7"; W149°22' 25.2"; TAPS M.P. 154.
Pipeline:	Elevated
Slope:	Gentle
Drainage:	Inside - well-drained gravel fill; Outside - perched over permafrost
Vegetation:	Moist to dry shrub/tundra complex

Site No. 10 is located just north of Trevor Creek in the Atigun River drainage south of Pump Station 4. The valley was carved by glacial action. This location is in a glacial valley, with relatively steep slopes to the east and the valley basin toward the west. Access to the site is via a gravel road from the Dalton Highway. The elevated pipeline is situated on the west side of the ROW. A roadway is on the east side. The natural vegetation is predominantly low shrub tundra. Tall and low willow patches formed a mosaic of stands. Among these willow stands were open areas of low shrubs and moss mats. The absence of typical heath shrub species was noteworthy, the product of soil alkalinity and general lack of moisture. The natural landscape is sloping and relatively dry, but the moss accumulation on the surface holds water, increasing the habitat wetness.

The soil in the ROW beneath the pipeline was about 61% gravel, and the soil outside the ROW was about 13% gravel. Soil moisture was 12% under the pipeline and about 26% in the adjacent soil. Soil reaction was alkaline in both the ROW (pH 8.11) and the undisturbed (pH 8.10) area. The gravel fill was a finer mixture of stones than at Site No. 9, and similar to typical river gravel. The undisturbed soil was also stony, probably outwash from nearby Trevor Creek. Total C for the ROW soil was 1.83%. The undisturbed soil contained 1.86% C. For both soils, a portion of the total C was from inorganic carbonates. Total soil N was 0.08% within the ROW and 0.06% in the adjacent soil. The C:N ration for the ROW soil was 23.9 and that for the undisturbed soil was 31.0. Based on similarities in soil conditions between the ROW and the adjacent habitat, it is anticipated that natural colonization of the ROW by adjacent vegetation would have a good chance at this site.

Available N inside the ROW was only 3 ppm, but no available N was measured in the undisturbed soil. Available P was 2 ppm in the gravel fill of the ROW and 1 ppm in the undisturbed soil. Available K in the ROW was 41 ppm, double that of the undisturbed soil (20 ppm). Both K values are within background levels of soils for the region. Cumulative evidence of availabilities for the three macro elements indicates a possible carryover of fertilizers applied during revegetation. The organic mat in the ROW consisted primarily of vascular plant litter in combination with moss and lichen. Much of the ROW was well vegetated except for wheel tracks.

Thirty-five vascular plant species were identified at this location. Twenty-six species were listed within the ROW and 26 in the natural community. About half of the species found were common to both habitats, a remarkable degree of conformity for a tundra vegetation site.

Nine shrub species were found at this site. Eight species were listed for the ROW and nine for the undisturbed vegetation. Eight shrub species were common to both habitats. *Betula nana*

Photo 10-1. Southward along east side of elevated pipe in Atigun Canyon. ROW is being recolonized with indigenous plants, Salix lanata *var.* richardsonii *being one of the most prominent. Seeded grasses line the wheel tracks in the roadway.*

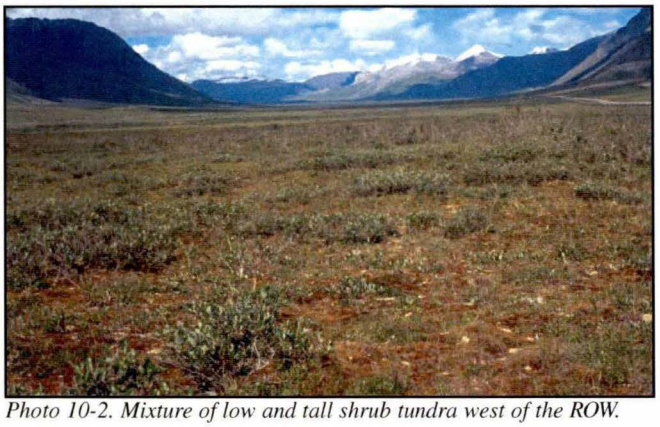


Photo 10-2. Mixture of low and tall shrub tundra west of the ROW.

Site No. 10 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	60.8	13.3
Moisture %	12.1	25.5
Total C %	1.83	1.86
Total N %	0.08	0.06
C:N ratio	22.9	31
Organic matter %	4.1	4.1
pH	8.11	8.10
NH_4-N (ppm)	1	Not detectable
NO_3-N (ppm)	2	Not detectable
P (ppm)	2	1
K (ppm)	41	20
Organic mat thickness (cm)	1 - 2.75	7

was the only species confined only to the undisturbed habitat. Judging from the species of shrubs present, the site and its surroundings represent a serial vegetation stage rather than a climax tundra community. Tall willow plants were scattered across the ROW as opposed to lining the margins.

Seventeen forb species were identified at this location. Fourteen forb species occurred within the ROW and 11 in the adjacent tundra. Eight of the species found at this site were common to both habitats. Of the 14 forbs of the ROW habitat, six were not found in the adjacent natural communities. One species, *Tofieldia coccinia*, was found in the undisturbed and not in the ROW. Similarity between the ROW and adjacent tundra habitat was reinforced in the fact that a large percentage of the forbs at this location were common to both habitats.

Seven grass species were found at this location. There were four grass species in each habitat, but only one (*Bromus pumpellianus*) was common to both habitats. The only seeded grass persisting within the ROW was *Festuca rubra*; the other three were indigenous colonizers. The presence of these tufted (caespitose) indigenous grasses was an indication of habitat dryness. *Festuca rubra* formed a thick understory among the willows established on ROW. It was most visible in the roadway, where willows were less common. The roadway portion of the workpad supported considerable vegetation, as opposed to many areas along the pipeline where the roadway is often barren. This is the northernmost record for Festuca altaica in this survey. It is a common indigenous bunchgrass. This grass has invaded the ROW at nine locations and was recorded in nineteen undisturbed habitats in this survey.

Two sedge species were identified at this location. Both sedges occurred in the undisturbed habitat, and none were found in the ROW. The lack of moss to hold soil moisture was probably a factor which prevented sedges from colonizing this site.

Signs and sightings of wildlife were not recorded for this site; however, fox, ground squirrel, wolf, sheep, goats, and possibly caribou would be expected in this locale.

Photo 10-3. Example of short willow growth in adjacent shrub tundra.

Photo 10-4. Moss and mat willows in adjacent shrub tundra.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 10.

Species Names	Inside	Outside
Shrubs		
Arctostaphylos alpina	•	•
Betula nana		•
Dryas integrifolia	•	•
Salix alaxensis	•	•
Salix arctica	•	•
Salix brachyophylla ssp nyphoclada	•	•
Salix lanata var richardsonii	•	•
Salix planifolia ssp. pulchra	•	•
Salix reticulata	•	•
Total Shrubs	8	9
Forbs		
Anemone parviflora	•	•
Aster sibiricus	•	
Astragalus alpinus	•	
Astragalus eucosmus	•	•
Castelleja elegans	•	
Epilobium latifolium	•	
Equisetum arvense	•	•
Equisetum scirpoides	•	•
Gentiana propinqua	•	•
Hedysarum alpinum	•	•
Hedysarum mackenzii	•	•
Oxytropis borealis	•	
Parnassia palustris		•
Pedicularis capitata		•
Pyrola grandiflora	•	
Senecio conterminus	•	•
Tofieldia coccinia		•
Total Forbs	14	11
Grasses		
Agropyron spp.	•	
Arctagrostis latifolia		•
Bromus pumpellianus	•	•
Festuca altaica		•
Festuca baffinensis		•
Festuca rubra	•	
Trisetum spicatum	•	
Total Grasses	4	4
Sedges		
Carex aquatilis		•
Carex bigelowii		•
Total Sedges	0	2
Total Vascular Species	***26***	***26***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #11

Date Examined:	28 July 1999
Location:	N68°11' 56.6"; W149°25' 52.2"; TAPS M.P. 163.4.
Pipeline:	Buried
Slope:	Gradual to moderate
Drainage:	Inside - well-drained gravel fill; Outside - well-drained gravel
Vegetation:	Moist to dry shrub/tundra complex

Site No. 11 is located in the Atigun River drainage south of Pump Station 4. The site lies east of the Dalton Highway. Access is via a gravel road. The pipeline is buried in the bed of a glacial stream, the east fork of the Atigun headwaters. There is relatively little vegetation within the ROW, and no evidence of a roadway. The stream flows on the east side of the ROW. This location is in a fairly narrow glacial valley, with steep slopes to the east and west which restrict the direct sunlight available to plants. The natural landscape is relatively dry, but the moss accumulation on the surface holds water, locally increasing the habitat wetness. The high elevation and less silt also places stress on plants at this location. Based on the undisturbed community on the west side of the ROW, the natural vegetation is predominantly alpine dry shrub tundra. We are uncertain if the ROW supported this type of vegetation prior to construction. Tall and low willow patches formed a mosaic of stands, with interspersed islands of *Dryas*. Limited soil development and geomorphic processes have kept this vegetation from advancing. For management purposes, the vegetation at this site will remain as it is indefinitely, because limited soil fines combined with periodic flooding prevent vegetation development from progressing.

Gravel content inside and outside the ROW was about 62% and 74%, respectively. Soil reaction was alkaline in the ROW (pH 8.09) and acidic (pH 6.30) in the undisturbed. There appeared to be no gravel added to the ROW, it was simply material excavated on site for burying the pipeline. The undisturbed soil was also stony colluvial and alluvial geologic material. Soil moisture within the ROW was about 5% and for the undisturbed soil 6%.

Total C was ten times greater in the undisturbed area than in the ROW (4.10% vs 0.47%) This translated to 1% organic matter for the ROW soil and 3% for the adjacent habitat, both relatively low values. A portion of the C in the ROW was probably carbonates, which would inflate the organic matter estimate. Total soil N was 0.07% within the ROW and 0.09% outside. The C:N ratios were 6.2 for the ROW and 15.7 for the tundra soils. Available N inside the ROW was only 1 ppm (nitrate), and 5 ppm in the undisturbed. Seventy-five percent of the available N in the undisturbed soil was in the ammonium form, typical for acidic soils. Available P was 2 ppm in the ROW and 4 ppm in the undisturbed soil. Available K was 26 ppm in the ROW and 19 ppm in the natural soil; both K values are within background levels of soils for the region. The ROW had no organic mat, and even though these data show a 10.5 cm mat outside the ROW, it is difficult to state whether or not that represents pre-construction conditions at this location. Most of the valley bottom was disturbed during construction, leaving little or no natural communities for comparison. The ROW supported a scattered collection of vascular plants. Plant density appeared to be directly

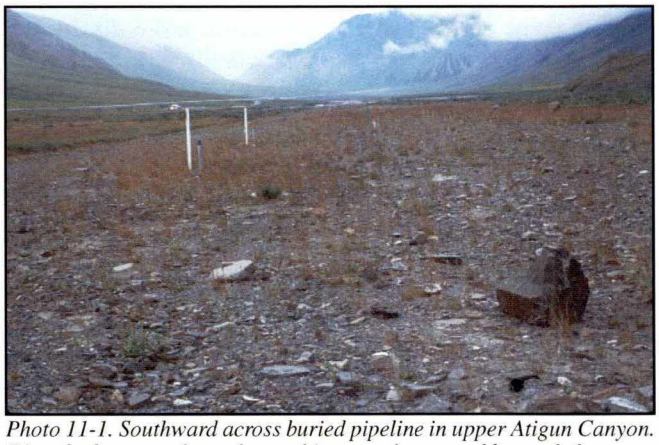


Photo 11-1. Southward across buried pipeline in upper Atigun Canyon. Disturbed stream channel gravel is sparsely covered by seeded grasses and naturally-established forbs and shrubs.

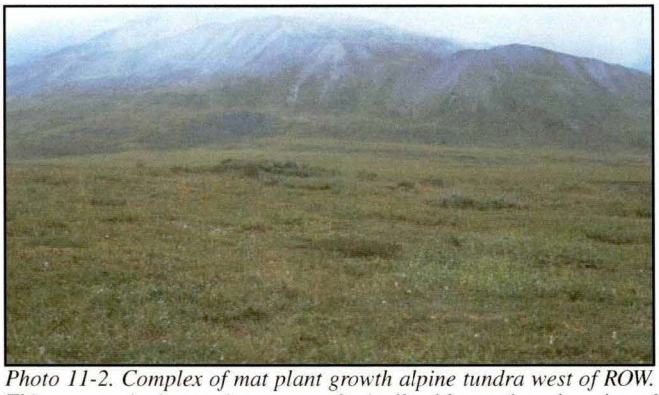


Photo 11-2. Complex of mat plant growth alpine tundra west of ROW. This community is growing on a geologically older surface than that of the ROW before construction.

Site No. 11 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	62.1	74.1
Moisture %	4.9	6.4
Total C %	0.47	4.10
Total N %	0.07	0.09
C:N ratio	6.2	15.7
Organic matter %	1	3.1
pH	8.09	6.30
NH_4-N (ppm)	Not detectable	4
NO_3-N (ppm)	1	1
P (ppm)	2	4
K (ppm)	26	19
Organic mat thickness (cm)	0	10.5

related to the amount of soil fines in the substrate.

A total of 44 vascular plant species were found at this site. Ten species were common to both habitats. There were 25 species within the ROW and 30 in the natural community. There were considerable dissimilarities in the vegetation between the two habitats. The ROW exceeded the natural stands in numbers of grasses, while the undisturbed produced greater numbers of shrubs and sedges. Both habitats contained 14 forbs, but only four were common to both habitats, all colonizers of open ground. Most of the disparity between plant species can be attributed to differences in soil conditions.

Eight shrub species were found at this location. Three shrub species occurred within the ROW, and seven were found in the adjacent alpine tundra. Only *Salix alaxensis* and *Salix arctica* were common to both habitats. The only other shrub species within the ROW was *Salix lanata* var. *richardsonii*.

Twenty-four forb species were found at this location. Fourteen forbs were identified in each of the two habitats. Only three species (*Astragalus alpinus, Epilobium latifolium,* and *Salix tricuspidata*) were common to both habitats.

Eight grass species were recorded at this location. Seven were found within the ROW and five in the adjacent habitat. The seven grass species of the ROW consisted of colonizers and seeded species. Certainly *Festuca rubra* and possibly *Poa glauca* and *Arctagrostis latifolia* had been seeded. The one grass species unique to the undisturbed community was *Heirochloe alpina*, an indigenous grass of well-developed plant communities. Presence of these tufted (caespitose) grasses was another indication of habitat dryness.

Three sedges and one rush were found at this location. All four species were observed in the undisturbed community. Only the sedge (*Carex lugens*) occurred within the ROW. Most likely poor soil conditions (dryness) was the main reason for sedges not colonizing within the ROW.

Dall sheep, mountain goats, and wolves are the most common large wildlife species in this locality. We have observed them here in the past, but not at the time of this survey.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 11.

Species Names	Inside	Outside
Shrubs		
Arctostaphylos alpina		•
Dryas octopetala		•
Salix alaxensis	•	•
Salix arctica	•	•
Salix brachyophylla ssp nyphoclada		•
Salix lanata var richardsonii	•	
Salix planifolia ssp. pulchra		•
Salix reticulata		•
Total Shrubs	3	7
Forbs		
Anemone richardsonii		•
Artemisia borealis		•
Astragalus alpinus	•	•
Astragalus umbellatus		•
Cerastium beeringinanum	•	
Crepis nana	•	
Draba spp	•	
Epilobium angustifolium	•	
Epilobium latifolium	•	•
Erigeron compositus	•	
Erigeron pulcherrima	•	
Geum rossii		•
Luetkea pectinata	•	
Lycopodium selago		•
Minuartia macrocarpa	•	
Pedicularis capitata		•
Polygonum bistora subsp. plumosum		•
Potentilla hookeriana		•
Pyrola grandiflora		•
Sagina intermedia	•	
Saxifraga tricuspidata	•	•
Solidago multiradiata	•	
Stellaria longipes	•	•
Valeriana capitata		•
Total Forbs	14	14
Grasses		
Agropyron spp.	•	
Arctagrostis latifolia	•	•
Festuca altaica	•	•
Festuca rubra	•	
Heirochloe alpina		•
Poa arctica	•	•
Poa glauca	•	
Trisetum spicatum	•	•
Total Grasses	7	5
Sedges		
Carex aquatilis		•
Carex atrofusca		•
Carex lugens	•	•
Luzula spp.		•
Total Sedges	1	4
Total Vascular Species	***25***	***30***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #12

Date Examined:	28 July 1999
Location:	N68°05' 06.5"; W149°18' 44.5"; TAPS M.P. 165.5.
Pipeline:	Buried
Slope:	Steep
Drainage:	Inside - well-drained rocky rubble; Outside - well-drained rocky rubble
Vegetation:	Dry shrub/tundra complex

Site No. 12 is located in the Atigun River drainage at the northeast base of Atigun Pass. Access to the site is available by taking a turnout from the Dalton Highway. The natural vegetation at this location is alpine tundra. The combination of extreme climate and lack of soil offers a harsh habitat for vegetation. The ROW ascends a steep slope, and the surface over the buried pipeline was rocky rubble. Outside the ROW, mat willow patches formed a mosaic with lichens and *Dryas* among the rocks. The natural landscape is sloping and relatively dry, but patches of moss on the surface holds water, locally increasing the habitat wetness and permitting survival of higher plants. Limited soil development and geomorphic processes have kept this vegetation from advancing. For management purposes, the natural vegetation within the ROW will remain as it is indefinitely.

Rock content outside the ROW was about 50%. This is not an accurate reflection of the whole soil/rubble complex, because only small stones were included in the sample. There was no soil inside the ROW to sample. Moisture content of the alpine tundra soil was 40%. Soil reaction was acidic (pH 5.22) in the undisturbed habitat. This soil represented an accumulation of loess and organic matter on the surface of the rubble. Total C was 3.6%. The calculated organic matter percentage was 8%. Total soil N of the adjacent soil was 0.25%. The C:N ratio for the undisturbed soil was 14.5, quite adequate to supply vegetation with N from decomposing organic matter. Available N was 4 ppm, available P was 3 ppm, and available K was 32 ppm. These values are all within range of natural soils of the region. Without soil to sample there was no way to determine fertilizer persistence from revegetation of the ROW.

This location was affected by an oil spill on 10 June 1979 (BLM, 1984). The spill occurred upslope, and oil flowed past this site and into the Atigun River. There was no evidence of the spill when we examined this location, although the site was reportedly disturbed by spill cleanup and containment actions in 1979. There was recent evidence of crawler tractor activity in the ROW, possibly from recent pipeline maintenance which had eliminated all plants from the affected area. There were tracks where someone had attempted to take a 4-wheel drive vehicle up the slope over the buried pipe. This was most likely a tourist or hunter, not employees of the pipeline company.

The ROW supported a scattered collection of vascular plants that greatly exceeded the number of species in the undisturbed community. The density of plants in the ROW was extremely sparse. A denser stand of grass appeared in the ROW upslope, but that vegetation was short and contributed relatively little to the biological aspect of the area.

Forty-one species were identified at this location. Six species were common to both habitats. There were 30 vascular species within the ROW. Most of these were found along the margins,

Photo 12-1. Westward view of buried pipeline, north base of Atigun Pass. Barren gravel predominates. The site was disturbed by maintenance after an oil spill. With more fines, the substrate could support vegetation.

Site No. 12 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	n/a	50.3
Moisture %	n/a	40.7
Total C %	n/a	3.63
Total N %	n/a	0.25
C:N ratio	n/a	14.5
Organic matter %	n/a	8.1
pH	n/a	5.22
NH_4-N (ppm)	n/a	2
NO_3-N (ppm)	n/a	2
P (ppm)	n/a	3
K (ppm)	n/a	32
Organic mat thickness (cm)	0	7

which unlike the central section had not been recently disturbed. Seventeen species were found in the adjacent natural community.

Eight shrub species were found at the site. Six species occurred within the ROW, and four in the adjacent tundra. All but one of the shrubs were willow. Two species, *Salix arctica* and *Salix reticulata*, were common to both habitats.

Twenty-four forbs were identified at this location, seventeen in portions of the ROW, and nine in the adjacent undisturbed habitat. *Epilobium latifolium* and *Stellaria longipes* were common to both habitats. These species are noted as pioneers on open ground.

Six species of grasses were found at this site. All six occurred within the ROW and only one in the adjacent tundra. Half of the grass species within the ROW (*Alopecurus pratensis*, *Arctagrostis latifolia*, and *Festuca rubra*) resulted from seed applied to vegetate over the buried pipe. This was the northernmost location in which *Alopecurus pratensis* was recorded. Predominance of tufted (caespitose) indigenous grasses was an indication of the habitat's dryness. Only one grass species (*Poa arctica*) was found in the undisturbed habitat.

Two sedge and one rush species were found at this location. All three occurred in the natural tundra, while only *Carex lugens* was found in the ROW.

Large mammals common to this location include wolves, dall sheep and mountain goats. Sheep and goats frequently grazed the newly seeded ROW grasses in years past. However, as the seeded grasses matured and lost their lushness (largely due to an abundance of soil fertilizer nutrients), grazing pressures diminished.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 12.

Species Names	*Inside*	*Outside*
Shrubs		
Dryas octopetala		•
Salix alaxensis	•	
Salix arctica	•	•
Salix glauca	•	
Salix lanata var richardsonii	•	
Salix planifolia ssp. pulchra		•
Salix reticulata	•	•
Salix rotundifolia	•	
Total Shrubs	6	4
Forbs		
Antennaria pulcherrima	•	
Arnica lessingii	•	
Artemisia telesii	•	
Astragalus alpinus	•	
Astragalus umbellatus		•
Cardamine bellidifolia	•	
Cerastium beeringinanum	•	
Draba spp	•	
Epilobium angustifolium	•	
Epilobium latifolium	•	•
Erigeron pulcherrima	•	
Geum rossii	•	
Luetkea pectinata		•
Pedicularis sudetica		•
Petasites frigidus	•	
Polygonum bistora subsp. plumosum		•
Polygonum viviparum	•	
Potentilla gracilis		•
Pyrola grandiflora		•
Rumex acetosa	•	
Saxifraga cernua	•	
Saxifraga oppositifolia	•	
Saxifraga punctata		•
Stellaria longipes	•	•
Total Forbs	17	9
Grasses		
Alopecurus pratensis	•	
Arctagrostis latifolia	•	
Festuca baffinensis	•	
Festuca rubra	•	
Poa arctica	•	•
Trisetum spicatum	•	
Total Grasses	6	1
Sedges		
Carex bigelowii		•
Carex lugens	•	•
Luzula spp.		•
Total Sedges	1	3
Total Vascular Species	***30***	***17***

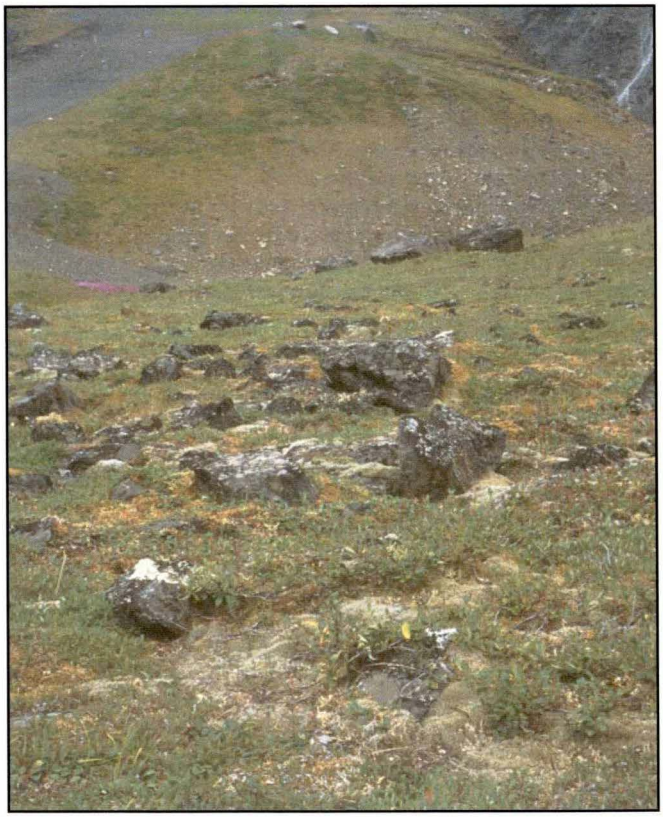


Photo 12-2. Undisturbed alpine vegetation consisting of mat willows, Dryas, Arctostaphylos, *moss and lichen. Fertilizer effects on undisturbed alpine vegetation are visible in the background, to the right of the ROW.*

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #13

Date Examined:	28 July 1999
Location:	N68°07' 49.2"; W149°28' 49.2"; TAPS M.P. 166.
Pipeline:	Buried
Slope:	Steep
Drainage:	Inside - well-drained rocky rubble; Outside - well-drained rocky rubble
Vegetation:	Dry shrub/tundra complex

Site No. 13 is located atop Atigun Pass. The combination of extreme climate and lack of soil at this location provides a harsh habitat for vegetation. The ROW was cut through rocky rubble, and the pipeline was buried. Mat willow patches formed a mosaic with lichens and *Dryas* among the rocky rubble in the adjacent undisturbed habitat. There was less *Dryas* here than at the lower elevation of Site 12. The natural landscape is sloping and relatively dry, but the moss accumulation on the surface holds water, locally increasing the habitat wetness and permitting establishment of higher plants. Limited soil development and geomorphic processes have kept this vegetation from advancing beyond the subclimax state. From a practical viewpoint, the ROW and natural vegetation will remain as they are indefinitely.

No soil samples were collected at this location. Outside the ROW there are pockets of organic soil and collections of loess among the stones. There was no soil inside the ROW to sample. The surface over the buried pipeline was mostly rocky rubble, but considerably smoother than the adjacent natural landscape southwest of the pipeline, which was uneven and punctuated with angular boulders. Northwest of the pipeline, a slope of finer rocks was similar to the surface over the buried pipe.

Inclement weather (strong breeze and icing) during our stop at this location restricted a detailed observation of the flora. A more careful examination is in order. The ROW supported a scattered collection of vascular plants that slightly exceeded the number of species in the undisturbed community. The density of plants in the ROW was extremely sparse. It is noteworthy that moss had colonized in portions of the ROW. This was probably encouraged by fertilizer added during revegetation.

Twenty-six vascular plant species were recorded at this location. There were 18 vascular species within the ROW. Most of these were found along the margins and in pockets where fines had collected. Fifteen vascular species were found in the adjacent natural community. Five species were common to both habitats at this location.

Seven shrubs were found at this site. Two species (*Salix arctica* and *Salix rotundata*) were common to both habitats. Contrary to the usual trend, there were more shrub species in the disturbed habitat than in the adjacent alpine tundra (six vs three). Willow species and *Dryas* were the only shrubs identified at this site.

Eleven forb species were found at this location. Eight forbs were recorded within the ROW, and seven were found in the undisturbed. Four species (*Draba* spp., *Saxifraga davurica, Saxifraga hirculus,* and *Stellaria edwardsii*) were common to both habitats. Three species were unique to the ROW (*Antennaria pulcherrima, Epilobium latifolium, Saxifraga cernua,* and *Taraxacum lacerum*). *Cardamine bellidifolia, Luetkea pectinata,* and *Saxifraga bronchialis* were unique to the undisturbed habitat.

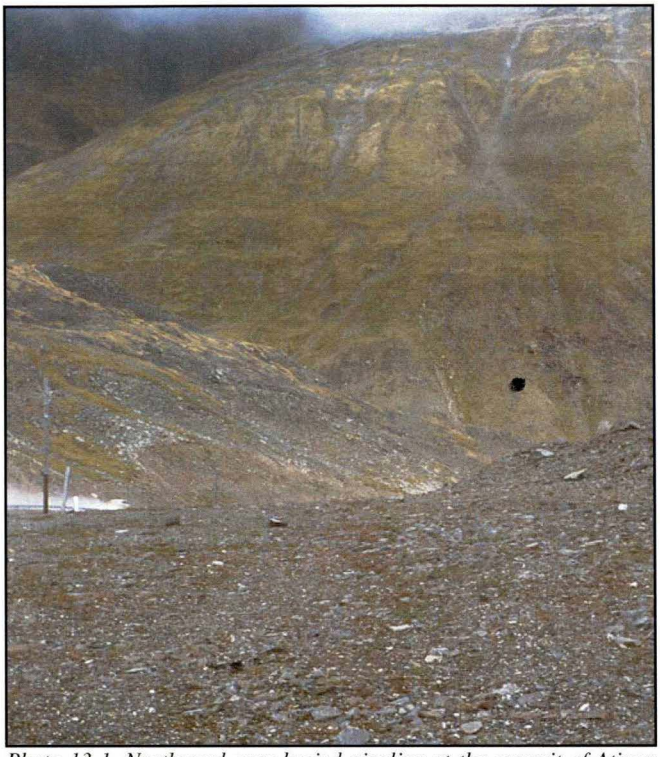


Photo 13-1. Northward over buried pipeline at the summit of Atigun Pass. Barren rock rubble predominates this site.

Photo 13-2. Alpine mat vegetation in the undisturbed habitat adjacent to the ROW. Moss and soil mineral fines provide a rooting substrate that supports higher plant life forms.

At Site No. 13 no soil data were collected.

Five grass species were identified at this site. Three species were recorded in the ROW and in the adjacent community. *Trisetum spicatum*, an indigenous species, was the only grass common to both habitats. *Festuca rubra* and *Poa pratensis*, two seeded grasses, were found only within the ROW. The indigenous *Poa arctica* and *Poa paucispicula* were unique to the undisturbed habitat.

Three species of sedge/rush were identified at this location. *Juncus* spp. was the only species of this group found within the ROW. *Carex lugens* and *Carex* spp. were found only in the adjacent vegetation.

Vegetation within the ROW was confined to small niches of soil fines. The general aspect was broken rocks. The shrub and forb species at this site were representative of those that colonize rocky habitats. These included members of the family *Saxifragaceae* and willows common to gravel along streams. Attempts to increase the plant cover within the ROW would necessitate adding soil to the surface. That would be very expensive and would require robbing some other location of soil.

This habitat is used by Dall sheep and mountain goat.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 13.

Species Names	*Inside*	*Outside*
Shrubs		
Dryas octopetala	•	
Salix alaxensis	•	
Salix arctica	•	•
Salix glauca	•	
Salix ovalifolia	•	
Salix reticulata		•
Salix rotundifolia	•	•
Total Shrubs	6	3
Forbs		
Antennaria pulcherrima	•	
Cardamine bellidifolia		•
Draba spp	•	•
Epilobium latifolium	•	
Luetkea pectinata		•
Saxifraga bronchialis		•
Saxifraga cernua	•	
Saxifraga davurica	•	•
Saxifraga hirculus	•	•
Stellaria edwardsii	•	•
Taraxacum lacerum	•	
Total Forbs	8	7
Grasses		
Festuca rubra	•	
Poa arctica		•
Poa paucispicula		•
Poa pratensis	•	
Trisetum spicatum	•	•
Total Grasses	3	3
Sedges		
Carex lugens		•
Carex spp.?		•
Juncus spp.	•	
Total Sedges	1	2
Total Vascular Species	***18***	***15***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #14

Date Examined:	28 July 1999
Location:	N68°06' 56"; W149°31' 45.8"; TAPS M.P. 168.5.
Pipeline:	Buried
Slope:	Steep
Drainage:	Inside - well-drained rocky rubble; Outside - fair to impeded
Vegetation:	Moist sedge/shrub complex

Site No. 14 is located at the lower end of the southwest side of Atigun Pass, in the drainage of the west fork of the north fork of the Chandalar River. Access to this site is via the Dalton Highway turnoff at the base of the pass. The pipeline is buried in rocky rubble, which was recently disturbed for pipeline maintenance. During the growing season, weather is usually milder at this site than at the summit and on the northern side of the pass (Sites 13 and 12, respectively). Here the natural alpine tundra vegetation is a mixture of tussock cottongrass and willow. The amount and composition of vegetation between the ROW and undisturbed habitats are vastly different. Vascular plant cover in the ROW is almost nil, while that in the undisturbed was 100%, at least on the lower slopes. Besides absence of soil, the meager vegetation within the ROW can be attributed to recent pipeline maintenance and repair activities, which included excavation and backfilling the trench.

The ROW was cut through vegetated rocky rubble. Following construction, the surface remaining was rocky rubble devoid of fines. Little vegetation developed from either seeding or natural processes, because soil fines are absent. Soil could not be sampled within the ROW at this location. Outside the ROW there is an organic mat and soil over the rubble.

Soil of the undisturbed habitat consisted of about 39% gravel. Moisture in the natural soil was 28%. Total C accumulation was 1.68%, translating to an organic matter percentage of 3.7%. Total soil N was 0.08%, producing a C:N ratio of 21, adequate to provide N to vascular plants. Soil reaction was slightly acidic (pH 6.87). Available soil N was 2 ppm. Available soil P was 4 ppm. Available soil K was 16 ppm. All these values are relatively low, but within

Site No. 14 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	n/a	38.7
Moisture %	n/a	28.3
Total C %	n/a	1.68
Total N %	n/a	0.08
C:N ratio	n/a	21
Organic matter %	n/a	3.7
pH	n/a	6.87
NH_4-N (ppm)	n/a	1
NO_3-N (ppm)	n/a	1
P (ppm)	n/a	4
K (ppm)	n/a	16
Organic mat thickness (cm)	0	14.5

Photo 14-1. Barren gravel covers the buried pipeline on the south side of Atigun Pass. Recent maintenance activities on the pipeline at this location removed any plants that established following construction at this site.

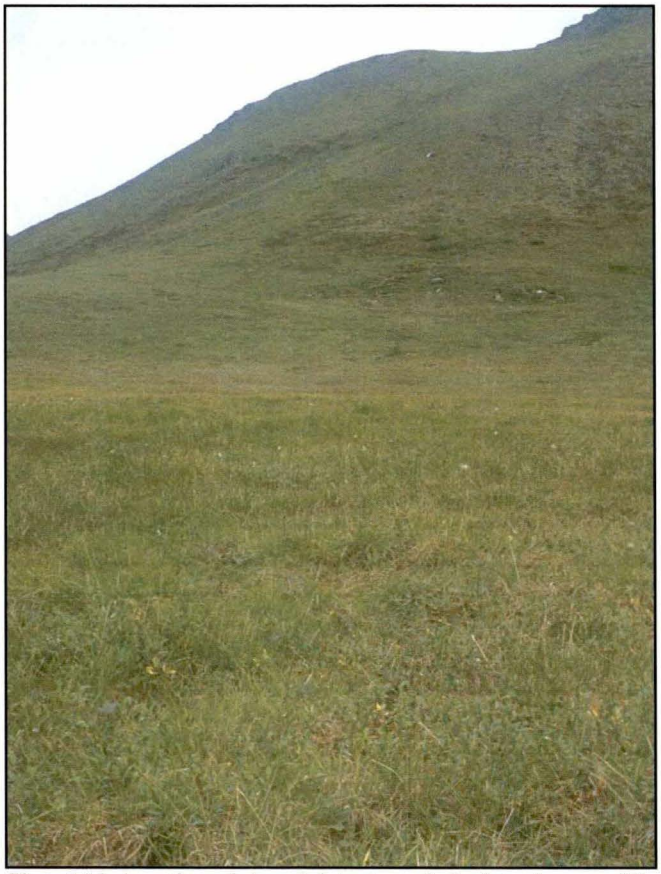


Photo 14-2. A northward view of alpine tussock shrub tundra east of the ROW. Added warmth on this south facing slope produces notably more plant cover in contrast to that on the north side of the pass.

the range found in most soils of the ROW. The organic mat was 16 cm thick at this location and consisted of plant litter, moss and lichens.

Thirty-six vascular plant species were recorded at this location. Twenty-three species were found within the ROW, and 14 in the undisturbed habitat. Only one species (*Carex lugens*) was common to both habitats. Seven shrub species were identified at this location. Two were found within the ROW and five in the adjacent tundra community. None of the shrub species found were common to both habitats. *Salix alaxensis* and *Salix glauca* were found only within the ROW.

Twenty-one forbs were identified at this location. None were common to both habitats. Fifteen species were found within the ROW, and six in the adjacent community. All forbs within the ROW were common colonizers of open habitats and gravel. Those in the tundra were common species of moist tundra. This was our southernmost record for *Oxytropis borealis*.

Five grass species were found at this location, all occurring exclusively within the ROW. Among the grasses, two species (*Festuca rubra* and *Poa pratensis*) were introduced during revegetation. *Arctagrostis latifolia* and *Poa glauca* may also have been seeded (this is uncertain). *Trisetum spicatum* was a natural colonizer.

Three sedges were found at this location. One occurred within the ROW and three in the adjacent tundra. *Carex lugens* was the species common to both habitats.

Plants within the ROW were confined to niches where soil fines were present. Further development of vegetation within the ROW at this location will be limited by the overall absence of soil.

Wildlife using this habitat included wolf, Dall sheep, mountain goat, lemming, and ground squirrel.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 14.

Species Names	*Inside*	*Outside*
Shrubs		
Cassiope tetragona		•
Dryas octopetala		•
Salix alaxensis	•	
Salix glauca	•	
Salix planifolia ssp. pulchra		•
Salix reticulata		•
Salix rotundifolia		•
Total Shrubs	2	5
Forbs		
Arnica lessingii	•	
Aster sibiricus	•	
Astragalus alpinus	•	
Cerastium beeringinanum	•	
Draba spp	•	
Epilobium latifolium	•	
Equisetum arvense	•	
Minuartia macrocarpa	•	
Oxytropis borealis	•	
Papaver macounii	•	
Pedicularis sudetica		•
Petasites frigidus		•
Poa arctica		•
Polygonum bistora subsp. plumosum		•
Polygonum viviparum		•
Sagina intermedia	•	
Saxifraga cernua	•	
Saxifraga davurica	•	
Saxifraga hirculus		•
Senecio resedifolius	•	
Stellaria edwardsii	•	
Total Forbs	15	6
Grasses		
Arctagrostis latifolia	•	
Festuca rubra	•	
Poa glauca	•	
Poa pratensis	•	
Trisetum spicatum	•	
Total Grasses	5	0
Sedges		
Carex aquatilis		•
Carex lugens	•	•
Eriophorum angustifolium		•
Total Sedges	1	3
Total Vascular Species	***23***	***14***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #15

Date Examined:	30 July 1999
Location:	N68°02' 55.1"; W149°36' 29.3"; TAPS M.P. 173.7.
Pipeline:	Buried
Slope:	Level to gentle
Drainage:	Inside - well-drained gravel fill; Outside - fair over permafrost
Vegetation:	Moist to dry shrub/tundra complex

Site No. 15 is located atop the Chandalar Shelf, in glaciated terrain near the divide between the Chandalar and Dietrich drainages. The pipeline is on the east side of the Dalton Highway. The buried pipeline is on the east side of the ROW and the roadway on the west. Access to the site is from the Dalton Highway via a spur road. Slope is toward the east and southeast. The natural vegetation in the vicinity is tundra, with both treeline and timberline at the base of the Chandalar Shelf just below this site. Absence of trees outside the ROW at this location is controlled by altitude as well as latitude. At lower elevations toward the east, the vegetation is a mixture of moist sedge and low shrub tundra. Low willow patches formed a mosaic with openings of heath shrubs and forbs. The disturbance created an environment suited to tall willows, which lined the margins of the ROW and were absent in the adjacent undisturbed habitat. The natural landscape becomes seasonally dry, but the moss and lichen mat on the surface holds water, increasing the habitat wetness above that which would otherwise prevail. The ROW is well vegetated at this location. The roadway portion of the workpad supported considerable vegetation, as opposed to many areas along the pipeline where the roadway is often barren. The ROW margins were lined with tall shrubs, and the central portion was dominated by seeded grasses. The pattern is typical of that observed in the northern foothills of the Brooks Range. The substrate consists of gravel fill and subsoil from the pipeline trench.

The ROW over the pipeline was about 62% gravel, and the soil outside the ROW about 29% gravel. Soil moisture was about 18% within the ROW and 20% outside. Soil reaction was alkaline (pH 7.05) in the ROW and acidic (pH 5.42) outside. Total C in the ROW soil was 1.82 % and 1.32% in the adjacent habitat. The ROW soil probably had carbonate C, which inflated the total C percentage. Calculated organic matter was 4% for the ROW and about 3% for the undisturbed soil. Total soil N within the ROW was 0.05% and outside 0.09%. The C:N ratios were 20.2 and 14.7, respectively. Available soil N was 2 ppm within the ROW and 1 ppm in the undisturbed soil. Available P was 6 ppm within the ROW, and 4 ppm in the undisturbed soil. Available K in the ROW was 51 ppm, over three times that of the undisturbed soil (14 ppm). Both K values are within background levels of soils for the region. Cumulative evidence of availabilities for the three macro elements indicates a possible carryover of fertilizers applied during revegetation. The organic mat within the ROW (5 cm) consisted primarily of vascular plant litter in combination with moss and lichen. The organic mat in the adjacent tundra was 7.5 cm and consisted primarily of partially decomposed moss and lichen.

Forty vascular plant species were found at this location. Twenty-seven occurred within the ROW and 20 in the adjacent

Photo 15-1. Southward view over buried pipeline on Chandalar Shelf. Seeded Festuca rubra *and a few natural forbs dominate the ROW center. Tall willow and cottonwood are colonizing margins of the gravel fill.*

Photo 15-2. Northward view. Seeded F. rubra, *indigenous species and introduced dandelion (*Taraxacum officinale*) are in the foreground. The background mountains are part of the Continental Divide.*

Site No. 15 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	61.9	29
Moisture %	17.6	20.1
Total C %	1.82	1.32
Total N %	0.05	0.09
C:N ratio	20.2	14.7
Organic matter %	4	2.9
pH	7.05	5.42
NH_4-N (ppm)	Not detectable	1
NO_3-N (ppm)	2	Not detectable
P (ppm)	6	4
K (ppm)	51	14
Organic mat thickness (cm)	0 - 5	7.5

tundra. Seven species were common to both habitats. One tree species (*Populus balsamifera*) was found at this location. This is the northernmost location that trees occurred along the TAPS corridor. The range of *P. balsamifera* was actually extended northward and upslope in this vicinity as a result of the opening of habitat during pipeline construction. No trees were found in the adjacent tundra community.

Thirteen shrub species were identified at this location. Ten species occurred within the ROW and nine in the tundra. Five shrub species were common to both habitats. *Ledum decumbens, Salix alaxensis, Salix brachyophylla* ssp. *nyphoclada*, and *Salix glauca* were found only within the ROW. *Cassiope tetragona, Dryas octopetala, Empetrum nigrum,* and *Vaccinium vitis-idaea* were confined to the natural tundra.

Eighteen forb species were identified at this location. Ten forb species occurred within the ROW and eight in the adjacent community. One forb (*Petasites frigidus*) was common to both habitats. The disparity of species between the two habitats is largely due to differences in soil and to competition from seeded grasses. *Taraxacum officinalis* was the only weed found at this location. This was the northernmost location in the survey in which we found an introduced weed species.

Six grass species were found at this location. No grass species was common to both habitats. Five species of grass occurred in the ROW. Four of these were seeded (*Alopecurus pratensis, Arctagrostis latifolia, Festuca rubra*, and *Poa pratensis*), and one (*Puccinellia borealis*) was a natural colonizer. The indigenous fescue (*Festuca altaica*) was confined to the undisturbed

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 15.

Species Names	Inside	Outside
Trees		
Populus balsamifera	•	
Total Trees	1	0
Shrubs		
Betula nana	•	•
Cassiope tetragona		•
Dryas octopetala		•
Empetrum nigrum		•
Ledum decumbens	•	
Salix alaxensis	•	
Salix arctica	•	•
Salix brachyophylla ssp nyphoclada	•	
Salix glauca	•	
Salix planifolia ssp. pulchra	•	•
Salix reticulata	•	•
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea		•
Total Shrubs	10	9
Forbs		
Achillea sibirica	•	
Anemone parviflora		•
Arnica lessingii		•
Artemisia borealis		•
Astragalus alpinus	•	
Epilobium angustifolium	•	
Equisetum arvense	•	
Erigeron acris	•	
Minuartia macrocarpa		•
Parnassia palustris	•	
Pedicularis sudetica		•
Petasites frigidus	•	•
Polygonum bistora subsp. plumosum		•
Polygonum viviparum		•
Solidago multiradiata	•	
Stellaria longipes	•	
Taraxacum alaskanum	•	
Taraxacum officinale	•	
Total Forbs	10	8
Grasses		
Alopecurus pratensis	•	
Arctagrostis latifolia	•	
Festuca altaica		•
Festuca rubra	•	
Poa pratensis	•	
Puccinellia borealis	•	
Total Grasses	5	1
Sedges		
Carex bigelowii		•
Carex lugens	•	•
Total Sedges	1	2
Total Vascular Species	**27**	**20**

Photo 15-3. Cottonwood (Populus balsamifera) *sapling on the Chandalar Shelf. This tree's natural geographical range was extended northward after construction of the pipeline opened new habitat.*

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #15
Date Examined:	30 July 1999
Location:	N68°02' 55.1"; W149°36' 29.3"; TAPS M.P. 173.7.
Pipeline:	Buried
Slope:	Level to gentle
Drainage:	Inside - well-drained gravel fill; Outside - fair over permafrost
Vegetation:	Moist to dry shrub/tundra complex

Continued

vegetation. *Festuca rubra* was most prominent in the roadway, whereas the taller grass species were largely confined to the margins.

Two sedge species were identified at this location, one in the ROW and two in the adjacent tundra. *Carex lugens* was common to both habitats. *Carex bigelowii* was confined to the tundra. The site's relative dryness probably limited the number of sedges.

Caribou and perhaps moose were the main large mammals using this habitat. Ground squirrel and lemming may have also occurred here. We observed no animals during the site visit.

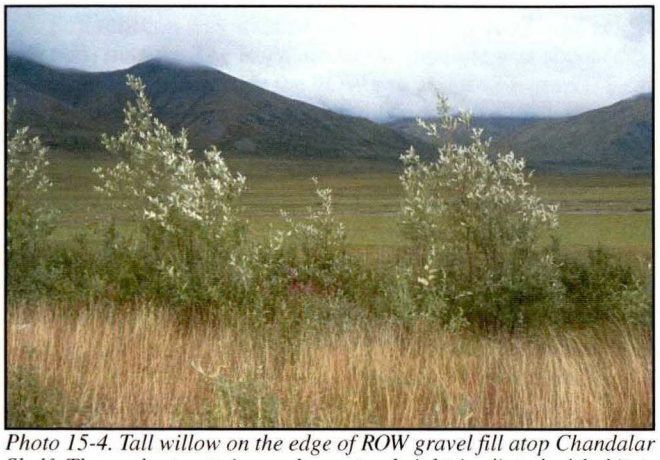


Photo 15-4. Tall willow on the edge of ROW gravel fill atop Chandalar Shelf. These plants attain much greater height in disturbed habitats than those in the adjacent undisturbed alpine community.

Photo 15-5. Willow, dwarf birch and dry lichen community adjacent to the ROW on Chandalar Shelf.

This page deliberately left blank

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #16

Date Examined:	28 July 1999
Location:	N68°01' 47.2"; W149°40' 44.4"; TAPS M.P. 176.5.
Pipeline:	Elevated
Slope:	Moderate west and south
Drainage:	Inside - drained fill; Outside - fair over permafrost
Vegetation:	Moist tall shrub savannah/tundra complex at the edge of the boreal forest

Site No. 16 is located below the Chandalar Shelf in the Dietrich River valley near treeline, the northernmost extension of forest. Treeline and timberline (elevational limits of forest) coincide here. This location is in glaciated terrain incised by fluvial erosion. Woody stumps within the ROW indicate this section of the corridor had been brushed in the past, but it had not been cut recently. Data were taken at one location, but we have photo records dating back to 1976 from farther south at the North Slope Borough boundary. Those images appear in the main portion of this document and illustrate colonization by alder on the winter haul road used to move equipment to Prudhoe Bay before the Dalton Highway was constructed. This location from the Chandalar shelf appears in Photo 16-3.

Soil reaction was alkaline (pH 8.03) in the ROW and acidic (pH 6.15) outside. The ROW under the pipeline was about 66% gravel, and the soil outside the ROW was about 43% gravel. Total C was somewhat similar in both substrates, 3.47% within the ROW and 2.35% outside. Very likely a portion of the C in the ROW soil was carbonates. Calculated organic matter for the ROW was 7.7% and for the outside soil 5.2%. Some of this difference may be attributed to carbonates in the ROW soil inflating the organic C value. There was a wider C:N ratio in the ROW soil (57.8) than in the undisturbed mineral soil (13.1). The high C:N ratio for ROW soil suggests N could be limiting plant growth, but it may be an inflated ratio due to carbonate C. Available N inside the ROW was only 1 ppm, and none was measured in the undisturbed soil. The ROW available N was in the nitrate form. N in the undisturbed soil was probably being used as quickly as it became available. There were 8 ppm available P in the gravel fill of ROW and 3 ppm in the undisturbed soil. Available K in the ROW was 15 ppm, similar to the undisturbed soils at 16 ppm. Both K values are within background levels of soils for the region. Evidence of availabilities for the three macro elements indicates no significant carryover of fertilizers applied during revegetation, except possibly for P. However, because of pH differences between ROW and undisturbed substrates, different P extraction methods were used in the laboratory. Thus, it is difficult to compare available P data between these two habitats. Usually alkaline soils in the Alaska Arctic that have not been affected by either fertilizer or other additions of P, produce available P values of 5 ppm or less. The organic mat in the ROW consisted primarily of vascular plant litter in combination with moss and lichen. The ROW was well vegetated, except for wheel tracks of the roadway.

This was the northernmost location that trees occurred along the TAPS corridor at the time of construction. However, due to the disturbance, the range of cottonwood (*Populus balsamifera*) was actually extended northward and upward from this location, as observed at Site No. 15. This location is still the northern limit of spruce trees along the TAPS corridor, as well as the northern

Photo 16-1. Tall shrubs and tree saplings dominate the edges of the ROW at the base of Chandalar Shelf. Seeded grasses line the margins of the roadway.

Photo 16-2. Undisturbed vegetation east of the pipeline. This near-treeline community consists of alpine shrub vegetation with patches of horsetail (Equisetum arvense) *appearing in pockets of wet soils.*

Site No. 16 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	6.4	24.1
Moisture %	14.9	7.9
Total C %	3.47	2.35
Total N %	0.06	0.18
C:N ratio	57.8	13.1
Organic matter %	7.7	5.2
pH	8.03	6.15
NH_4-N (ppm)	Not detectable	Not detectable
NO_3-N (ppm)	1	Not detectable
P (ppm)	8	3
K (ppm)	15	16
Organic mat thickness (cm)	2	11.4

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 16.		
Species Names	*Inside*	*Outside*
Trees		
Picea glauca		•
Populus balsamifera	•	
Total Trees	1	1
Shrubs		
Alnus crispa	•	•
Arctostaphylos alpina	•	•
Betula nana		•
Cassiope tetragona		•
Dryas octopetala	•	•
Empterum nigrum	•	•
Potentilla fruiticosa	•	
Rhododendron lapponicum		•
Salix alaxensis	•	
Salix arbusculoides	•	
Salix brachyophylla ssp nyphoclada	•	
Salix glauca	•	
Salix lanata var richardsonii		•
Salix planifolia ssp. pulchra	•	
Shepherdia canadensis	•	
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea		•
Total Shrubs	12	10
Forbs		
Anemone parviflora	•	
Artemisia borealis		•
Astragalus alpinus	•	
Astragalus umbellatus		•
Boykinia richardsonii		•
Epilobium angustifolium	•	
Equisetum arvense	•	•
Geum rossii		•
Hedysarum mackenzii		•
Parnassia palustris	•	•
Pedicularis sudetica		•
Polygonum bistora subsp. plumosum		•
Polygonum viviparum		•
Saussurea angustifolia		•
Total Forbs	5	11
Grasses		
Arctagrostis latifolia		•
Festuca altaica		•
Festuca rubra	•	
Total Grasses	1	2
Sedges		
Carex aquatilis		•
Carex lugens	•	•
Total Sedges	1	2
Total Vascular Species	***20***	***26***

limit of the little tree willow (*Salix arbusculoides*), which was found only within the ROW at this location.

The ROW transects low and tall shrub tundra vegetation. Up slope from this location, the vegetation becomes more open. Down slope, the vegetation is affected by stream erosion and consists of tall shrubs. Low willow patches formed a mosaic with openings of heath shrubs and forbs. The natural landscape becomes dry seasonally, but the moss and lichen mat on the surface holds water, increasing the habitat wetness above that which would otherwise prevail. Only two species of heath shrubs (*Empetrum nigrum* and *Vaccinium uliginosum*) occurred within the ROW. It was noteworthy for these species to have invaded the alkaline ROW soil, which is measurably drier that the adjacent habitat. The construction disturbance created an environment suited to tall willows and cottonwood trees, which lined the margins of the ROW and developed beneath and around the pipeline. This woody growth presents a maintenance problem for the pipeline operation. Shrubs and trees were excluded from the vehicle tracks, but found everywhere else within the ROW.

There were 20 vascular plant species within the ROW and 26 in the natural community. Differences between the substrate environments was a significant factor affecting differences in species composition between the habitats. Only five shrubs, two forbs, and one sedge (no trees or grasses) were common to both habitats. One species of grass (*Festuca rubra*) occurred in the ROW; this species was introduced by revegetation. The roadway portion of the workpad supported considerable vegetation, as opposed to many areas along the pipeline where the roadway is often barren. *Festuca rubra* was most prominent in the roadway, and woody species were most prominent beneath the pipeline and on margins of the fill.

Wildlife in this vicinity included moose, squirrel, fox, wolf, and bear. None were observed during our inspection.

Photo 16-3. This site appears near the center of this photo taken from atop the Chandalar Shelf.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #17

Date Examined:	23 July 1999
Location:	N67°52' 58.4"; W149°49' 19.2"; TAPS M.P. 188.
Pipeline:	Buried
Slope:	Moderate south
Drainage:	Inside - drained; Outside - perched over permafrost
Vegetation:	Boreal forest

Site No. 17 is located in the Dietrich River valley on a broad ridge extending from the east. This location is in glaciated terrain incised by fluvial erosion.

Soil reaction was alkaline both in the ROW and outside (pH 8.17 and 7.91). The soil over the pipeline was about 52% gravel, and the soil outside the ROW was about 75% gravel. The outside sample was obtained in the forest across the Dalton Highway from the pipeline. Total C was similar in both substrates, 4.61 in the ROW and 4.62 outside. A portion of the C in both soils was probably carbonates. Organic matter was 10.2% and 10.3%, respectively. C:N within the ROW was 65.9 and outside 51.3. Both of these ratios were higher than desirable to supply N to vascular plants and soil microorganisms. The C:N ratios may have been inflated by carbonate C. Available N inside the ROW was only 2 ppm, and 1 ppm was measured in the undisturbed soil. The ROW available N was in the nitrate and ammonium forms. N in the undisturbed soil was found only in the nitrate form. There was 1 ppm available P, both in the ROW and in the undisturbed soil. Available K in the ROW was 23 ppm, nearly twice that of the undisturbed soil, which contained 12 ppm available K. Both K values are within background levels of soils for the region. Availabilities for the three macro elements indicates no carry forward of fertilizers applied during revegetation, except possibly for K.

The organic mat in the ROW consisted primarily of vascular plant litter in combination with moss. The organic mat in the adjacent forest consisted of moss, lichens, and plant litter. The ROW was well vegetated, with grasses and fireweed currently dominating. The invading trees and shrubs had been cut within the previous two growing seasons. These were sprouting from stumps and expected to eventually overtop the grass canopy. Fireweed was especially abundant over the buried pipeline, producing a lavender strip of flowers that was quite noticeable from the Dalton Highway, on the day we sampled this site.

The ROW crosses a broad forested ridge at this location. To the east, there is a spruce forest with an open understory of willow. The forest floor is carpeted with *Dryas* and there are indigenous legumes present. These species suggest the forest may be in the latter stages of recovering from a wildfire. The moss and lichen mat on the forest floor holds water, increasing the habitat wetness above that which would otherwise prevail. All heath shrub species found at this location were present within the ROW as well as the adjacent forest.

A total of 38 vascular species were recorded at this location, 32 within the ROW and 20 in the natural community. No grasses or sedges were common to both habitats. Two trees, ten shrubs, and two forbs were common to both habitats. Three species of grass occurred in the ROW. Two were seeded, *Alopecurus pratensis* and *Festuca rubra*. *Calamagrostis canadensis* was the

*Photo 17-1. Northward view over buried pipe in Dietrich Valley. Fireweed (*Epilobium angustifolium*) and tall grasses dominate the central portion, most prominently over the buried pipeline. Willow are regrowing tall shrub canopies after being cut back as part of ROW maintenance.*

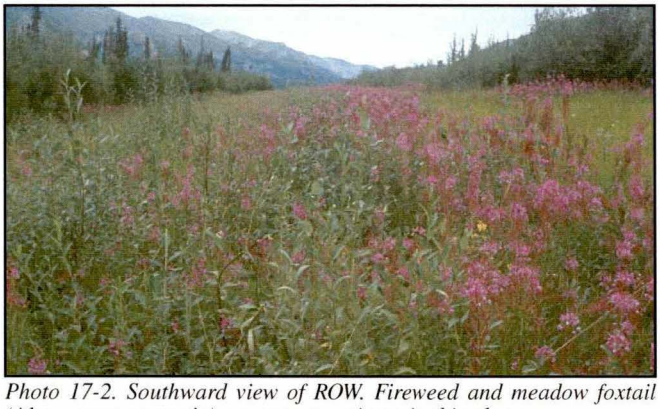


*Photo 17-2. Southward view of ROW. Fireweed and meadow foxtail (*Alopecurus pratensis*) are most prominent in this photo.*

Site No. 17 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	52.3	75.0
Moisture %	14.9	7.9
Total C %	4.61	4.62
Total N %	0.07	0.09
C:N ratio	65.9	51.3
Organic matter %	10.2	10.3
pH	8.17	7.91
NH_3-N (ppm)	1	Not detectable
NO_3-N (ppm)	1	1
P (ppm)	1	1
K (ppm)	23	12
Organic mat thickness (cm)	3.5	11.5

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 17.		
Species Names	*Inside*	*Outside*
Trees		
Picea glauca	•	•
Picea mariana	•	•
Populus balsamifera	•	
Total Trees	3	2
Shrubs		
Alnus crispa	•	•
Arctostaphylos alpina	•	•
Dryas drummondii	•	•
Empterum nigrum	•	•
Potentilla fruiticosa	•	
Salix alaxensis	•	•
Salix arbusculoides	•	•
Salix arctica	•	
Salix glauca	•	
Salix hastata?	•	
Salix lanata var richardsonii	•	•
Salix reticulata	•	
Shepherdia canadensis	•	•
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea	•	•
Total Shrubs	15	10
Forbs		
Anemone parviflora	•	
Antennaria pulcherrima	•	
Aster sibiricus	•	
Astragalus alpinus	•	
Boschniakia rossica		•
Epilobium angustifolium	•	•
Gentiana glauca	•	
Hedysarum alpinum		•
Hedysarum mackenzii	•	
Oxytropis campestris		•
Parnassia palustris	•	
Pedicularis labradorica		•
Pedicularis sudetica		•
Pyrola minor	•	
Pyrola minor		•
Taraxacum officinale	•	
Total Forbs	10	7
Grasses		
Alopecurus pratensis	•	
Calamagrostis canadensis	•	
Festuca rubra	•	
Total Grasses	3	0
Sedges		
Carex lugens	•	
Eleocharis acicularis		•
Total Sedges	1	1
Total Vascular Species	**32**	**20**

only indigenous grass found within the ROW but not in the adjacent forest. This was the northernmost location in which we found *Calamagrostis canadensis* in this survey. This species was observed in the Dietrich Valley by Mitchell (1970), prior to construction of the pipeline. It is a tall, rhizomatous grass, often associated with fireweed during regrowth of burned forests in Alaska. The roadway portion of the workpad supported considerable vegetation, as opposed to many areas along the pipeline, where the roadway is often barren. Because the pipeline lies close to the Dalton Highway at this location, there is less need for driving next to the pipeline to carry out maintenance activities and inspections. Hence, there is less pipeline traffic here than at many other locations along the corridor.

Wildlife in this vicinity include moose, hare, and bear. We saw none during our inspection.

Photo 17-3. Spruce with an understory of willow and ground cover of Dryas *occurs east of the Dalton Highway at this location.*

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #18

Date Examined:	28 July 1999
Location:	N67°51' 30.2"; W149°49' 40.1"; TAPS M.P. 190.
Pipeline:	Buried
Slope:	Moderate south
Drainage:	Inside - well drained; Outside - permafrost with probable perching
Vegetation:	Tall shrub, dominated by *Salix alaxensis*

Site No. 18 is located in the Dietrich River valley. The location is 2 mi south of Site No. 17. The ROW and control sites were in the river floodplain. The pipeline is west of and parallels the Dalton Highway. There is a light vehicle trail along the pipeline at this location, and vegetation covers the entire ROW, except in these wheel tracks. These vehicle tracks were also partially vegetated with seeded and indigenous grass species. The ROW shrubs were shorter than those in the undisturbed, and controlled by brushing.

The ROW over the pipeline was about 54% gravel, and the soil outside the ROW was about 24% gravel. Moisture contents of both soils were relatively low, and nearly equal (19-20%). Total C was similar in both substrates, and a portion of the C in both substrates was probably carbonate. C:N ratios in the ROW and the undisturbed mineral soil were similar. Both soils contained a C:N ratio favorable to higher plants, based on these data. Soil reaction was alkaline in both habitats. Available N inside and outside the ROW was 2 ppm, all in the nitrate form. Available P was low at 1 ppm in both the ROW and undisturbed soils. Available K in the ROW was 32 ppm and 15 ppm in undisturbed soil. Both K values are within background levels of soils for the region, and it appeared that there may have been residual K from revegetation in the ROW. Evidence of availabilities for the three macro elements indicates no carryforward of N and P fertilizers applied during revegetation. The organic mat in the ROW consisted primarily of vascular plant litter in combination with scattered clumps of moss. The undisturbed organic mat consisted of moss and lichens, and to a lesser extent leaf fall and twigs from the shrubs.

Site No. 18 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	54.3	23.5
Moisture %	18.5	20.6
Total C %	2.73	2.22
Total Nn %	0.51	0.11
C:N Ratio	24.8	22.2
Organic matter %	6.1	4.9
pH	8.20	7.97
NH_4-N (ppm)	Not detectable	Not detectable
NO_3-N (ppm)	2	2
P (ppm)	1	1
K (ppm)	32	15
Organic mat thickness (cm)	1	0 - 2

Photo 18-1. Northward view of buried pipe in Dietrich Valley. Seeded and natural grasses dominate this section of the ROW. Widely spaced shrubs and indigenous forbs have begun to invade.

Photo 18-2. Fluvial gravel with a thin covering of silt in the adjacent habitat produces a shrub-dominated community.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 18.		
Species Names	*Inside*	*Outside*
Trees		
Populus balsamifera	•	
Total Trees	1	0
Shrubs		
Alnus crispa	•	•
Arctostaphylos alpina		•
Dryas octopetala	•	•
Potentilla fruiticosa	•	
Salix alaxensis	•	•
Salix brachyophylla ssp nyphoclada		•
Salix glauca	•	•
Shepherdia canadensis	•	•
Total Shrubs	6	7
Forbs		
Artemisia telesii	•	
Aster sibiricus	•	
Castelleja elegans	•	
Crepis capillaris	•	
Epilobium angustifolium	•	
Erigeron pulcherrima	•	
Gentiana glauca	•	
Hedysarum mackenzii	•	•
Minuartia stricta		•
Oxytropis campestris	•	
Parnassia palustris	•	•
Polygonum viviparum		•
Pyrola grandiflora	•	
Taraxacum alaskanum	•	
Total Forbs	12	4
Grasses		
Agropyron spp.		•
Festuca rubra	•	•
Hordeum jubatum	•	
Trisetum spicatum		•
Total Grasses	2	3
Sedges		
Carex lugens		•
Eleocharis acicularis	•	
Total Sedges	1	1
Total Vascular Species	**22**	**15**

The ROW is maintained in herbaceous vegetation by brushing. Grasses and fireweed developed greater canopy height over the buried pipe, suggesting a beneficial effect from the heated pipeline. Seeded grass (*Festuca rubra*) dominated most of the ROW and provided a greater low ground cover than in the tall shrub-dominated stand outside the ROW.

There were 22 vascular plant species within the ROW and 15 in the natural community. The only tree species at this location was cottonwood, which occurred in the ROW, but not in the adjacent undisturbed area. Six shrub species occurred in the ROW and seven in the undisturbed habitat. Five of the shrub species were common to both habitats. *Arctostaphylos alpina*, and *Salix brachyophylla ssp nyphoclada* occurred only in the undisturbed habitat, and *Potentilla fruticosa* was present only in the ROW. There were 12 forb species in the ROW and four in the undisturbed. Two of the forbs in the undisturbed (*Minuartia stricta* and *Polygonum viviparum*) were not found in the ROW.

One forb in the ROW (*Crepis capillaris*) was introduced from Switzerland, according to Hultén (1969). This species was recorded by Hultén at one location in Alaska, but is now found in several locations in the Alaska Interior, mostly along roadsides and waste areas near settlements. Its occurrence at this location is a northward range extension. It was introduced here either as a seed contaminant during revegetation and/or by vehicles traveling along the ROW. The latter is most likely, as it could easily have collected on mud splattered underneath vehicles. This was our northernmost record for *Crepis capillaris*, which was found at nine locations in this survey. The plant seems to have increased with habitat disturbance. It is common on the grounds at Pump Station 12.

One seeded grass, *Festuca rubra*, and one indigenous species, *Hordeum jubatum*, were surviving in the ROW. Native *Festuca rubra, Agropyron* spp., and *Trisetum spicatum* were found in the undisturbed habitat. Sedges were insignificant at this location, with only two species being recorded, neither common to both habitats.

Animal sightings and signs at this location included moose, fox, bear, hare, butterfly, and grasshoppers. Moose and hare browsing of willows outside the ROW was very intense at this location.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #19

Date Examined:	28 July 1999
Location:	N67°36' 45.7"; W149°47' 00.5"; TAPS M.P. 208.3.
Pipeline:	Elevated
Slope:	Moderate south
Drainage:	Inside - well drained; Outside - Fair with probable perching over permafrost
Vegetation:	Scrub forest

Site No. 19 is located in the valley of the middle fork of the Koyukuk River, north of Coldfoot and west of Sukakpak Mountain. The control site was in the river floodplain and had been recently flooded. The ROW was on a terrace immediately above the most recently flooded portion of the floodplain. The undisturbed vegetation was scattered conifer forest with tall shrubs (dwarf birch and willow) predominating among the trees. There were no indications that the ROW had been flooded recently at this location. The pipeline is west of and parallels the Dalton Highway. There is a light vehicle trail along the east side of the pipeline at this location, and except for these wheel tracks, shrub-forb dominated vegetation (willow and fireweed) covers the entire ROW. These vehicle tracks were partially vegetated with seeded grasses and indigenous plant species. Heights of the ROW shrubs were shorter than those in the undisturbed, and controlled by periodic brushing. Considerable moss colonization had occurred beneath the elevated pipeline.

Soil reaction was alkaline both in the ROW and outside (pH 8.22 and pH 7.96). The ROW under the pipeline was about 67% gravel, and the soil outside the ROW was about 2% gravel. Moisture content of the ROW soil was quite low (3.5%), while moisture content of the undisturbed soil was 20.7%. Total C in both soils was lower than found at many of the locations examined, about 2% in the ROW and 3.4% in the undisturbed. A portion of this C was probably in the carbonate form and not organic in origin. Total soil N was also quite low in both soils, 0.01% for the ROW and 0.09% for the undisturbed. The C:N ratio in the ROW was 196, which would be largely unfavorable for vascular plants. The C:N ratio in the undisturbed soil was

Site No. 19 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	66.6	1.9
Moisture %	3.5	20.7
Total C %	1.96	3.39
Total N %	0.01	0.09
C:N ratio	196	37.7
Organic matter %	4.4	7.5
pH	8.22	7.96
NH_4-N (ppm)	1	3
NO_3-N (ppm)	1	Not detectable
P (ppm)	1	1
K (ppm)	8	5
Organic mat thickness (cm)	0 - 1.5	12.7

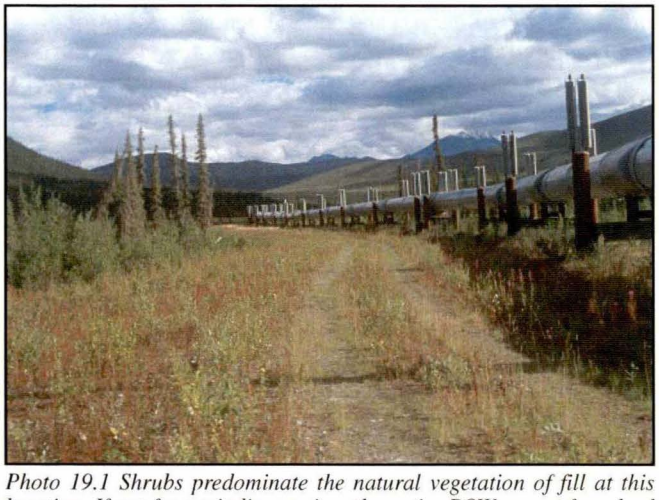


Photo 19.1 Shrubs predominate the natural vegetation of fill at this location. If not for periodic mowing, the entire ROW except for wheel tracks of the roadway would be covered with shrubs and trees. This is a southward view along elevated pipe.

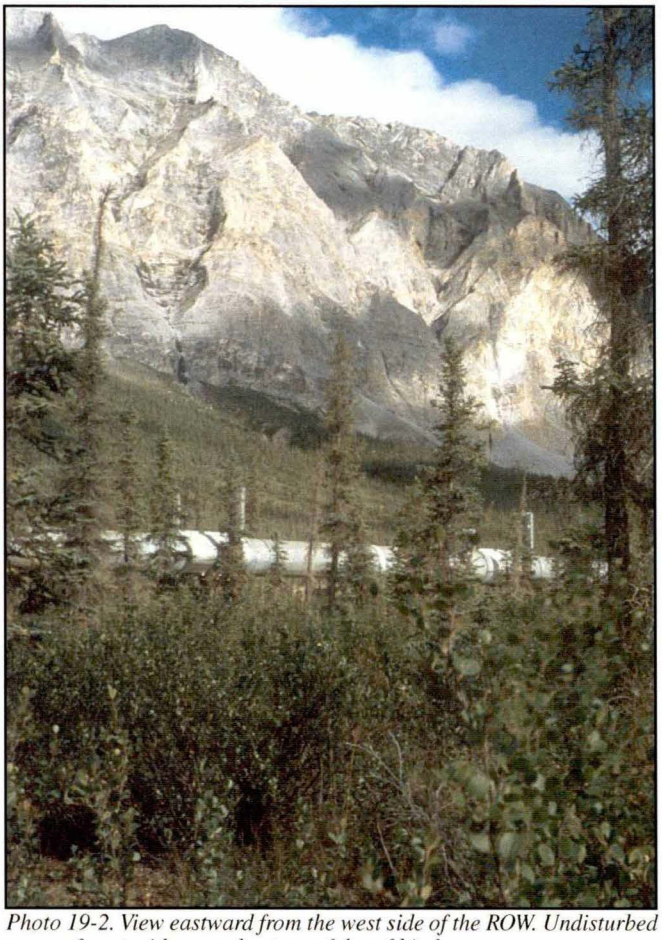


Photo 19-2. View eastward from the west side of the ROW. Undisturbed spruce forest with an understory of dwarf birch.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 19.		
Species Names	*Inside*	*Outside*
Trees		
Picea glauca	•	•
Picea mariana		•
Populus balsamifera	•	
Total Trees	2	2
Shrubs		
Andromeda polifolia		•
Arctostaphylos alpina	•	•
Arctostaphylos rubra	•	•
Betula nana	•	•
Dryas octopetala	•	
Ledum decumbens		•
Ledum groenlandicum		•
Potentilla fruiticosa	•	•
Rhododendron lapponicum		•
Salix alaxensis	•	
Salix arbusculoides	•	
Salix brachyophylla ssp nyphoclada	•	
Salix lanata var richardsonii		•
Salix reticulata		•
Shepherdia canadensis	•	
Vaccinium uliginosum		•
Total Shrubs	9	11
Forbs		
Anemone parviflora		•
Antennaria pulcherrima	•	
Epilobium angustifolium	•	
Gentiana algida	•	
Parnassia palustris	•	
Platanathera hyperborea	•	
Polygonum bistora subsp. plumosum		•
Pyrola grandiflora	•	
Solidago multiradiata	•	
Tofieldia coccinia	•	
Total Forbs	8	2
Grasses		
Agropyron spp.	•	
Festuca altaica		•
Festuca rubra	•	
Poa pratensis	•	
Total Grasses	3	1
Sedges		
Carex aquatilis		•
Carex lugens		•
Eleocharis acicularis		•
Total Sedges	0	3
Total Vascular Species	***22***	***19***

37.7, greater than the 30 threshold normally considered favorable for higher plants. If significant portions of the soil C were in the carbonate form, then these C:N ratios were not as wide as our calculations indicated.

Available N was 2 ppm inside the ROW, and 3 ppm outside. These data indicate that N was being used about as fast as it was mineralized, leaving little available in the soil. Available P was low at 1 ppm in both habitats. Available K was 8 ppm in the ROW and 5 ppm in the undisturbed soil. Both K values are quite low for vascular plants. Evidence of availabilities for the three macro elements indicates no carryforward of fertilizers applied during revegetation.

The organic mat in the ROW and undisturbed habitats consisted primarily of vascular plant litter in combination and moss. Organic mat of the undisturbed habitat consisted of several lichens and vascular plant litter.

Fireweed provided much of the canopy cover in the ROW. Shrubs were co-dominant with the fireweed. Seeded grasses did not dominate at this location, in contrast with many other sites examined. However, grasses were more significant a few hundred feet south of this location. Those grasses appear as light vegetation in Photo 19-1. The ROW was well vegetated and without periodic brushcutting would probably convert to a shrub type.

A total of 36 vascular plant species were recorded at this location, 22 species within the ROW and 19 in the natural community. White and black spruce were the two tree species of the undisturbed forest. Within the ROW, white spruce and cottonwood had colonized. The disturbance resulting from construction created open habitat that allowed cottonwood trees to colonize at this location.

Of 16 shrub species found at this location, nine were found in the ROW and 11 in the undisturbed. Four shrub species were common to both habitats (*Arctostaphylos alpina*, *A. rubra*, *Betula nana*, and *Potentilla fruticosa*). Only a portion of the heath shrubs at this location were found in the ROW. Ten forb species were found at this site. Eight occurred in the ROW and two in the undisturbed, but no forb species were common to both habitats. There was already an inherent difference between these two habitats before pipeline construction, which was accentuated by the change in substrate during construction. Flooding of the adjacent forest was a factor keeping forbs from that habitat.

Four grass species were found at this location, three in the ROW and one in the forest. Two seeded grass species (*Festuca rubra*, and *Poa pratensis*) and one indigenous grass (*Agropyron* spp.) occurred in the ROW. Native *Festuca altaica* was the only grass species found in the undisturbed habitat. Sedges were also insignificant at this location, with three species being recorded only in the undisturbed habitat.

Animal sightings and signs at this location included moose, bear, and hare. Browsing of willows by moose and hare was less noticeable at this location, in contrast to Site 18.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #20

Date Examined:	29 July 1999
Location:	N67°24' 50.3"; W150°05' 27.6"; TAPS M.P. 225.5.
Pipeline:	Elevated
Slope:	Moderate south and west
Drainage:	Inside - well drained; Outside - Perching over permafrost
Vegetation:	Scrub black spruce forest

Site No. 20 is located in the valley of the middle fork of the Koyukuk River, north of Coldfoot and Minnie Creek. The site is directly across the river from Wiseman. The control site was a forest area (80% tree canopy) above the river. This forest had been cut over in the past with axes. Timber harvesting was presumably to supply logs for cabin construction and firewood for the village of Wiseman. The tree harvesting had limited effect on the understory, and spruce recolonized the cut-over forest. There was also evidence of fires in this forest. The pipeline is west of and parallels the Dalton Highway. There is a light vehicle trail along the west side of the pipeline at this location. Shrubs dominated the community under the pipeline. Shrubs in the center of the ROW and beneath the pipeline were shorter than those along the margins; this height difference was due to brushing. When I visited this location in July 1997, the shrub canopy reached to the overhead pipeline and had not been cut for some time (see Photo 1 in McKendrick, 2001). By 1999, the vegetation had been cut. Presumably these plants were cut either in 1997 or 1998, and the growth shown in 1999 (Photo 20-1) had been produced within one, or at most two growing seasons. Grasses dominated the portion of the ROW where vehicle travel occurs. The vehicle tracks were partially vegetated with the seeded grass as well as indigenous species. Moss and lichen colonization had occurred beneath the elevated pipeline.

Soil reaction was alkaline both inside (pH 8.16) and outside (pH 8.12) the ROW. Soil under the pipeline was about 58% gravel, and the soil outside the ROW was about 28% gravel. Moisture content of ROW soil was quite low at about 5%. Moisture content of the undisturbed soil was approximately 20%. Total C in both soils was lower than found at many of the locations examined, about 2.4% in the ROW and 1.4% in the undisturbed. A portion of this C was probably in the carbonate form and not organic. Organic matter was calculated to be 5.4% and 3.0% for the ROW and forest soils, respectively. Total soil N was also quite low in the ROW (0.02%) and the undisturbed soil (0.06%). The C:N ratio in the ROW was wide (121.5) and unfavorable for vascular plants. The C:N ratio in the undisturbed soil (22.5) was well below the 30 threshold. If significant portions of the soil C were in the carbonate form, then these calculated organic matter and C:N ratios would be lower and narrower, respectively.

Available N was 2 ppm inside and 1 ppm outside the ROW. In both soils, the N was in the ammonium form, which is inconsistent with the alkaline soil reaction. These data indicate that N was being used about as quickly as it was mineralized, leaving little available in the soil. Available P was 2 ppm in the ROW soil and below detection limits in the undisturbed soil. Those data indicated P could be a limiting nutrient. Available K was 11 ppm in the ROW soil and 10 ppm in the undisturbed soil. Both K values are quite low for vascular plants, and it too may

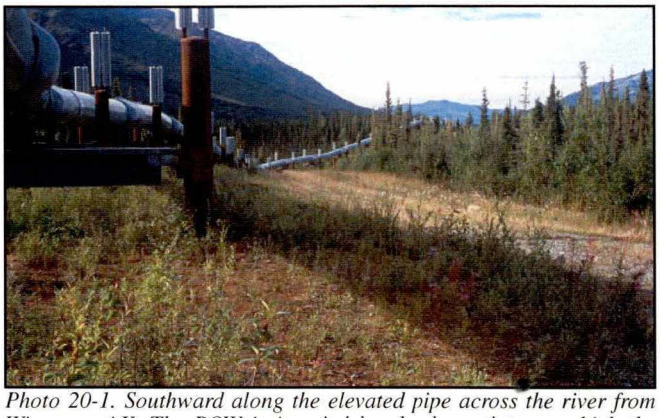


Photo 20-1. Southward along the elevated pipe across the river from Wiseman, AK. The ROW is invaded by shrubs and trees, which the pipeline company cuts back. Grasses predominate along wheel track margins.

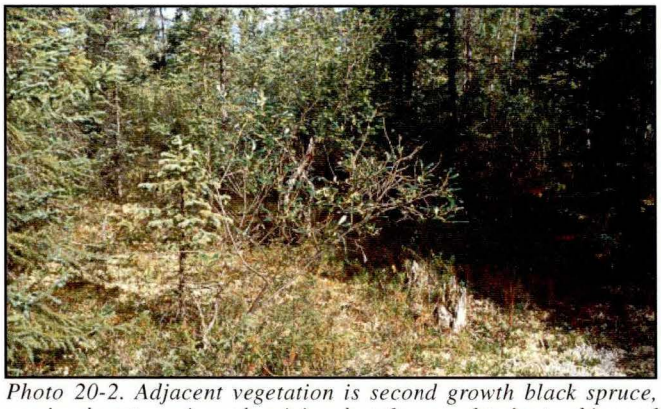


Photo 20-2. Adjacent vegetation is second growth black spruce, previously cutover in early mining days for wood to heat cabins and melt permafrost.

Site No. 20 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	58.3	28.2
Moisture %	4.8	19.7
Total C %	2.43	1.35
Total N %	0.02	0.06
C:N ratio	121.5	22.5
Organic matter %	5.4	3
pH	8.16	8.12
NH_4-N (ppm)	Not detectable	Not detectable
NO_3-N (ppm)	2	1
P (ppm)	2	Not detectable
K (ppm)	11	10
Organic mat thickness (cm)	0 - 2	14.5

be a limiting nutrient. Evidence of availabilities for the three macro elements indicates no carryforward of fertilizers applied during revegetation.

The organic mat in the ROW and undisturbed habitats consisted primarily of vascular plant litter in combination with moss. The undisturbed habitat organic mat consisted mostly of moss, with smaller amounts of vascular plants and lichen litter.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 20.

Species Names	Inside	Outside
Trees		
Picea glauca	•	
Picea mariana		•
Populus balsamifera	•	
Total Trees	2	1
Shrubs		
Alnus crispa	•	
Arctostaphylos uva-ursi	•	
Arctostaphylos rubra	•	•
Betula nana		•
Dryas octopetala	•	•
Empetrum nigrum		•
Juniperus communis		•
Ledum groenlandicum		•
Rubus arcticus	•	
Salix alaxensis	•	
Salix arbusculoides	•	
Salix bebbiana	•	
Salix glauca	•	•
Salix myrtillifolia	•	
Salix planifolia ssp. pulchra	•	•
Salix reticulata	•	•
Shepherdia canadensis	•	
Spirea beauverdiana		•
Vaccinium uliginosum		•
Vaccinium vitis-idaea		•
Total Shrubs	13	12
Forbs		
Anemone parviflora	•	
Antennaria pulcherrima	•	
Epilobium angustifolium	•	
Erigeron pulcherrima	•	
Gentiana glauca	•	
Geocaulon lividum		•
Hedysarum mackenzii	•	•
Matricaria matricarioides	•	
Plantago major var. major	•	
Solidago multiradiata	•	•
Taraxacum officinale	•	
Tofieldia coccinia	•	
Total Forbs	11	3
Grasses		
Agropyron spp.	•	
Arctagrostis latifolia		•
Festuca altaica	•	•
Festuca rubra	•	
Hordeum jubatum	•	
Puccinellia borealis	•	
Total Grasses	5	2
Sedges		
Carex lugens	•	•
Total Sedges	1	1
Total Vascular Species	**32**	**19**

Fireweed provided much of the canopy cover in the ROW. Shrubs were co-dominant with the fireweed, and grasses ranked last. Seeded grasses did not dominate at this location, in contrast with many other sites examined. In Photo 20-1, a light patch of grass appears in the distance between the roadway and edge of the ROW. Most of the ROW supported vascular plant cover, with partially barren areas appearing only in the light vehicle tracks along the pipeline.

Forty-two vascular species were found at this site, 32 species within the ROW and 19 in the natural community. Only nine species were common to both habitats, however. Black spruce was the only tree of the adjacent forest. White spruce and cottonwood had colonized within the ROW. The disturbance resulting from construction created open mineral soil habitat, allowing cottonwood to establish.

Thirteen shrub species were found in the ROW and 12 in the undisturbed. Five shrub species were common to both habitats. Except for the two *Arctostaphylos* shrubs, all heath shrubs occurred only in the adjacent forest. Twelve forb species occurred at this location. Eleven were recorded within the ROW and three in the forest. Two forb species were common to both habitats. This difference in forbs and shrub species between habitats may have resulted from differences in soil environments; one a bare mineral soil, the other covered by a thick mat of lichen and mosses. This was our northernmost record for *Matricaria matricarioides*. Two other exotic weeds were found at this site: *Plantago major* var. *major* and *Taraxacum officinale*.

Six grasses were found at this location. Five occurred in the ROW and two in the adjacent forest. One was common to both habitats. *Festuca rubra* was the only species surviving from the revegetation application. Four indigenous grasses (*Agropyron* spp., *Festuca altaica*, *Hordeum jubatum*, and *Puccinellia borealis*) occurred in the ROW. Native *Arctagrostis latifolia* and *Festuca altaica* were the only grass species found in the undisturbed habitat. Sedges were insignificant at this location, with three species being recorded only in the undisturbed habitat.

Animal sightings and signs at this location included moose, bear, and hare.

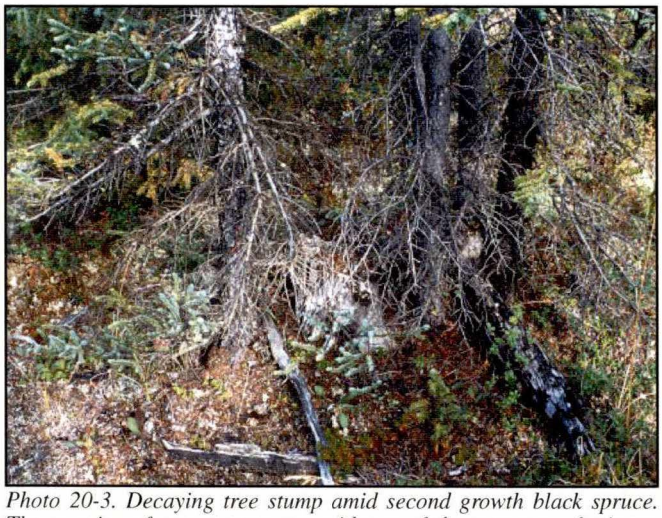


Photo 20-3. Decaying tree stump amid second growth black spruce. The remains of ax-cut trees are evidence of the presence of miners, trappers and settlers in the early 20th century in this part of Alaska.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #21

Date Examined:	29 July 1999
Location:	N67°09' 52.5"; W150°20' 34.4"; TAPS M.P. 245.4.
Pipeline:	Elevated
Slope:	Flat surface sloping toward east and south
Drainage:	Inside - well drained; Outside - fairly drained
Vegetation:	Mixed forest with hardwoods dominating, and young softwoods developing

Site No. 21 is located approximately 1.5 mi south of Rosie Creek south of Coldfoot. The location is west of the Dalton Highway. The elevated pipeline is on the east side of the ROW. Vehicle travel within the ROW occurs on the west side of the pipeline, and the ROW is vegetated except for these wheel tracks. Brush and trees dominate beneath the pipeline, while grasses predominate in the roadway. The site is within the floodplain of the Middle Fork of the Koyukuk River. Vegetation prior to construction was a mixed spruce-cottonwood forest with alder and birch. This is the northernmost location in which we recorded birch trees and highbush cranberry. The forest experienced considerable natural and some human disturbance prior to pipeline construction. Flooding appears to have been common, and forest fires may have affected this habitat. Old trails in the forest were probably from early mining activities in the region, predating Dalton Highway and pipeline construction. Contemporary liquor bottles discarded in the forest indicated recent human use, probably by hunters. Fill had been placed within the ROW at this location.

Shrubs and trees invading the ROW had not been cut during the 1999 growing season, but dry brush stacked along the edge indicated this section of the ROW has been hand cut in previous years. Without brushing, this section of ROW would soon become dominated by alder brush and cottonwood trees. Moss development beneath the pipeline was prominent at this location. The forest floor west of the ROW was covered with silt, indicating a recent flooding event had occurred.

Soil reaction was alkaline both inside and outside the ROW (pH 7.97 and 7.81, respectively). Soil under the elevated pipe contained about 80% gravel, while soil of the adjacent forest contained no gravel. This dissimilarity in gravel content resulted from fill placement. Soil moisture was about 5.5% inside the ROW and about 41% outside. Total soil C was 1.78% within the ROW and 3.48% outside. These C values translate to 4.0% and 7.7% organic matter for the ROW and adjacent soils, respectively. C content of the ROW and the adjacent forest was low, but within reason for this habitat. Periodic flooding and silt deposition may have been a factor in limiting organic C accumulation in the forest soil. Total soil N was 0.04% within the ROW and 0.14% outside, quite low in both. The C:N ratio was 44.5 in the ROW and 24.9 in the forest soil. In the ROW, this ratio was greater than that likely capable of supplying adequate N to vegetation.

The amount of available soil N was low inside the ROW and below laboratory detection limits in the adjacent forest. Within the ROW, available ammonium and nitrate N were 1 and 2 ppm, respectively. There was no apparent carryover of N fertilizer from revegetation at this location. Vegetation was probably using N as quickly as it was being mineralized from organic matter within the forest. Available soil P was 3 ppm within the ROW soil and 1 ppm in the adjacent forest soil, quite low and possibly limiting plant growth. Available K was 25 ppm inside the ROW and 10

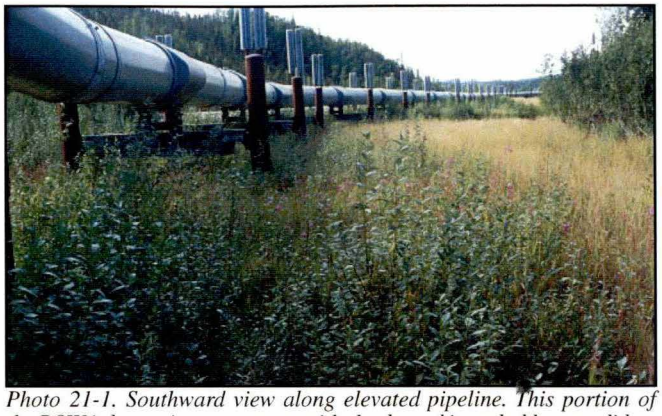


Photo 21-1. Southward view along elevated pipeline. This portion of the ROW is becoming overgrown with shrubs and is probably a candidate for brush removal. The gravel roadway is well-vegetated by grasses.

Photo 21-2. The adjacent forest has a prominent understory of tall shrubs (willow and alder).

Site No. 21 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	79.4	0
Moisture %	5.5	41.0
Total C %	1.78	3.48
Total N %	0.04	0.14
C:N ratio	44.5	24.9
Organic matter %	4	7.7
pH	7.97	7.81
NH_4-N (ppm)	1	Not detectable
NO_3-N (ppm)	2	Not detectable
P (ppm)	3	1
K (ppm)	25	10
Organic mat thickness (cm)	2	13

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 21.		
Species Names	*Inside*	*Outside*
Trees		
Betula papyrifera	•	
Picea glauca	•	•
Populus balsamifera	•	
Total Trees	3	1
Shrubs		
Alnus crispa	•	•
Arctostaphylos rubra	•	•
Empterum nigrum		•
Ledum groenlandicum		•
Linnaea borealis		•
Potentilla fruiticosa	•	•
Rosa acicularis		•
Rubus arcticus		•
Salix alaxensis	•	
Salix bebbiana	•	
Salix glauca	•	•
Salix lanata var richardsonii		•
Shepherdia canadensis	•	•
Vaccinium uliginosum		•
Vaccinium vitis-idaea		•
Viburnum edule		•
Total Shrubs	7	14
Forbs		
Achillea sibirica	•	
Anemone parviflora		•
Antennaria pulcherrima		•
Aster sibiricus	•	•
Epilobium angustifolium	•	
Equisetum arvense	•	
Erigeron pulcherrima	•	
Geocaulon lividum		•
Hedysarum mackenzii	•	•
Oxytropis deflexa	•	
Parnassia palustris	•	•
Plantago major var. major	•	
Potentilla hookeriana	•	
Pyrola grandiflora	•	
Zygadenus elegans		•
Total Forbs	11	7
Grasses		
Agropyron spp.	•	
Alopecurus pratensis	•	
Bromus inermis	•	
Bromus pumpellianus	•	
Calamagrostis canadensis		•
Calamagrostis lapponica		•
Festuca rubra	•	
Hordeum jubatum	•	
Poa arctica		•
Puccinellia arctica	•	
Trisetum spicatum	•	
Total Grasses	8	3
Sedges		
Carex aquatilis		•
Carex bigelowii		•
Carex lugens		•
Total Sedges	0	3
Total Vascular Species	***29***	***28***

ppm outside, also low in both soils. This may mean either a limited carryover from revegetation applications, or that the fill material was inherently higher in K than the silty forest soil.

Within the ROW the organic mat consisted of plant debris, moss, and crustose lichen up to 2 cm in thickness. The 13-cm organic mat in the adjacent forest consisted of variously decayed plant debris typical for this vegetation.

Thirty-nine vascular plant species were recorded at this location. Twenty-nine were recorded within the ROW and in the adjacent cottonwood-spruce habitat. Two trees, five shrubs, and three forb species were common to both habitats; there were no grasses or sedges in common. The limited commonality of species between the locations was caused by construction, which created a drier habitat, and by revegetation that introduced grass species.

Three tree species were found at this site. All tree species were present within the ROW, and two were found in the adjacent forest. This was the northernmost site in which paper birch trees were recorded in this survey. *Betula papyrifera* was recorded only within the ROW. Sixteen shrub species were found at this location. Five shrubs (*Alnus crispa, Arctostaphylos rubra, Potentilla fruticosa, Salix glauca,* and *Shepherdia canadensis*) were common to both habitats. Seven shrub species were found in the ROW, and fourteen within the adjacent forest.

Fifteen forb species were recorded at this location, eleven found in the ROW and seven in the adjacent forest. Three forbs (*Aster sibiricus, Hedysarum mackenzii,* and *Parnassia palustris*) were common to both habitats. One introduced forb species (*Plantago major* var. *major*) was found at this site. This plant may have been introduced with seed applications and/or carried to the site by vehicles. It occurs at several locations along the ROW, and seed could easily have been carried with mud on trucks traveling along the pipeline. This is a common weed in Alaska, found in waste places, lawns, fields and yards. One poisonous plant was recorded, *Zygadenus elegans* (death camas). *Z. elegans* is a member of the lily family, and its underground bulb is toxic. It occurs widely throughout much of Alaska, and its presence here was not unusual. It can be found at various locations in the vicinity. It was observed only in the adjacent forest at this particular location. We found this species at three sites in this survey. This was our northernmost record for the plant, even though its range extends to the Beaufort Sea (Hultén, 1968).

Eleven grass species were found at this location. Nine were indigenous to Alaska. *Agropyron* spp. was perhaps the most common grass at this location. Three indigenous grass species (*Calamagrostis canadensis, Calamagrostis lapponica,* and *Poa arctica*) occurred within the adjacent forest, but were absent from the ROW. Two exotic species of grass (*Alopecurus pratensis* and *Bromus inermis*) occurred only within the ROW at this site. These two grasses were introduced at this location during revegetation. *Festuca rubra* is an indigenous species to Alaska; this grass does not occur in forests, but does occur along stream channels. It may have been in the region prior to pipeline construction. Its abundance can be traced to revegetation of the ROW. No introduced grass species had invaded the adjacent undisturbed habitat.

No sedges occurred within the ROW at this location. Three sedges (*Carex aquatilis, Carex bigelowii,* and *Carex lugens*) were found in the adjacent undisturbed habitat. Absence of sedges from the ROW can probably be attributed to the ROW soils being too dry.

Moose, squirrel, and hare appeared to be the major animals using this habitat. Apparently there was sufficient spruce in the vicinity to support a squirrel population.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #22

Date Examined:	29 July 1999
Location:	N66°59' 39.0"; W150°18' 24.2"; TAPS M.P. 258.25.
Pipeline:	Elevated
Slope:	Flat surface sloping toward west and north
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Mixed forest with blueberry and lichen matrix understory

Site No. 22 is located approximately 2 mi south of the Koyukuk River bridge, and east of the Dalton Highway. The elevated pipeline is on the west side of the ROW. Vehicle travel within the ROW occurs on the east side of the pipeline, and the ROW is vegetated except for that roadway. Brush and young trees dominate beneath the pipeline, and an open stand of short grasses line margins of the otherwise largely barren roadway. The site is in a drainage that flows northward into the Koyukuk River. Vegetation prior to construction was a mixed spruce-birch forest with an open shrub understory of blueberry, dwarf (shrub) birch, and paper birch X shrub birch hybrids. The forest floor in openings was dominated by lichen species typical for the region. The forest had experienced natural disturbance (wildfires) prior to pipeline construction. Fill was placed within the ROW during pipeline construction at this location.

Shrubs and trees invading the ROW had not been cut during the 1999 growing season, but brushing had occurred in prior years. Otherwise this section of ROW would soon become dominated by alder, spirea, willow, and blueberry brush and birch, spruce, cottonwood, and aspen trees. Moss and lichen (*Stereocaulon*) were important ground colonizers at this location beneath the pipeline.

Soil reaction was alkaline inside the ROW (pH 8.04) and acidic outside (pH 5.75). Soil under the elevated pipe contained about 72% gravel, while that of the adjacent forest contained about 10% gravel. This is explained by the use of stony fill to construct a workpad for installing and maintaining the pipeline. Soil moisture was about 5.0% inside the ROW and about 27.6% outside. Total soil C was 0.48% within and 1.09% outside the ROW, translating to 1.10% and 2.4% organic matter, respectively. C content was low but not unusual for these soils. Periodic forest fires may also have limited soil C accumulation, Total soil N was below detection limits within the ROW and 0.07% outside, extremely low in both areas.

Available soil N was also low, at 1 ppm for both soils. The alkaline ROW soil N was in the nitrate form, and that in the acidic forest soil was as ammonium. There was no carryover of N fertilizer from revegetation at this location. Vegetation was probably using N as quickly as it was being mineralized from organic matter; otherwise there is an enigma as to where plants were obtaining N. Available soil P was 4 ppm within the ROW soil and 11 ppm in the adjacent forest soil. This is quite low in both soils and could be limiting plant growth. There was no obvious carryover of P fertilizer from revegetation. However, it is important to note that different extractions were used to measure available P at this site. The alkaline soil was extracted with sodium bicarbonate, and the acidic soil was extracted with Bray P-1 (an acid mixture). Relationships between these two methods and plant field responses for Alaska soils is largely speculative. Available

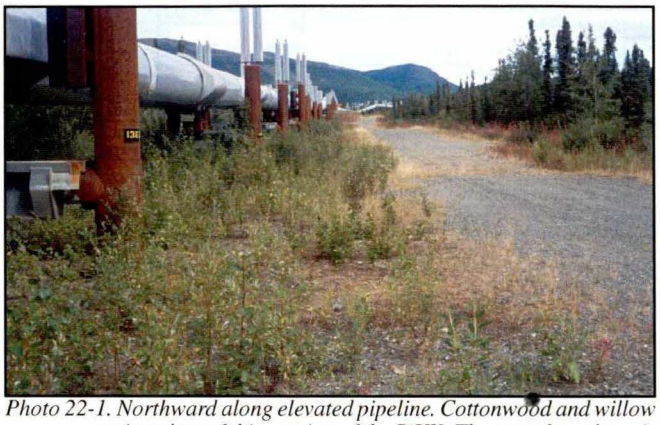


Photo 22-1. Northward along elevated pipeline. Cottonwood and willow are common invaders of this portion of the ROW. The gravel roadway is largely barren with a fringe of grasses along the margins of wheel tracks.

Photo 22-2. Open mixed forest with shrubs and thick patches of lichen occur in the undisturbed habitat at this location.

Site No. 22 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	71.6	9.5
Moisture %	5.0	27.6
Total C %	0.48	1.09
Total N %	Not detectable	0.07
C:N ratio	Not applicable	15.6
Organic matter %	1.1	2.4
pH	8.40	5.75
NH_4-N (ppm)	Not detectable	1
NO_3-N (ppm)	1	Not detectable
P (ppm)	4	11
K (ppm)	40	15
Organic mat thickness (cm)	1 - 2	6

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 22.		
Species Names	*Inside*	*Outside*
Trees		
Betula papyrifera	•	•
Picea glauca	•	
Picea mariana	•	•
Populus balsamifera	•	
Populus tremuloides	•	
Total Trees	5	2
Shrubs		
Alnus sinuata	•	
Betula nana	•	•
Salix bebbiana	•	
Salix glauca	•	•
Vaccinium uliginosum	•	•
Betula glandulosa X B. papyrifera		•
Ledum decumbens		•
Spirea beauverdiana		•
Vaccinium vitis-idaea		•
Total Shrubs	5	7
Forbs		
Achillea borealis	•	
Achillea sibirica	•	
Aster sibiricus	•	
Epilobium angustifolium	•	
Thlaspi arvense	•	
Geocaulon lividum		•
Total Forbs	5	1
Grasses		
Bromus inermis	•	
Calamagrostis canadensis	•	•
Festuca rubra	•	
Puccinellia borealis	•	
Festuca altaica		•
Total Grasses	4	2
Sedges		
Carex bigelowii		•
Total Sedges	0	1
Total Vascular Species	***19***	***13***

K was 40 ppm inside the ROW and 15 ppm outside. This is marginally low within the ROW and certainly low in the forest soil. Either there was a limited carryover from revegetation applications, or the fill material was inherently higher in K than the forest soil.

Within the ROW the organic mat consisted of plant debris, moss, and crustose lichen up to 2 cm thick. The 6-cm organic mat in the adjacent forest consisted of plant debris typical for this vegetation, and moss/lichen accumulations in forest openings.

Twenty-seven vascular plant species were recorded at this location. Nineteen were recorded within the ROW and 13 in the adjacent spruce-cottonwood habitat. Two tree species, three shrubs and one grass were common to both habitats; no forbs or sedges were in common. This disparity was caused by the habitat changes associated with construction, which created a drier habitat within the ROW. Relative successional age of the two sites may have been an important factor also. With time, the two communities may reach greater similarity.

Five tree species were found at this site. All five occurred within the ROW, and two (*Betula papyrifera* and *Picea mariana*) were common to both habitats. *Picea glauca, Populus balsamifera,* and *Populus tremuloides* occurred only within the ROW, indicating that the disturbance allowed these trees to expand their local ranges to this site. Ten shrub species were found at this location. *Betula nana* (and probably *B. glandulosa), Salix glauca,* and *Vaccinium uliginosum* were common to both habitats. Five shrub species were found in the ROW, and seven within the forest. All tree and shrub species at this location were indigenous.

Six forb species were recorded at this location. Five occurred in the ROW, and only one (*Geocaulon lividum*) was recorded for the adjacent forest. This species' common name is northern comandra, and its red fruit is reportedly edible. No forbs were common to both habitats. One introduced forb species (*Thlaspi arvense*) was found only within the ROW at this site. This plant may have been introduced with seed applications and/or carried to the site by vehicles. It occurred at ten locations along the ROW. Its seed could easily have been carried with mud on trucks traveling along the pipeline. This is a common weed in Alaska, found in waste places, lawns, fields and yards.

Five grass species were found at this location. Four occurred within the ROW, and two in the adjacent forest. The indigenous *Calamagrostis canadensis* was common to both habitats. One exotic species (*Bromus inermis*) occurred only in the ROW. This grass was introduced during revegetation. *Festuca rubra* is indigenous to Alaska, but its presence here resulted from seed applications following pipeline construction. Indigenous (*Festuca altaica*) was found only in the adjacent forest.

No sedges occurred within the ROW at this location. *Carex bigelowii* was found in the adjacent habitat. Absence of sedges from the ROW can probably be attributed to the dry soils.

Moose, squirrel, fox, spruce grouse, and hare appeared to be the major animals using this habitat.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #23

Date Examined:	29 July 1999
Location:	N66°47' 55.0"; W150°41' 17.4"; TAPS M.P. 276.
Pipeline:	Elevated
Slope:	Moderately flat sloping north
Drainage:	Inside - drained; Outside - perched over permafrost
Vegetation:	Black spruce forest and muskeg bog

Site No. 23 is located in the Prospect Creek drainage south of Pump Station 5. The location is in a bog/black spruce forest complex with poorly drained soils. The bog is wetter and has fewer and smaller trees than do the patches of forest. The undisturbed plant community has a well-developed lichen-moss and cottongrass cover. The mineral soil was not thawed on the date we examined this site, making it difficult to obtain a sample outside the ROW. The only tree species in the undisturbed habitat was black spruce, while five tree species were colonizing on the ROW fill. There were two undisturbed habitat types, one with *Salix planifolia* ssp. *pulchra* (diamond leaf willow) and one without. We inventoried these separately. Dwarf birch was associated with the diamond leaf willow.

Fill was being added to depressions between pipeline VSMs during the summer of 1999. Under the pipe and along the margins of fill within the ROW, trees and shrubs were colonizing vigorously. Brushing the ROW to control invading shrubs and trees within the ROW has occurred at this location. The roadway was mostly bare gravel with a fringe of grass along the margins.

Soil reaction was alkaline (pH 8.65) inside the ROW and acidic (pH 5.31) outside. Soil under the elevated pipe contained 59% gravel, and that outside contained no gravel. This was the result of stony soil fill hauled to provide support for traffic during and after construction. Soil moisture was 7.0% inside the ROW and about 24% outside. Total C both within the ROW and outside was low (0.44 and 1.87, respectively). Total soil N was not

Site No. 23 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	59.2	0
Moisture %	7.0	24.4
Total C %	0.44	1.87
Total N %	Not detectable	0.11
C:N ratio	Not applicable	17
Organic matter %	1	4.2
pH	8.65	5.31
NH4-N (ppm)	Not detectable	4
NO_3-N (ppm)	1	2
P (ppm)	5	1
K (ppm)	60	19
Organic mat thickness (cm)	1.5 - 3	30

Photo 23-1. Pump Station 5 is visible in the background of this northward view along an elevated section of pipe. Beneath the pipe, gravel fill has been invaded largely with shrubs. The grass Hordeum jubatum *lines the wheel tracks of the roadway. Fresh heaps of fill are visible between pipeline VSMs. This fill is being used to bring depressions to grade. Frost bulbs have formed and lifted the soil, leaving low spots between VSMs.*

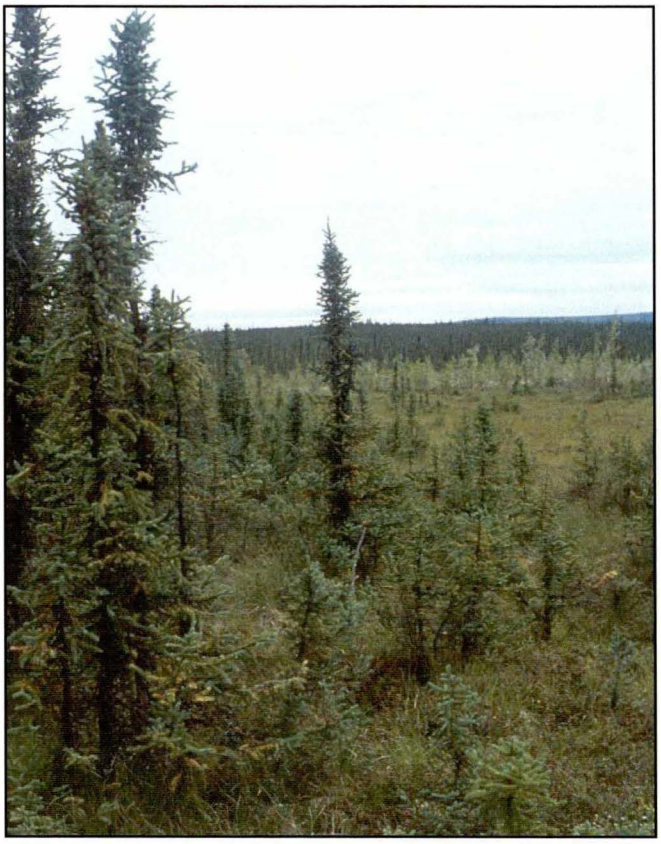


Photo 23-2. The adjacent habitat is a matrix of bog and black spruce, with the spruce occurring on higher ground. Soil samples were difficult to obtain on 29 July 1999 since the ground was frozen just beneath the organic mat.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 23.			
Species Names	*Inside*	*Outside S. Planifolia*	*Outside No S. Planifolia*
Trees			
Betula papyrifera	•		
Picea glauca	•		
Picea mariana	•	•	•
Populus balsamifera	•		
Populus tremuloides	•		
Total Trees	5	1	1
Shrubs			
Andromeda polifolia	•		
Betula nana	•		•
Empetrum nigrum	•	•	
Ledum decumbens	•	•	•
Salix alaxensis	•		
Salix arbusculoides	•		
Salix bebbiana	•		
Salix glauca	•		
Salix planifolia ssp. pulchra	•		•
Salix reticulata	•		
Shepherdia canadensis	•		
Vaccinium uliginosum	•	•	•
Vaccinium vitis-idaea	•	•	•
Rubus chamaemorus		•	•
Total Shrubs	13	5	6
Forbs			
Astragalus alpinus	•		
Crepis capillaris	•		
Crepis nana	•		
Epilobium angustifolium	•		
Erigeron pulcherrima	•		
Plantago major var. major	•		
Matricaria matricarioides	•		
Total Forbs	7	0	0
Grasses			
Agrostis scabra	•		
Bromus inermis	•		
Festuca rubra	•		
Hordeum jubatum	•		
Puccinellia borealis	•		
Total Grasses	5	0	0
Sedges			
Carex lugens	•		
Eriophorum angustifolium		•	
Total Sedges	1	0	0
Total Vascular Species	***31***	***6***	***7***

measurable within the ROW at this location. Total N in the adjacent forest soil was 0.11%. It is unlikely there has been any significant carryover from N fertilizer applied after construction at this location. The ROW soil contained 1 ppm nitrate N, and available ammonium N was not detected. The acidic forest soil contained 2 ppm nitrate N and 4 ppm available ammonium. Available soil N was low at this location, indicating that vegetation and soil microflora was probably consuming N to capacity. Measurable available soil P was 5 ppm in the ROW and 1 ppm in the adjacent soil. Available P was probably limiting in the undisturbed soil and marginally adequate in the ROW. There was evidence of a carryover of P fertilizer in the ROW soil. Available K was 60 ppm inside the ROW and 19 ppm outside. This indicated the element was adequate in the ROW but may be limiting plant growth in the forest. The dissimilarity of values between soils indicated a likely carryover from fertilization during revegetation. Within the ROW the organic mat varied from 1.5 to 3 cm in thickness. Much of this mat resulted from litter and mosses. The organic mat outside the ROW was a well-developed 30 cm layer of moss, lichens, and litter.

Thirty-four vascular plant species were recorded at this location. Thirty-one were found in the ROW, six in the adjacent habitat with diamond leaf willow, and seven in the adjacent habitat without diamond leaf willow. About half of the species found in the undisturbed habitat also occurred within the ROW. This disparity of species between the ROW and adjacent natural plant communities was caused by differences in habitat moisture and because of the recent ROW disturbance, in contrast to the advanced successional stage of the adjacent forest-bog complex.

Five tree species were found at this site: *Picea glauca, Picea mariana, Betula papyrifera, Populus balsamifera,* and *Populus tremuloides*. All of these occurred in the ROW, Only *Picea mariana* was found in the adjacent habitat. Fourteen shrub species occurred between the two habitats. All shrub species except *Rubus chamaemorus* were found in the ROW. Eight shrub species occurred in the undisturbed communities.

Seven forb species were recorded at this location. All occurred in the ROW and none in the forest-bog complex. Three exotic weeds were observed at this location: *Crepis capillaris*, *Plantago major* var. *major*, and *Matricaria matricarioides*.

Five grass species were found at this location. All occurred solely in the ROW. Three of the grass species were indigenous. Two seeded grasses, *Bromus inermis* and *Festuca rubra,* persist at this site. It is significant to observe that no introduced grass species had invaded the adjacent forest-bog communities. Two indigenous sedge species were found at this location. *Carex lugens* had invaded the ROW naturally, and *Eriophorum vaginatum* was a natural component of the undisturbed vegetation.

Until sufficient organic mat accumulates on the ROW, vegetation composition at this site will remain distinct from the adjacent communities. However, there is little chance that exotic species occurring within the ROW will spread beyond, unless a major disturbance occurs to remove the vegetation and alter the natural soil outside the ROW.

Animals and animal signs observed included hare and moose.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #24

Date Examined:	29 July 1999
Location:	N66°29' 18.0"; W150°41' 59.5"; TAPS M.P. 299.7.
Pipeline:	Elevated
Slope:	Moderately flat sloping northwest
Drainage:	Inside - drained; Outside - perched over permafrost
Vegetation:	Tussock shrub tundra

Site No. 24 is located on a ridge between Fish Creek and the Kanuti River, just past the top of Beaver Slide on the Dalton Highway. The location is east of the Dalton Highway, with the pipeline on the east side of the ROW and the road on the west side. The vegetation prior to construction was a tussock shrub tundra with scattered alder and black spruce. Disturbance that removes the organic mat and exposes mineral soil causes a deepening of the annual thaw, increasing availability of soil nutrients. The natural recovery for this habitat initially consists of tall shrubs, such as alder and willow. In some locations, trees will accompany the invading shrubs, even though trees may not have been in the community prior to disturbance. Subsequently, as the organic mat develops, the annual thaw depth becomes shallow, and shrubs and trees diminish in density and height. Only one tree species (black spruce) occurred in the undisturbed habitat at this site, but cottonwood and black spruce were invading the ROW.

Shrubs along the outer margins of the ROW were double to more than triple the height of those in the undisturbed stand. Shrubs beneath the pipeline were shorter than on the ROW margins, and may have been cut in previous years. Evidence of ROW brushing was not recorded for this location in our survey. Moss, lichen alder, willow, and heath shrubs were colonizing under the pipe. Vegetation occupied the ROW, except in the wheel tracks of the road. The roadway in the ROW was mostly bare gravel with a fringe of grass along the margins of the wheel tracks.

Soil reaction was alkaline (pH 8.41) inside the ROW and acidic (pH 5.23) outside. Soil under the elevated pipe contained 39 % gravel, and that outside contained no gravel. This is the result of the stony soil fill hauled to provide support for traffic during and after construction. Soil moisture was 8.4% inside the ROW and about 34.3% outside. Total C within the ROW and outside was 0.78 and 5.24, respectively. Total soil N was not measurable within the ROW at this location. Total N in the adjacent shrub soil was 0.16%. It is unlikely there has been any significant carryover of N fertilizer applied following construction at this location. Available ammonium N was not detected in soil within the ROW. The ROW soil contained 1 ppm available nitrate N. In the undisturbed soil, available ammonium and nitrate N each measured 1 ppm. Available soil N was low at this location, indicating that utilization by vegetation and soil microflora was probably consuming N to capacity. No measurable available soil P was found in the ROW soil, and 2 ppm was recorded for the adjacent soil. Available P was probably limiting in both soils. There was no evidence of a carryover of P fertilizer from revegetation in the ROW soil. Available K was 77 ppm inside the ROW and 21 ppm outside. This element was adequate in the ROW but may be limiting plant growth in the tussock shrub tundra. The dissimilarity of these values indicates an inherent

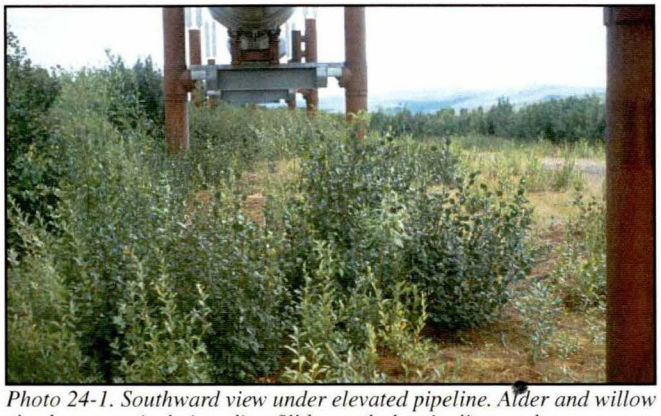


Photo 24-1. Southward view under elevated pipeline. Alder and willow shrubs are actively invading fill beneath the pipeline, and moss covers the soil surface. Wheel tracks in the roadway are barren gravel, and grasses line the road.

Photo 24-2. Alpine tussock shrub tundra occupies the adjacent habitat. A scattering of alder and spruce occur in this vegetation type.

Site No. 24 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	39.4	0
Moisture %	8.4	34.3
Total C %	0.78	5.24
Total N %	Not detectable	0.16
C:N ratio	Not applicable	32.8
Organic matter %	1.7	11.6
pH	8.41	5.23
NH_4-N (ppm)	Not detectable	1
NO_3-N (ppm)	1	1
P (ppm)	Not detectable	2
K (ppm)	77	21
Organic mat thickness (cm)	2	23.5

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 24.		
Species Names	*Inside*	*Outside*
Trees		
Picea mariana	•	•
Populus balsamifera	•	
Total Trees	2	1
Shrubs		
Alnus crispa	•	•
Betula nana	•	•
Ledum decumbens	•	•
Rubus chamaemorus		•
Salix alaxensis	•	
Salix arbusculoides	•	
Salix glauca	•	
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea		•
Total Shrubs	7	6
Forbs		
Epilobium angustifolium	•	
Equisetum arvense	•	
Erigeron pulcherrima	•	
Pedicularis labradorica		•
Pedicularis sudetica	•	
Petasites frigidus		•
Thlaspi arvense	•	
Total Forbs	5	2
Grasses		
Festuca rubra	•	
Hordeum jubatum	•	
Poa pratensis	•	
Puccinellia borealis	•	
Total Grasses	4	0
Sedges		
Carex aquatilis		•
Carex bigelowii		•
Eriophorum vaginatum		•
Total Sedges	0	3
Total Vascular Species	***18***	***12***

difference in mineralogy between the two soils and a possible carryover from fertilization during revegetation. Within the ROW the organic mat consisted of dense moss, up to 2 cm in thickness. The organic mat was a well-developed 23.5 cm layer of sphagnum, other moss, lichens, and litter outside the ROW.

Twenty-five vascular plant species were recorded at this location. Eighteen were recorded within the ROW and 12 in the adjacent habitat. One tree and four shrubs were common to both habitats. No forbs, grasses, or sedges were common between the ROW and adjacent tussock shrub tundra. This limited commonality of species was caused by differences in habitat moisture and stages of plant succession.

Two tree species (*Picea mariana* and *Populus balsamifera*) were found at this site. Only *P. mariana* was found in both habitats. Nine shrub species occurred between the two habitats. Two shrub species, *Rubus chamaemorus* and *Vaccinium vitis-idaea*, occurred exclusively in the adjacent shrub tundra. All trees and shrubs at this location were indigenous species.

Seven forb species were recorded at this location. All but two occurred in the ROW. The two that occurred exclusively outside the ROW were *Pedicularis labradorica* and *Petasites frigidus*. One forb, *Thlaspi arvense*, is an introduced species from Europe. It occurred only in the ROW and may have been introduced with revegetation seed and/or moved to the site later by vehicles. The species occurs widely in Alaska around settlements and along roads, and is often a weed in fields and gardens.

Four grass species were found at this location. All occurred in the ROW and none in the adjacent communities. Three of the grass species were indigenous, including *Festuca rubra*. Two seeded grasses, *Poa pratensis* and *Festuca rubra* were persisting at this site. Those two grass species had been introduced during revegetation. It is significant to observe that no introduced grass species had invaded the adjacent forest-bog communities. Three indigenous sedge species were found at this location. All were confined to the undisturbed habitat. The most common sedge was *Eriophorum vaginatum*, which form the tussocks of the tussock shrub tundra.

No animals and animal signs were observed at this location during the survey; however, it is known that ptarmigan, bear, moose and caribou use the area.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #25

Date Examined:	29 July 1999
Location:	N66°12' 10.6"; W150°15' 01.2"; TAPS M.P. 322.6.
Pipeline:	Elevated
Slope:	Gently sloping east and south
Drainage:	Inside - drained; Outside - fair to poor over permafrost
Vegetation:	Spruce forest

Site No. 25 is located on a slope of the valley east of the tributary of the Ray River. The location is east of the Dalton Highway, with the pipeline on the west side of the ROW and the road on the east side. The vegetation prior to construction was a mixture of white and black spruce forest. On 29 July 1999, a rust was prominent on *Salix planifolia* ssp. *pulchra* and on new growth of *Picea mariana*. The rust on *Picea* was more obvious just north of this location. This disease appears periodically and does not seem to kill the infected plants.

Disturbance that removes the organic mat and exposes the mineral soil causes a deepening of the annual thaw, which increases availability of soil nutrients. The natural recovery for this habitat initially consists of trees and tall shrubs, such as alder and willow. Alder and willow along the outer margins of the ROW were two to three times the height of those in the adjacent forest. Most of the heath shrubs within the undisturbed forest had not yet invaded the ROW. Moss, alder, willow, and two heath shrubs were colonizing under the pipe. Much of this vegetation under the pipeline had been recently disturbed by brushing operations. That increased the difficulty of identifying plant species, and may have caused us to overlook some species in our inventory. Vegetation occupied the ROW except in the wheel tracks of the road, which were mostly bare soil or gravel.

Soil reaction was acidic inside and outside the ROW (pH 5.34 and pH 5.00, respectively). Soil under the elevated pipe contained 78 % gravel, while that outside the ROW contained no gravel. The greater gravel content of the ROW resulted from stony soil fill hauled to provide support for traffic during and after construction. Soil moisture inside the ROW was 14.2% and

Site No. 25 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	77.9	0
Moisture %	14.2	46.2
Total C %	1.20	4.16
Total N %	0.11	0.18
C:N ratio	11	23.1
Organic matter %	2.7	9.2
pH	5.34	5.00
NH_4-N (ppm)	8	4
NO_3-N (ppm)	1	Not detectable
P (ppm)	21	1
K (ppm)	61	23
Organic mat thickness (cm)	0 - 3	15

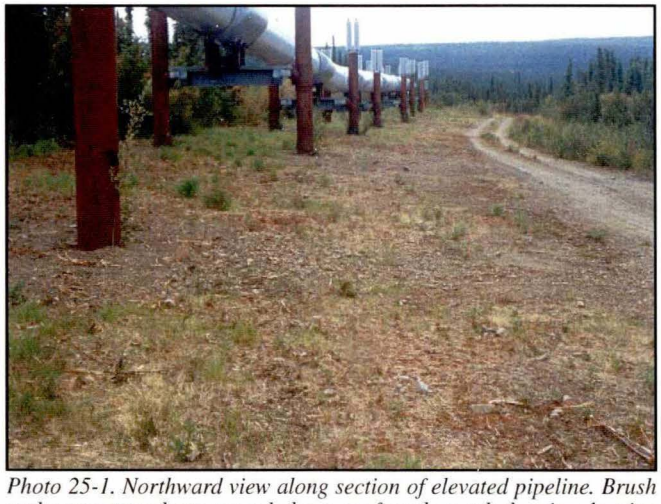


Photo 25-1. Northward view along section of elevated pipeline. Brush and young trees have recently been cut from beneath the pipe, leaving stumps and wood debris on the soil surface. Short grasses and uncut shrubs line the outer margin of the roadway. Wheel tracks are barren.

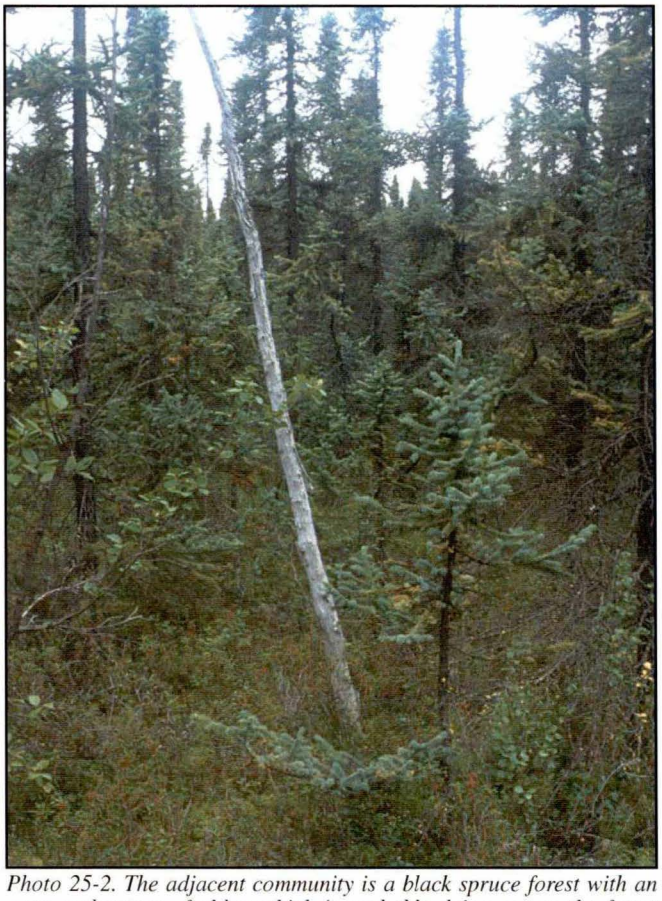


Photo 25-2. The adjacent community is a black spruce forest with an open understory of alder, which is probably dying out as the forest continues to develop. The short understory consists of heath shrubs, dwarf birch, Labrador tea, blueberry, and mountain cranberry.

outside about 46.2%. Total soil C was 1.2% within the ROW and 4.16% outside. Total soil N was 0.11% within the ROW and 0.18% outside. C:N ratios were 11 and 23 for ROW and outside soils, respectively. Organic matter percent was 2.7% for the ROW soil and 9.2% for the outside soil.

Laboratory data indicated two times more available N in the ROW soil than outside. That could suggest a possible carryover from fertilizer applied during revegetation. However, the difference in N more likely resulted from the recent removal of brush, which reduced plant uptake, warmed the soil, and increased mineralization of N. Ammonium N dominated the available N in both soils, consistent with that which predominates in acidic soils.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 25.

Species Names	*Inside*	*Outside*
Trees		
Betula papyrifera	•	
Picea glauca	•	•
Picea mariana	•	•
Populus balsamifera	•	
Populus tremuloides	•	
Total Trees	5	2
Shrubs		
Alnus crispa	•	•
Betula nana	•	•
Empterum nigrum	•	
Ledum decumbens		•
Ledum groenlandicum		•
Rubus chamaemorus		•
Salix glauca	•	
Salix planifolia ssp. pulchra	•	•
Spirea beauverdiana	•	•
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea		•
Total Shrubs	7	9
Forbs		
Epilobium angustifolium	•	
Equisetum arvense	•	•
Erigeron pulcherrima	•	
Taraxacum officinale	•	
Total Forbs	4	1
Grasses		
Alopecurus pratensis	•	
Calamagrostis lapponica	•	
Festuca altaica		•
Poa pratensis	•	
Total Grasses	3	1
Sedges		
Eriophorum vaginatum		•
Total Sedges	0	1
Total Vascular Species	***19***	***14***

Both ROW and undisturbed soils contained 1 ppm of available nitrate N. Available soil N was moderate at this location but more plentiful than that found at many other locations in our survey. Measurable available soil P was 21 ppm within the ROW soil and 1 ppm in the adjacent forest soil. This disparity was strong evidence of a carryover of P fertilizer from revegetation applications. Available P may be limiting in the forest soil, but it was more than adequate in soils within the ROW. Available K was 61 ppm inside the ROW and 23 ppm outside. This indicated the element was adequate in the ROW and may be limiting plant growth in the black spruce forest. The dissimilarity of values between soils indicated a possibility that K fertilizer had carried over from revegetation applications.

Within the ROW the organic mat consisted of plant debris and moss, up to 3 cm in thickness. The organic mat was a well-developed 15 cm layer of moss, lichens, and litter outside the ROW.

Twenty-five vascular plant species were recorded at this location. Nineteen were recorded within the ROW and 14 in the adjacent habitat. Two trees and five shrubs were common to both habitats. Only one forb and no grasses or sedges were common to the ROW and adjacent forest. This limited commonality of species between the habitats was due to differences in soil moisture and stages of plant succession.

Five tree species were found at this site. Only *Picea mariana* and *Picea glauca* were found in both habitats. Four shrub species (*Ledum decumbens, Ledum groenlandicum, Rubus chamaemorus* and *Vaccinium vitis-idaea*) occurred exclusively in the adjacent forest community.

Four forb species were recorded at this location. All occurred in the ROW. One forb, *Equisetum arvense*, was common to both habitats. *Taraxacum officinale* was the only exotic forb species found at this site. This species was introduced to the U.S. from Europe. *T. officinale* occurred at 21 disturbed sites along the ROW and may have been introduced during revegetation and/or moved to the site later by vehicles. Seeds of *T. officinale* may also have been carried by winds to this location. The species occurs widely in Alaska, especially around settlements, along roads, in disturbed soils, and is a common weed in fields, lawns, and gardens. It was found from the Chandalar Shelf southward in this survey.

Four grass species were found at this location. Three occurred in the ROW and one in the adjacent forest community. Two seeded grasses (*Alopecurus pratensis* and *Poa pratensis*) were persisting at this site, but no introduced grass species had invaded the adjacent forest community. It was interesting to note the absence of *Festuca rubra,* a seeded grass found at most locations along the pipeline route. Two indigenous grass species were found at this location, *Calamagrostis lapponica* and *Festuca altaica. Calamagrostis* was found only in the ROW, and *Festuca* only in the adjacent undisturbed habitat.

The only sedge found at this location was *Eriophorum vaginatum*, which form tussocks among the trees in the adjacent forest. *Eriophorum* did not occur within the ROW at this site.

No animals or animal signs were recorded at this location during the survey; however, squirrel, hare, bear, and moose are known to use the area.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #26

Date Examined:	22 July 1999
Location:	N65°55' 58.1"; W149°52' 02.5"; TAPS M.P. 346.9.
Pipeline:	Elevated
Slope:	Gently sloping south and west
Drainage:	Inside - drained; Outside - perched over permafrost
Vegetation:	Second growth mixed black spruce - aspen forest

Site No. 26 is located on a slope of the valley east of the tributary of the Ray River, about 7 mi north of the Yukon River. The location is east of the Dalton Highway, with the pipeline on the east side of the ROW and the road on the west side. The vegetation prior to construction was a mixed forest of black spruce and aspen. The natural recovery for this habitat initially consists of deciduous and evergreen trees and tall shrubs, such as alder and willow. Forest fire evidence was apparent at this location. Shrubs along the outer margins of the ROW were taller than those in the adjacent undisturbed forest. Shrubs and trees invading the ROW had been cut in past years. Deciduous trees, white, and black spruce were invading the ROW. Lichen was a notable colonizer under the pipeline and a prominent component of the forest floor (Photo 26-2). Vegetation occupied the ROW, except in the wheel tracks of the road, which were mostly bare soil or gravel. Grasses were common only along the margins of wheel tracks.

Soil reaction was alkaline both inside and outside the ROW (pH 8.09 and pH 7.96, respectively). Soil under the elevated pipe contained 56% gravel, while that outside contained no gravel. The greater gravel content of the ROW was from stony soil fill hauled to this location to provide support for traffic during and after construction. Soil moisture inside the ROW was 7.3% and outside about 37.8%. Total soil C values were low, at 0.22% within the ROW and 1.52% outside. Total soil N was also low at this location (below detection limits within the ROW and 0.04% outside). The C:N ratio outside was 38, relatively wide for undisturbed soil.

Available soil N was low, at 2 ppm for both ROW soils and the undisturbed soils. Available nitrate N was 2 ppm inside the ROW and 0 ppm outside. There appeared to be no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 3 ppm within the ROW soil and 2 ppm in the adjacent forest soil. There was probably no carryover of P fertilizer from revegetation. Available P may be limiting in both soils at this location. Available K was 66 ppm inside the ROW and 13 ppm outside. This indicated that element was adequate in the ROW and may be limiting plant growth in the forest. The dissimilarity of available K values indicates a possible carryover of K fertilizer applied during revegetation.

Within the ROW the organic mat consisted of lichens and plant debris up to 2 cm in thickness. Outside the ROW, the organic mat was a well-developed 16 cm layer of lichens, moss, and litter.

Forty-one plant species were recorded at this location. Thirty-three of these occurred within the ROW and 16 in the adjacent habitat. Only two trees, five shrubs, and one forb were common to both habitats. There were no grasses or sedges in common. The disparity of species between the two habitats was caused by

Photo 26-1. Vegetation under the pipeline includes naturally colonized lichens, shrubs and trees. Grasses appear in the roadway. Next to the forest, the ROW outer margin supports tall shrubs that have not been cut.

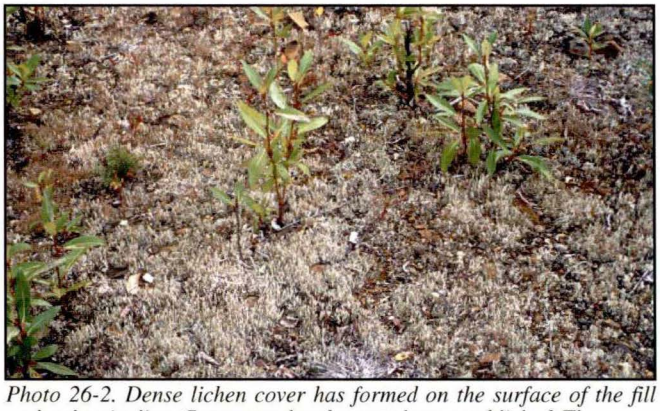


Photo 26-2. Dense lichen cover has formed on the surface of the fill under the pipeline. Cottonwood and spruce have established. The young trees in this photo appear to have been cut at least once.

Site No. 26 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	56.2	0
Moisture %	7.3	37.8
Total C %	0.22	1.52
Total N %	Not detectable	0.04
C:N ratio	Not applicable	38
Organic matter %	0.5	3.4
pH	8.09	7.96
NH_4-N (ppm)	2	2
NO_3-N (ppm)	2	Not detectable
P (ppm)	3	2
K (ppm)	66	13
Organic mat thickness (cm)	0.5 - 2	16

differences in moisture and stages of plant succession.

Of the five tree species found at this site, only *Picea mariana* and *Populus tremuloides* were found in both habitats. Thirteen shrub species were found at this location, nine in each habitat. Five shrub species were recorded in both habitats. Four shrub species were found exclusively in the ROW: *Alnus crispa, Arctostaphylos uva-ursi, Linnaea borealis,* and *Salix arbusculoides.* Similarly, four other shrub species occurred exclusively in the adjacent forest community: *Empetrum nigrum, Ledum groenlandicum, Rosa acicularis* and *Salix planifolia* ssp. *pulchra.*

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 26.

Species Names	Inside	Outside
Trees		
Betula papyrifera	•	
Picea glauca	•	
Picea mariana	•	•
Populus balsamifera	•	
Populus tremuloides	•	•
Total Trees	5	2
Shrubs		
Alnus crispa	•	
Arctostaphylos alpina	•	•
Arctostaphylos uva-ursi	•	
Empterum nigrum		•
Ledum groenlandicum		•
Linnaea borealis	•	
Potentilla fruiticosa	•	•
Rosa acicularis		•
Rubus arcticus	•	•
Salix arbusculoides	•	
Salix glauca	•	•
Salix planifolia ssp. pulchra		•
Shepherdia canadensis	•	•
Total Shrubs	9	9
Forbs		
Achillea sibirica	•	
Crepis capillaris	•	
Epilobium angustifolium	•	
Epilobium palustre	•	
Equisetum scirpoides		•
Erigeron acris	•	
Mertensia paniculata	•	•
Parnassia palustris	•	
Potentilla hookeriana	•	
Pyrola grandiflora		•
Senecio lugens	•	
Stellaria laeta	•	
Taraxacum officinale	•	
Thalespi arvense	•	
Total Forbs	12	3
Grasses		
Agropyron spp.	•	
Alopecurus pratensis	•	
Arctagrostis latifolia		•
Calamagrostis canadensis	•	
Festuca rubra	•	
Hordeum jubatum	•	
Poa pratensis	•	
Total Grasses	6	1
Sedges		
Carex bigelowii		•
Carex spp.?	•	
Total Sedges	1	1
Total Vascular Species	***33***	***16***

Fourteen forb species were recorded at this location. Twelve occurred in the ROW. Three forb species occurred in the adjacent forest. *Mertensia paniculata* was the only forb common to both habitats. Two introduced weed species, *Taraxacum officinale* and *Thlaspi arvense*, occurred only in the ROW and may have been introduced during revegetation and/or moved to the site later by vehicles. Seeds of *T. officinale* are air borne and may have been carried by winds to this location. Both weed species occur widely in Alaska, along roadsides, fields and settlements. The other twelve forbs found at this location were indigenous.

Seven grass species were found at this location. Six occurred in the ROW and one in the adjacent forest community. Three seeded species of grass (*Alopecurus pratensis, Festuca rubra,* and *Poa pratensis*) were recorded at this site. All three were introduced during revegetation. However, no introduced grass species had invaded the adjacent forest community. Four indigenous grass species were found at this location: *Agropyron* spp. *Arctagrostis latifolia, Calamagrostis canadensis* and *Hordeum jubatum. Arctagrostis* was found only in the undisturbed forest and was the only grass species within the forest. All other species were confined to the ROW.

Two sedges were found at this location, one in each habitat. *Carex bigelowii* was the only sedge found in the forest. An unidentified sedge was colonizing in the ROW.

Animals and animal signs observed at this location included bear, moose, wolf, ptarmigan, grey squirrel, and ants. This was the northernmost location where anthills were observed in this survey.

Photo 26-3. The adjacent forest consists of black spruce and aspen trees, with openings dominated by a thick lichen mat. Rose is the predominant shrub, and suppressed Festuca altaica *clumps are the most obvious herbaceous species in this image.*

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #27

Date Examined:	22 July 1999
Location:	N65°50' 36.2"; W149°34' 20.7"; TAPS M.P. 360.2.
Pipeline:	Elevated
Slope:	Gently sloping north
Drainage:	Inside - fair; Outside - fair
Vegetation:	Second growth mixed black spruce - aspen forest

Site No. 27 is located on the side of a valley that drains into the Yukon River, about 5 mi south of Pump Station 6. The location is west of the Dalton Highway, with the pipeline on the east side of the ROW and the road on the west. The vegetation prior to construction was a forest of black spruce. After the pipeline was built, a forest fire burned on the west side of the ROW. The fire probably occurred in 1997 or 1998, based on plant growth at the time of our survey. The fire stopped at the ROW. Natural recovery for this habitat initially consists of forbs, deciduous and evergreen trees and tall shrubs, such as alder and willow. Shrubs, trees and forbs had colonized much of the ROW, with the exception of wheel tracks in the road, which were partially bare soil and gravel. Grasses predominated along the margins of wheel tracks.

Shrubs along the outer margins of the ROW were taller than those in the adjacent undisturbed forest. Shrubs and trees invading the ROW had been cut in past years. Deciduous trees, white spruce and black spruce were invading the ROW. Moss and lichen were colonizers under the pipeline and prominent components of the forest floor. The willow *Salix planifolia* ssp. *pulchra* and the current growth of black spruce were infected with the same rust observed at Site No. 26.

Soil reaction was alkaline (pH 8.08) inside the ROW, and acidic (pH 6.16) outside. Soil under the elevated pipe contained 70% gravel, while that outside contained no gravel. The greater gravel content of the ROW was from stony soil fill hauled to this location to provide support for traffic during and after construction. Soil moisture inside the ROW was 10.5% and outside about 96.4%. Total soil C was 1.14% and 1.94%, respectively. These values are moderate. Organic matter was calculated as 2.5% and 4.3% in the ROW and outside, respectively.

Total soil N was relatively low at 0.02% within the ROW

Site No. 27 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	70.1	0
Moisture %	10.5	96.4
Total C %	1.14	1.94
Total N %	0.02	0.08
C:N ratio	57	24.3
Organic matter %	2.5	4.3
pH	8.08	6.16
NH_4-N (ppm)	Not detectable	2
NO_3-N (ppm)	1	Not detectable
P (ppm)	3	Not detectable
K (ppm)	90	12
Organic mat thickness (cm)	3	18

Photo 27-1. The ROW at this site is covered with vegetation, except for wheel tracks. The area beneath the pipe and next to the road are becoming overgrown with shrubs and small trees. These woody plants appeared to have been cut in prior years. Grasses dominate next to and between wheel tracks.

Photo 27-2. The adjacent black spruce forest with an understory of heath shrubs and diamond-leaf willow. A mat of lichens covers the forest floor.

and 0.08% outside. C:N for soil within the ROW was 57 and was 24 outside. Available ammonium N was also low; it was below detection limits inside the ROW, and 2 ppm in the undisturbed soil. Available nitrate N was 1 ppm and below detection limits, respectively. There appeared to be no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 3 ppm within the ROW soil and below detection limits in the adjacent forest soil. There may have been limited carryover of P fertilizer from revegetation. Available P may be limiting in both soils at this location. Available K was 90 ppm inside the ROW and 12 ppm outside. This indicated that element was adequate in the ROW but may be limiting plant growth in the forest. The dissimilarity of values between soils indicated a carryover of K fertilizer applied during revegetation.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 27.

Species Names	Inside	Outside
Trees		
Betula papyrifera	•	
Picea glauca	•	
Picea mariana	•	•
Picea mariana	•	
Total Trees	4	1
Shrubs		
Alnus crispa	•	
Arctostaphylos rubra	•	
Empetrum nigrum	•	•
Salix alaxensis	•	
Salix glauca	•	
Salix planifolia ssp. pulchra	•	•
Shepherdia canadensis	•	
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea	•	
Betula nana		•
Ledum groenlandicum		•
Rubus chamaemorus		•
Total Shrubs	9	6
Forbs		
Achillea borealis	•	
Achillea sibirica	•	
Crepis capillaris	•	
Epilobium angustifolium	•	
Equisetum arvense	•	•
Erigeron pulcherrima	•	
Matricaria matricarioides	•	
Polygonum aviculare	•	
Potentilla hookeriana	•	
Pyrola grandiflora	•	
Taraxacum officinale	•	
Thlaspi arvense	•	
Petasites frigidus		•
Total Forbs	12	2
Grasses		
Agropyron spp.	•	
Alopecurus pratensis	•	
Bromus inermis	•	
Festuca altaica	•	•
Poa arctica	•	
Poa pratensis	•	
Puccinellia borealis	•	
Arctagrostis latifolia		•
Calamagrostis lapponica		•
Total Grasses	7	3
Sedges		
Total Sedges	0	0
Total Vascular Species	**32**	**12**

Within the ROW the organic mat consisted of mosses, lichens and plant debris up to 3 cm in thickness. The organic mat outside the ROW was a well-developed 18 cm layer of lichens, moss, and litter.

Thirty-eight plant species were recorded at this location. Thirty-two of these were recorded within the ROW and 12 in the adjacent habitat. Only one tree, three shrub, one forb, and one grass species were common to both habitats. No sedges were found at this location. Limited commonality of species between the ROW and adjacent natural plant communities was due to differences in habitat moisture and stages of plant succession.

Four tree species were found at this site. All four were present in the ROW, and one (*Picea mariana*) occurred in the adjacent forest. Twelve shrub species were found at this location. Three species were common in both habitats: *Empetrum nigrum, Salix planifolia* ssp. *pulchra,* and *Vaccinium uliginosum*. Three shrub species were found exclusively in the adjacent forest: *Betula nana, Ledum groenlandicum,* and *Rubus chamaemorus*. Six shrub species occurred exclusively in the ROW.

Thirteen forb species were recorded at this location. Twelve occurred in the ROW. Three forb species occurred in the adjacent forest. *Equisetum arvense* was the only forb common to both habitats. Four introduced weed species (*Matricaria matricarioides, Polygonum aviculare, Taraxacum officinale* and *Thlaspi arvense*) occurred within the ROW and may have been introduced during revegetation and/or moved to the site later by vehicles and/or wind. No weed species occurred outside the ROW. All four weed species occur widely in Alaska, along roadsides, fields and settlements. The other nine forbs found at this location were indigenous.

Nine grass species were found at this location. Seven occurred in the ROW and three in the adjacent forest and burned community. Three exotic species of grass (*Alopecurus pratensis, Bromus inermis,* and *Poa pratensis*) were recorded at this site. All three had been introduced during revegetation. *Festuca rubra* was conspicuously absent from our data. No introduced grass species had invaded the adjacent forest community. Six indigenous grass species were found at this location: *Agropyron* spp. *Festuca altaica, Poa arctica, Puccinellia borealis, Arctagrostis latifolia,* and *Calamagrostis lapponica.* Three indigenous grasses were found outside the ROW: *Festuca altaica, Arctagrostis latifolia,* and *Calamagrostis lapponica.*

Animals and signs observed here included moose and hare.

Photo 27-3. On the west side of the ROW, a wildfire destroyed the forest. Fireweed, forbs and sprouting shrubs have begun to occupy this burned area.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #28

Date Examined:	22 July 1999
Location:	N65°29' 26.5"; W148°41' 26.4"; TAPS M.P. 396.
Pipeline:	Buried
Slope:	Moderate grading to steep northward
Drainage:	Inside - well drained; Outside - perched over permafrost
Vegetation:	Closed canopy, mixed spruce - alder forest

Site No. 28 is located on an east-west ridge that drains into the West Fork of Livengood Creek. This site is just north of the Dalton and Elliott highway junction. The location is west of the Dalton Highway, with the buried pipeline in the middle of the ROW. The road is on the west side of the pipeline, which is elevated northward from this location. Vegetation prior to construction was a second growth forest of black spruce and alder. The forest floor consists of a complex of feather moss, lichens, and shrubs. Shrubby cinquefoil, sedge, and bluebells are the predominant understory vascular plant species in the forest. The natural recovery for this habitat initially consists of bluejoint reedgrass, forbs (fireweed), deciduous and evergreen trees and tall shrubs, such as alder, heath shrubs, and at least two willow species. Willows are not as significant at this location as they are in other habitats. Vegetation occupied the ROW, except in the wheel tracks of the road. Shrubs and trees invading the ROW had been cut in past years. This brushing action appeared to have caused significant disturbance to moss and lichens that are attempting to colonize open ground within the ROW (Photo 28-3). Deciduous trees, white spruce, black spruce, and shrubs were invading the ROW. Tall larkspur (*Delphinium glaucum*), a forb poisonous to some ungulate grazers, was observed in both the ROW and the adjacent forest at this site. Moss and lichen colonize over the pipeline and are prominent components of the natural forest floor; however, the species of these lichens and mosses differ between the two habitats (Photos 23-3 and 23-4). The wheel tracks in the ROW roadway were mostly vegetated.

Soil reaction was alkaline inside the ROW (pH 8.04) and slightly alkaline outside (pH 7.36). Soil over the buried pipe contained 68% gravel, and adjacent forest soil was 64% gravel. These similar gravel contents reflect their similarity of soils; no stony fill was hauled to this location during construction. Soil moisture inside the ROW was about 9% and outside about 29%. Total soil C was 3.63% within the ROW and 3.97% outside, both moderate values. Organic matter was estimated at 8% and 9% for the ROW and forest soils, respectively. Total soil N was relatively low at 0.01% within the ROW and 0.10% outside, at this location. C:N ratio for the ROW was 363, and was 39.7 for the forest soil. These are very wide ratios.

The amount of available soil N was low at this location both inside and outside the ROW. Available ammonium N was 1 ppm in the ROW and 2 ppm in the undisturbed soil. Available nitrate N was 3 ppm inside the ROW and below detection limits in the undisturbed area. Although available N within the ROW was greater, there was probably no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 15 ppm within the ROW soil and 11 ppm in the adjacent forest soil. These are values adequate for vegetation. Any carryover of P fertilizer from revegetation would have been minimal. Available

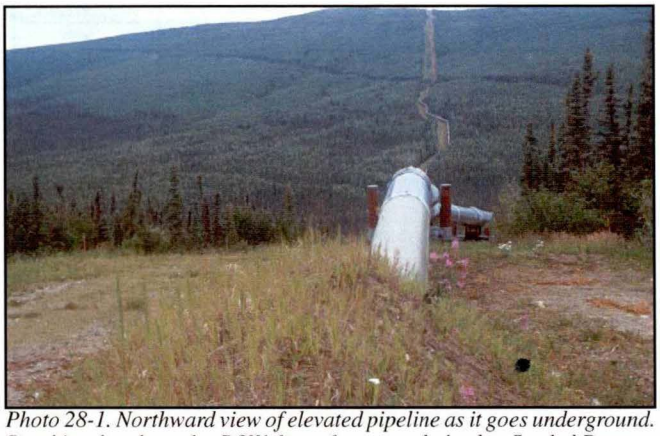


Photo 28-1. Northward view of elevated pipeline as it goes underground. Brushing has kept the ROW free of trees and shrubs. Seeded Bromus inermis *occupies the mound of soil over the buried pipe.*

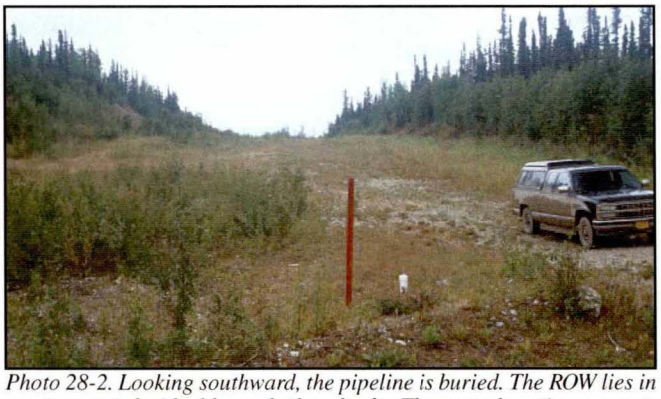


Photo 28-2. Looking southward, the pipeline is buried. The ROW lies in a cut vegetated with alder and other shrubs. The central portion supports mostly grasses and has been brushed to remove invading trees and shrubs.

Site No. 28 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	68.0	63.5
Moisture %	9.2	29.0
Total Cn %	3.63	3.97
Total N %	0.01	0.10
C:N ratio	363	39.7
Organic matter %	8.1	8.8
pH	8.04	7.36
NH_4-N (ppm)	1	2
NO_3-N (ppm)	3	Not detectable
P (ppm)	15	11
K (ppm)	22	24
Organic mat thickness (cm)	0 - 1.5	26.7

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 28.		
Species Names	*Inside*	*Outside*
Trees		
Calamagrostis lapponica	•	
Picea glauca	•	
Picea mariana	•	•
Populus balsamifera	•	
Populus tremuloides	•	
Total Trees	5	1
Shrubs		
Alnus crispa	•	•
Arctostaphylos alpina		•
Arctostaphylos uva-ursi	•	
Ledum groenlandicum		•
Potentilla fruticosa	•	•
Rosa acicularis		•
Salix alaxensis	•	
Salix barclayi	•	
Shepherdia canadensis	•	
Spirea beauverdiana		•
Vaccinium uliginosum		•
Vaccinium vitis-idaea		•
Viburnum edule		•
Total Shrubs	6	9
Forbs		
Achillea borealis	•	
Achillea sibirica	•	
Crepis capillaris	•	
Delphinium glaucum	•	•
Epilobium angustifolium	•	
Erigeron acris	•	
Galium boreale	•	
Geocaulon lividum		•
Matricaria matricarioides	•	
Mertensia paniculata	•	•
Petasites frigidus		•
Plantago major var. peligre	•	
Polemonium acutiflorum	•	
Senecio lugens	•	
Stellaria laeta	•	
Taraxacum officinale	•	
Thalespi arvense	•	
Trifolium hybridum	•	
Total Forbs	16	4
Grasses		
Agropyron spp.	•	
Agrostis scabra	•	
Bromus inermis	•	
Calamagrostis canadensis		•
Festuca rubra	•	
Poa pratensis	•	
Total Grasses	5	1
Sedges		
Carex bigelowii		•
Total Sedges	0	1
Total Vascular Species	***30***	***16***

K was 22 ppm inside the ROW and 24 ppm outside; this element was deficient to marginally adequate in both habitats. The similarity of these values indicated that K fertilizer applied during revegetation had not carried over, and that these two soils had similar origins.

The organic mat within the ROW was comprised of mosses, lichens and plant debris up to 1.5 cm thick. The adjacent organic mat was a well-developed 26.7 cm layer of lichens, moss, and litter.

Forty-three vascular plant species were recorded at this location, 30 in the ROW and 16 in the adjacent forest habitat. Only one tree, two shrub, and two forb species were common to both habitats. Of the six grasses and one sedge species found at this location, none were common to both habitats. This disparity of species was caused by revegetation and by differences in stages of plant succession. The more advanced vegetation of the forest maintained a cooler and more moist soil than that within the ROW.

Five tree species were found at this site. All tree species were present in the ROW, while only one (*Picea mariana*) occurred in the adjacent forest. Of the thirteen shrub species found at this location, two (*Alnus crispa* and *Potentilla fruticosa*) were common in both habitats. Seven shrub species were found exclusively in the adjacent forest: *Arctostaphylos alpina, Ledum groenlandicum, Rosa acicularis, Spirea beauverdiana, Vaccinium uliginosum, V. vitis-idaea,* and *Viburnum edule.* Three shrub species occurred exclusively in the ROW: *Arctostaphylos uva-ursi, Salix alaxensis, and Shepherdia canadensis.*

Eighteen forb species were recorded at this location. Sixteen occurred in the ROW, and four occurred in the adjacent forest. *Delphinium glaucum* and *Mertensia paniculata* were the only forbs common to both habitats. Four introduced weed species (*Crepis capillaris, Matricaria matricarioides, Taraxacum officinale* and *Thlaspi arvense*) occurred within the ROW; they may have been introduced during revegetation or moved to the site later by vehicles and/or wind. An exotic clover (*Trifolium hybridum*) was also found in the ROW, bringing the total introduced species at this location to five. *T. hybridum* (alsike clover) was found at 12 sites within the ROW. This was our northernmost record of the species. The plant was found at each site from this location to the Delta Junction vicinity. It was absent from Donnelly Dome and through the Alaska Range, not reappearing until Site 49 in the Chugach Mountain range. It was not on the Alyeska Pipeline Service Co.'s list of seeded species. It may have been introduced with hay and straw mulches. In this survey, it was never found outside the area disturbed by construction. This legume was reported growing on the TAPS ROW by Land Design (1979d) and Native Plants Inc. (1980). Land Design considered it important for building soil N. Native Plants (undated) regarded clover seeding an important revegetation component for the proposed Northwest natural gas pipeline corridor, even though it is not a species indigenous to Alaska.

Another weedy species, *Plantago major* var. *pilgeri*, was present within the ROW. Hultén (1969) indicated this species was first described in Bohemia, but was perhaps a native of Alaska. The plant is considered a weed, regardless of its origin. None of the exotic plant species occurred outside the ROW. All of these introduced species occur widely in Alaska, along roadsides, fields

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #28
Date Examined:	22 July 1999
Location:	N65°29' 26.5"; W148°41' 26.4"; TAPS M.P. 396.
Pipeline:	Buried
Slope:	Moderate grading to steep northward
Drainage:	Inside - well drained; Outside - perched over permafrost
Vegetation:	Closed canopy, mixed spruce - alder forest

Continued

and settlements. All other forbs found at this location were indigenous.

Six grass species were found at this location. Five occurred in the ROW and one in the adjacent forest. Two exotic species of grass, *Bromus inermis* and *Poa pratensis*, were recorded at this site. One weedy grass, *Agrostis scabra,* was also found. This species is indigenous to North America, and because it is unpalatable to grazers and usually invades poor open soils, it is often considered a weedy grass. *Festuca rubra* is an indigenous species to Alaska; however, the species was most likely introduced to this portion of the ROW during revegetation, along with *Bromus* and *Poa*. No introduced grass species had invaded the adjacent forest community. The only grass found in the forest was *Calamagrostis canadensis*, which is indigenous and was not apparent within the ROW. The only other indigenous grass species at this site was *Agropyron* spp., which occurred exclusively in the ROW.

One sedge species was found at this location, *Carex bigelowii*. This indigenous sedge was found only within the ROW at this location.

Animals and animal signs observed at this location included wolf, grey squirrel, and ants.

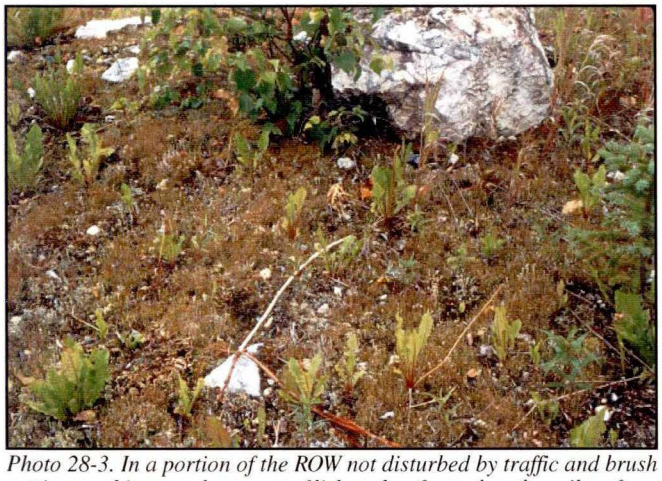


Photo 28-3. In a portion of the ROW not disturbed by traffic and brush cutting machinery, a dense mat of lichens has formed on the soil surface. Dandelion, an introduced weed, grows among the lichens. Paper birch and white spruce seedlings are in this image.

Photo 28-4. The adjacent spruce forest at this location has an understory of alder, low heath shrubs and lichens.

This page deliberately left blank

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #29
Date Examined:	9 September 1999
Location:	N65°23' 58.6"; W148°27' 02.8"; TAPS M.P. 406.
Pipeline:	Buried
Slope:	Steep southward
Drainage:	Inside - well drained; Outside - drained
Vegetation:	Closed canopy, mixed spruce-birch forest

Photo 29-1. Southward view of buried section of pipeline. The ROW in this location is heavily invaded by shrubs and trees. This section was recently brushed to control these woody species, which will allow grasses and herbs to predominate for a short time. The roadway is largely barren gravel. Water bars to control runoff are evident on the distant slope.

Site No. 29 is located on a steep south-facing slope on the north side of Slate Creek valley. This site is approximately 6.5 mi north of Pump Station 7. A marker from the 1970s was found east of the ROW. Labeling on the marker indicated it was a bore hole site for Northwest Pipeline Company, which was planning a natural gas pipeline. The location is about 5 miles west of the Dalton Highway. The buried pipeline is in the middle of the ROW. The road is on the east side of the pipeline, which is elevated just north and south from this location. Vegetation prior to construction was a second growth forest of black spruce and birch. The forest floor consists of a complex of litter, moss, lichens, and shrubs. Wildfire is a common natural disturbance. The natural recovery for this habitat initially consists of bluejoint reedgrass, forbs (fireweed), deciduous and evergreen trees and tall shrubs, such as alder, heath shrubs, and willow species. Willows are more significant at this location than they are at Site No. 28. However, heath shrubs were the dominant understory within the undisturbed forest. Grass-forb vegetation occupied the ROW, except in the road. Shrubs and trees invading the ROW had been recently cut. This brushing action encouraged the herbaceous ROW plant species by reducing competition from shrubs and trees. Without brushing, this section of ROW would be dominated by willow, alder, and trees. There was a limited amount of moss colonizing the ROW. The roadway within the ROW was mostly barren and very stony.

Soil reaction was slightly acidic (pH 6.59) inside the ROW and acidic (pH 5.43) outside. Soil over the buried pipe contained 70% gravel, while that of the adjacent forest contained 2.6 % gravel. The dissimilarity in gravel content indicated stony subsoil

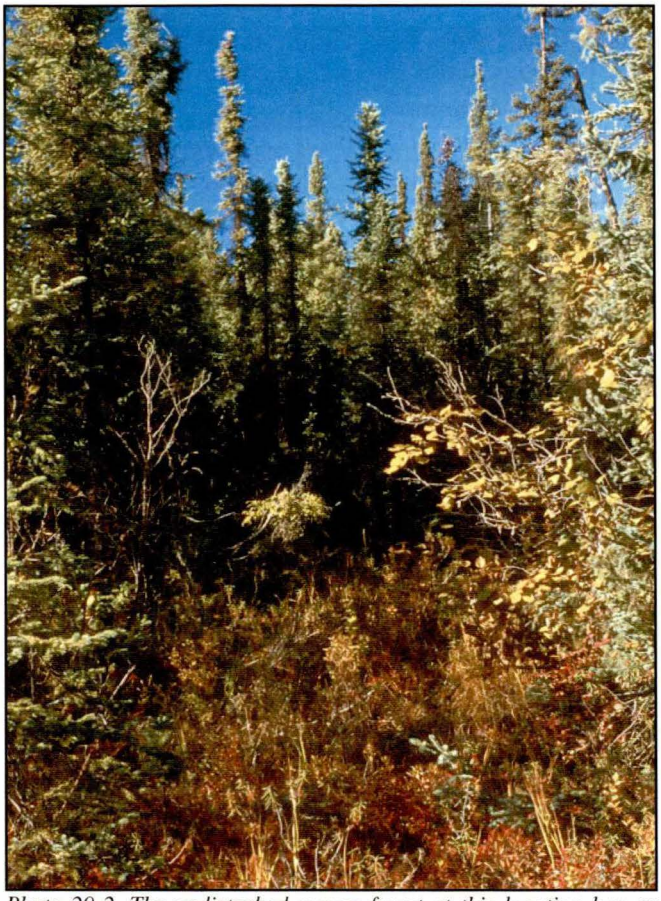


Photo 29-2. The undisturbed spruce forest at this location has an understory of heath shrubs and willow.

Site No. 29 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	70.0	2.6
Moisture %	13.2	36.1
Total C %	2.55	4.18
Total N %	0.18	0.19
C:N ratio	14.2	22
Organic matter %	5.7	9.3
pH	6.59	5.43
NH_4-N (ppm)	3	Not detectable
NO_3-N (ppm)	Not detectable	Not detectable
P (ppm)	11	3
K (ppm)	89	33
Organic mat thickness (cm)	0 - 0.5	3 - 5

was on the surface over the buried pipe. Stony fill may have been hauled to this location to build up the roadway. The roadway appeared to contain more stones than the soil over the pipeline. Soil moisture inside the ROW was about 13% and outside about 36%. Total soil C within the ROW and outside was 2.55% and 4.18%, respectively. These values are moderate to low, indicating an organic matter content for the ROW soil at 5.6%, and 9.3% for the forest soil. Total soil N is relatively low at this location, at 0.18% within the ROW and 0.19% outside. C:N ratios were 14 and 22, respectively, for ROW and forest.

The amount of available soil N was low at this location both inside and outside the ROW. Ammonium N was the only form detected in these soils. This is consistent with ammonium N predominating over nitrate N in acidic soils. Ammonium N was 3 ppm within the ROW, and below detection limits in the undisturbed soil. Available nitrate N was below detection limits in both soils. There was probably no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 11 ppm within the ROW soil and 3 ppm in the adjacent forest soil. These values are adequate within the ROW and marginally adequate outside. The higher available P in the ROW indicates a possible carryover of P fertilizer from revegetation at this location. Available K was 89 ppm inside the ROW and 33 ppm outside. This indicated that element was adequate in the ROW, and deficient to marginally adequate in the forest soil. The large disparity between available K levels indicated either a carryover of K fertilizer applied during revegetation or an inherently higher K content of the subsoil.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 29.

Species Names	Inside	Outside
Trees		
Betula papyrifera	•	•
Picea mariana	•	•
Picea glauca		•
Total Trees	2	3
Shrubs		
Alnus sinuata	•	
Salix glauca	•	
Salix myrtillifolia	•	
Salix scouleriana	•	•
Spirea beauverdiana	•	•
Ledum groenlandicum		•
Rosa acicularis		•
Vaccinium uliginosum		•
Vaccinium vitis-idaea		•
Total Shrubs	5	6
Forbs		
Achillea borealis	•	
Achillea sibirica	•	
Cornus canadensis	•	•
Crepis elegans	•	
Epilobium angustifolium	•	
Matricaria matricarioides	•	
Polygonum aviculare	•	
Potentilla hookeriana	•	
Taraxacum officinale	•	
Thalespi arvense	•	
Trifolium hybridum	•	
Equisetum arvense		•
Lycopodium annotinum		•
Petasites frigidus		•
Total Forbs	11	4
Grasses		
Alopecurus pratensis	•	
Bromus inermis	•	
Calamagrostis canadensis	•	•
Festuca rubra	•	
Phleum pratense	•	
Poa pratensis	•	
Festuca altaica		•
Total Grasses	6	2
Sedges		
Total Sedges	0	0
Total Vascular Species	***24***	***15***

Within the ROW the organic mat consisted of plant debris up to 0.5 cm in thickness. There was some moss and lichen (*Stereocaulon* spp.) colonizing within the ROW. That particular lichen species often appears on relatively dry, rocky soil. The organic mat (3 - 5 cm) was not highly developed in the adjacent forest, in contrast to that usually found in valley bottoms and on north-facing slopes in this region. Sphagnum, *Holcomium* spp., mosses, and *Cladonia* spp. lichens were the prominent living portions of the forest soil organic mat. These vegetation and soil features of the forest habitat are representative of relatively warm, dry south-facing slopes in the region.

Thirty-three plant species were recorded at this location. Twenty-four were recorded within the ROW and 15 in the adjacent forest habitat. Only two tree, two shrub, and one forb species were common to both habitats. Of the seven grasses were found at this location, only one was common to both habitats. No sedge species were found at this location. Limited commonality of species between the ROW and adjacent natural plant communities was caused by disturbance, revegetation and differences in stages of plant succession. The more advanced vegetation of the forest maintained a cooler and more moist soil than that of the ROW.

Three tree species were found at this site. All were present in the adjacent forest, and two (*Picea mariana* and *Betula papyrifera*) occurred within the ROW. *Picea glauca* recorded in the forest was not found within the ROW; however, it is likely that species was colonizing, but simply missed in our inventory which was taken soon after the ROW had been brushed. Nine shrub species were found at this location. Two were common in both habitats: *Salix scouleriana* and *Spirea beauverdiana*. Four shrub species were found exclusively in the adjacent forest: *Ledum groenlandicum, Rosa acicularis, Vaccinium uliginosum,* and *V. vitis-idaea.* Three shrub species occurred exclusively in the ROW: *Alnus sinuata, Salix glauca,* and *Salix myrtillifolia.*

Fourteen forb species were recorded at this location. Eleven occurred in the ROW, and four in the adjacent forest. *Cornus canadensis* was the only forb common to both habitats. Four introduced weed species (*Matricaria matricarioides, Polygonum aviculare, Taraxacum officinale*, and *Thlaspi arvense*) occurred within the ROW and were probably introduced during revegetation or moved to the site later by vehicles and/or wind. An exotic clover (*Trifolium hybridum*) was also found in the ROW, bringing the total introduced forb plant species at this location to five. (See discussion in Site 28.) None of the exotic plant species occurred outside the ROW. All of these introduced species occur widely in Alaska, along roadsides, fields and settlements. All other

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #29
Date Examined:	9 September 1999
Location:	N65°23' 58.6"; W148°27' 02.8"; TAPS M.P. 406.
Pipeline:	Buried
Slope:	Steep southward
Drainage:	Inside - well drained; Outside - drained
Vegetation:	Closed canopy, mixed spruce-birch forest

Continued

forbs found at this location were indigenous.

Seven grass species were found at this location. Six occurred in the ROW and two in the adjacent forest. Four exotic species of grass (*Alopecurus pratensis, Bromus inermis, Phleum pratense,* and *Poa pratensis*) were recorded at this site. *Festuca rubra* is an indigenous species to Alaska; however, the species was most likely introduced to this portion of the ROW during revegetation, along with the exotic forage grasses. No introduced grass species had invaded the adjacent forest community. The only grasses found in the forest were *Calamagrostis canadensis* and *Festuca altaica*, both of which are indigenous. *Calamagrostis* occurred in the forest and the ROW, but *Festuca altaica* occurred exclusively in the forest.

No sedges were found at this location. Absence of sedges was further evidence that this south-facing habitat is relatively dry.

Animals and animal signs observed at this location included moose, hare, and grey squirrel.

Photo 29-3. On the distant hills to the east, yellow fall colors accent the drainage patterns, which are lined with deciduous trees. This contrast between the deciduous foliage and the evergreen forest will likely appear within the ROW after the pipeline is removed, and natural recolonization reclaims the ROW.

This page deliberately left blank

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #30

Date Examined:	22 July 1999
Location:	N65°19' 31.1"; W148°19' 36.7"; TAPS M.P. 412.3.
Pipeline:	Elevated
Slope:	Flat, gently toward the west
Drainage:	Inside - moderate to poor; Outside - poor
Vegetation:	Closed canopy, mixed spruce-birch forest

Site No. 30 is located in the bottom of the Tatalina River valley. This site is at the north end of the river bridge, approximately 1/8 mi north of Pump Station 7, and 1/8 mi west of the Dalton Highway. The elevated pipeline is in the east side of the ROW. The road is on the west side of the pipeline. Vegetation prior to construction was a complex of mixed spruce and birch forest and scrub black spruce bog. The forest floor consists of litter, moss, lichens, grasses and shrubs. Much of the area at this site is a bog. A floating bog borders the east edge of the ROW. Wildfire and flooding from beaver dams are the two most common types of natural disturbance in the area. Fires probably stop when they reach this wet area, and if they do burn across it, crown fires may kill the trees without removing the organic mat on the forest floor. The plant species recovering from disturbances will vary, depending on degree of drainage on microhabitats. Sedges and grasses generally occupy the wetter portions, while trees and shrubs predominate in the better drained niches. Shrubs and trees invading the ROW had been cut the summer prior to this inventory. This brushing action was keeping the trees and shrubs from developing, otherwise this section of ROW would be dominated by willow, alder, and trees. The roadway within the ROW was mostly barren and very stony. Grasses dominated only along the margins of the roadway. Trees and shrubs dominated the ROW plant community beyond the road and under the pipeline. Moss and lichen (*Stereocaulon* and *Cladonia*) were colonizing within the ROW. Moss and lichens (*Cladonia* and *Peltigera*) occurred on the forest floor.

Soil reaction was slightly acidic (pH 6.84) inside the ROW and acidic (pH 5.41) outside. Soil under the elevated pipe contained about 65% gravel, and that of the forest contained no gravel. The difference in gravel content indicated that stony fill had been hauled to this location to provide a stable surface for construction and operation of the pipeline. Subsurface material cut to install VSMs was another source of rock. Gravel (mainly broken stones) had been hauled to this location to build up the roadway. The roadway appeared to contain more stones than the soil under the pipeline. Soil moisture inside the ROW was about 11% and outside about 193%. Total soil C was 1.01% within the ROW and 7.82% in the adjacent soils, translating to 2.2% and 17.4% organic matter, respectively. C content of the ROW was low, while that of the forest was moderate to high. Organic matter was estimated at 2.2% for the ROW soil and 17.4$ for the adjacent forest. Total soil N was relatively low (0.11%) within the ROW and moderate (0.33%) in the forest soil at this location. C:N ratio for ROW soil was calculated at 9.2 and about 24 for the forest soil.

The amount of available soil N was low at this location, both inside and outside the ROW. Ammonium N was the only form detected in both soils. In the undisturbed area, available

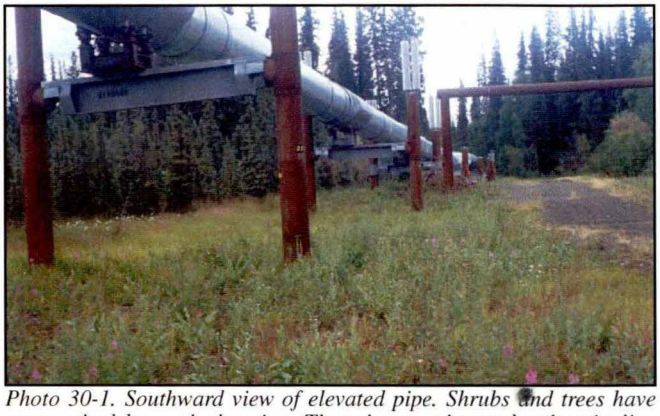


Photo 30-1. Southward view of elevated pipe. Shrubs and trees have encroached beneath the pipe. Though recently cut by the pipeline company, the stumps have sprouted and are rapidly replacing the canopy. The roadway is largely barren gravel, lined with low grasses.

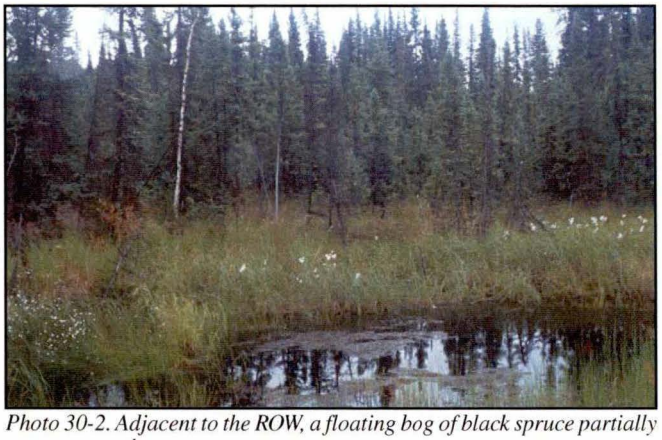


Photo 30-2. Adjacent to the ROW, a floating bog of black spruce partially covers a pond.

Site No. 30 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	64.5	0
Moisture %	10.9	193.8
Total C %	1.01	7.82
Total N %	0.11	0.33
C:N ratio	9.2	23.7
Organic matter %	2.2	17.4
pH	6.84	5.41
NH_4-N (ppm)	2	2
NO_3-N (ppm)	1	Not detectable
P (ppm)	8	2
K (ppm)	60	39
Organic mat thickness (cm)	0 - 6	29

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 30.		
Species Names	*Inside*	*Outside*
Trees		
Betula papyrifera	•	•
Picea glauca	•	•
Picea mariana		•
Populus balsamifera	•	
Populus tremuloides	•	
Total Trees	4	3
Shrubs		
Alnus crispa	•	
Ledum decumbens		•
Ledum groenlandicum		•
Ribies triste		•
Rosa acicularis		•
Rubus arcticus	•	
Rubus chamaemorus		•
Salix alaxensis	•	
Salix bebbiana	•	
Salix glauca	•	
Salix myrtillifolia		•
Salix planifolia ssp. pulchra	•	•
Spirea beauverdiana		•
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea	•	•
Total Shrubs	8	10
Forbs		
Achillea sibirica	•	
Cornus canadensis	•	
Dracocephalum parviflorum	•	
Epilobium angustifolium	•	
Epilobium palustre	•	
Equisetum arvense	•	•
Erigeron acris	•	
Parnassia palustris	•	
Plantago major var. peligre	•	
Polygonum alaskanum	•	
Potentilla hookeriana	•	
Potentilla palustris		•
Stellaria longipes		•
Taraxacum officinale	•	
Thlaspi arvense	•	
Thalictrum sparsiflorum		•
Trifolium hybridum	•	
Total Forbs	14	4
Grasses		
Agropyron spp.	•	
Agrostis scabra	•	
Alopecurus pratensis	•	
Arctophila fulva		•
Bechmannia erucaeformis	•	
Calamagrostis canadensis	•	•
Festuca altaica	•	
Festuca rubra	•	
Hordeum jubatum	•	
Poa pratensis	•	
Puccinellia borealis	•	
Total Grasses	10	2
Sedges		
Carex aquatilis		•
Carex rhynchophysa		•
Eriophorum vaginatum		•
Total Sedges	0	3
Total Vascular Species	***36***	***22***

ammonium N was 2 ppm, and nitrate N was below detection limits. Nitrate N (1 ppm) was detected only in the ROW soil. There was probably no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 8 ppm within the ROW soil and 2 ppm in the adjacent forest soil. These values are low to slightly adequate within the ROW soil, and possibly limiting in the undisturbed soils. The slightly higher available P in the ROW indicates a possible carryover of P fertilizer from revegetation at this location. Available K was 60 ppm inside the ROW and 39 ppm outside. This indicated that K was adequate in the ROW, and possibly deficient to marginally adequate in the forest soil. The difference in available K levels indicates a possible carryover of K fertilizer applied during revegetation.

Within the ROW the organic mat consisted of plant debris up to 6 cm in thickness. The organic mat was well developed (29 cm) in the adjacent forest. The organic mat outside the ROW was typical for these wet habitats.

Fifty-two vascular plant species were recorded at this location. Thirty-six were recorded within the ROW and 22 in the adjacent forest habitat. Only two tree, three shrub, one forb, and one grass species were common to both habitats. Limited commonality of species between the ROW and adjacent natural plant communities was caused by revegetation and by differences in habitat moistness and stages of plant succession. The more advanced vegetation of the forest maintained a cooler, moister soil than that within the ROW. Fill placed within the ROW created a drier habitat than that of the forest-bog complex.

Five tree species were found at this site. Three tree species were present in the adjacent forest, and four occurred within the ROW. *Betula papyrifera* and *Picea glauca* were found in both habitats. *Picea mariana* occurred only in the undisturbed bog community, while *Populus balsamifera* and *Populus tremuloides* occurred only in the ROW. Sixteen shrub species were found at this location. Ten shrub species were found in the forest, and eight in the ROW. Two species (*Vaccinium uliginosum* and *Vaccinium vitis-idaea*) were common in both habitats. Six shrub species were found only within the ROW: *Alnus crispa, Rubus arcticus, Salix alaxensis, Salix bebbiana, Salix glauca,* and *Salix scouleriana* (?).

Seventeen forb species were recorded at this location. Fourteen occurred in the ROW. Four forb species occurred in the adjacent forest-bog complex. *Equisetum arvense* was the only forb common to both habitats. Two indigenous weedy forbs, *Dracocephalum parviflorum* and *Plantago major* var. *pilgeri*, were found at this location. Two introduced weedy forbs, *Taraxacum officinale* and *Thlaspi arvense,* occurred within the ROW and were likely either introduced during revegetation, or moved to the site later by vehicles and/or wind. An exotic clover (*Trifolium hybridum*) was also found in the ROW, bringing the total introduced forb species at this location to three. (See discussion in Site 28.) None of the exotic plant species occurred outside the ROW. All of these introduced species occur widely in Alaska, along roadsides, fields and settlements. All other forbs found at this location were indigenous.

Eleven grass species were found at this location. Ten occurred in the ROW and two in the adjacent forest. Two indigenous grass species are often considered as weeds: *Agrostis scabra* and *Hordeum jubatum.* Two exotic species of forage grass, *Alopecurus pratensis* and *Poa pratensis,* were recorded at this site. *Bechmannia erucaeformis* was found within the ROW. It is a naturalized introduction from Siberia, according to Hultén (1969).

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #30

Date Examined:	22 July 1999
Location:	N65°19' 31.1"; W148°19' 36.7"; TAPS M.P. 412.3.
Pipeline:	Elevated
Slope:	Flat, gently toward the west
Drainage:	Inside - moderate to poor; Outside - poor
Vegetation:	Closed canopy, mixed spruce-birch forest

Continued

How this species arrived at this site is unclear. It may have been part of the natural vegetation along the stream, or introduced as a contaminant in seed during revegetation. *Bechmannia* may also have been carried to the site by vehicles. *Festuca rubra* is an indigenous species to Alaska; however, the species does not occur in forest-bog communities and was most likely introduced to this portion of the ROW during revegetation. No introduced grass species had invaded the adjacent forest and communities. The only grasses found in the undisturbed habitats were indigenous *Arctophila fulva* and *Calamagrostis canadensis*. *Calamagrostis* occurred in the forest and the ROW, and *Arctophila fulva* occurred exclusively along within the stream margins.

Three sedge species occurred outside the ROW at this location. No sedge species was found within the ROW, where the placement of fill had created a relatively dry habitat.

Animals and animal signs observed at this site included moose, owl, beaver, grey squirrel, and raven.

Photo 30-3. A stream lined with Arctophila fulva *plants flows across the ROW route.*

This page deliberately left blank

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #31

Date Examined:	9 September 1999
Location:	N65°10' 19.3"; W148°05' 55.7"; TAPS M.P. 426.26.
Pipeline:	Buried
Slope:	Steep west by northwest
Drainage:	Inside - well-drained; Outside - moderate
Vegetation:	Open black spruce forest

Site No. 31 is located on a ridge top between Globe and Agate Creeks. This site is approximately 12 mi south of Pump Station 7 and about 1/8 mi west of the Elliott Highway. The buried pipeline is in the middle of the ROW. The road is on the east side of the pipeline. Vegetation prior to construction was an open black spruce and shrub forest. The forest floor consists of litter, moss, and lichens. Wildfire is the most common type of natural disturbance in the area. Several years prior to 1999, a wildfire burned west of the pipeline and was stopped by the cleared ROW. The burn killed the trees and aerial portions of the shrubs. Following the fire, dwarf birch and the hybrid *Betula glandulosa* X *papyrifera* recolonized and now dominate the canopy. The ROW vegetation was a mowed grass/shrub community. Shrubs and trees invading the ROW had been cut during the 1999 growing season. This brushing action was keeping the trees and shrubs from developing, otherwise this section of ROW would be dominated by a mixed forest with shrub birch willow and heath shrubs. Wheel tracks within the roadway were mostly barren, with grasses dominating only along the margins of the roadway. Moss was colonizing within the burned forest. Mosses and lichens occurred on the unburned forest floor.

Soil reaction was acidic both inside and outside the ROW (pH 5.84 and 5.17, respectively). Soil over the buried pipe contained about 51% gravel, and that of the forest about 38% gravel. This similarity in gravel content indicated that soil within the ROW was probably not altered by added fill. Subsoil was probably left on the surface after backfilling the trench. Soil moisture was about 14% inside the ROW and 26% outside. C content of both soils was low: Total soil C was 1.62% within the ROW and 2.19% outside, translating into 3.6% and 4.9% organic matter, respectively. Total soil N was also low in both soils (0.10% within the ROW and 0.09% outside, at this location). The C:N ratio for the ROW and forest soils were 16 and 24, respectively.

The amount of available soil N was low at this location, both inside and outside the ROW. Ammonium N was the only form detected in both soils, which is consistent for acidic soils. Available ammonium N was 4 ppm inside the ROW and 3 ppm in the undisturbed soil. No nitrate N was measured in either soil. There was probably no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 15 ppm within the ROW soil and 4 ppm in the adjacent forest soil. These values are adequate for the ROW and low for the undisturbed soil. The higher available P in the ROW indicates a probable carryover of P fertilizer from revegetation at this location. Available K was 103 ppm inside the ROW and 58 ppm outside. This indicated that K was adequate in the ROW and marginally adequate in the forest. The difference in available K levels between the two soils indicated a carryover of K fertilizer applied during revegetation.

Within the ROW the organic mat consisted of plant debris up to 1 cm in thickness. The organic mat (4 to 8 cm) was poorly developed in the adjacent forest. The organic mat outside the

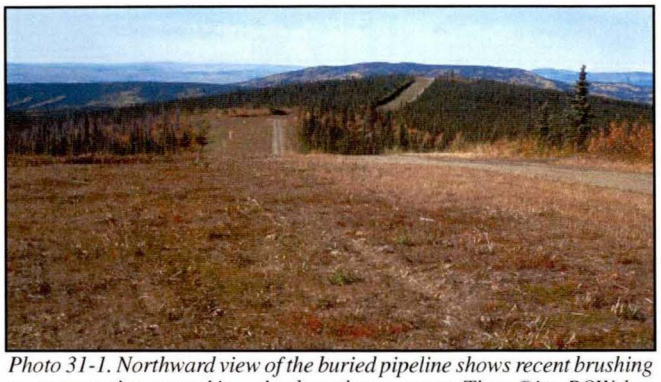


Photo 31-1. Northward view of the buried pipeline shows recent brushing to remove the overtaking shrub and tree cover. The entire ROW has been cut. Usually the outer margin beyond the roadway is not cut.

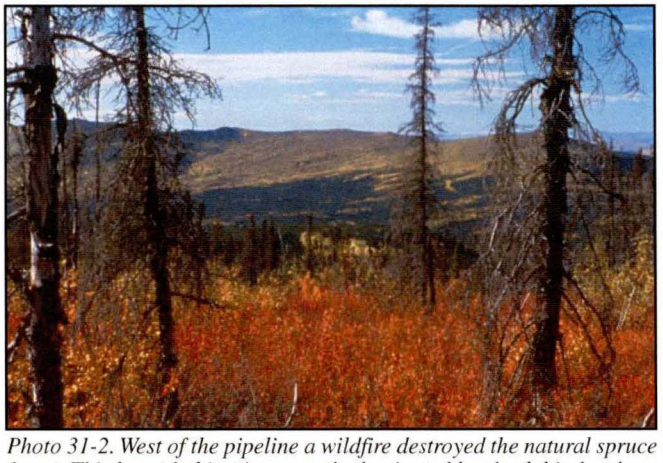


Photo 31-2. West of the pipeline a wildfire destroyed the natural spruce forest. This burnt habitat is currently dominated by shrub birch, whose leaves have turned red in this September photo.

Site No. 31 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	50.6	38.4
Moisture %	13.8	26.1
Total C %	1.62	2.19
Total N %	0.10	0.09
C:N ratio	16.2	24.3
Organic matter %	3.6	4.9
pH	5.84	5.17
NH_4-N (ppm)	4	3
NO_3-N (ppm)	Not detectable	Not detectable
P (ppm)	15	4
K (ppm)	103	58
Organic mat thickness (cm)	0 - 1	4 - 8

ROW was indicative of a relatively dry habitat that has been periodically burned.

Thirty-seven plant species were recorded at this location. Twenty-seven were recorded within the ROW, 15 in the adjacent forest habitat, and 14 in the burned forest. Only two tree, four shrub, and one forb species were common to the ROW and outside habitats. Limited commonality of species among the ROW and adjacent natural plant communities resulted primarily from differences in disturbance, competition from seeded grasses, and stages of plant succession.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 31.

Species Names	Inside	Outside Burned	Outside Not Burned
Trees			
Betula papyrifera	•		
Picea glauca	•	•	•
Picea mariana	•	•	•
Populus balsamifera	•		
Populus tremuloides	•		
Total Trees	5	2	2
Shrubs			
Arctostaphylos rubra		•	•
Betula nana			•
Betula glandulosa X B. papyrifera		•	•
Betula nana	•		
Empterum nigrum	•		•
Ledum decumbens		•	•
Ledum groenlandicum	•	•	•
Salix alaxensis	•		
Salix glauca	•	•	
Salix myrtillifolia	•		
Salix scouleriana		•	
Vaccinium uliginosum	•	•	•
Vaccinium vitis-idaea		•	•
Total Shrubs	7	8	8
Forbs			
Achillea borealis	•		
Achillea sibirica	•		
Cornus canadensis	•	•	•
Delphinium glaucum		•	•
Epilobium angustifolium	•		
Lycopodium annotinum		•	•
Pedicularis verticillata			•
Plantago major var. major	•		
Potentilla hookeriana	•		
Pyrola grandiflora	•		
Taraxacum officinale	•		
Thalespi arvense	•		
Trifolium hybridum	•		
Total Forbs	10	3	4
Grasses			
Agrostis scabra	•		
Bromus inermis	•		
Festuca altaica		•	•
Festuca rubra	•		
Hordeum jubatum	•		
Poa pratensis	•		
Total Grasses	5	1	1
Sedges			
Total Sedges	0	0	0
Total Vascular Species	**27**	**14**	**15**

Five tree species were found at this site. All five occurred in the ROW. Two tree species, *Picea glauca* and *Picea mariana*, were present in the adjacent forest and burn as well as the ROW. Twelve shrub species were found at this location. Four species were common to the ROW and at least one outside habitat: *Betula nana, Empetrum nigrum, Ledum groenlandicum,* and *Vaccinium uliginosum*. Eight shrub species were found in the forest and the burn, and seven in the ROW. All tree and shrub species at this location were indigenous. Hybrid birch was found only in the adjacent forest and burn. It was probably overlooked in the recently mowed ROW.

Thirteen forb species were recorded at this location. Ten occurred in the ROW. Four forb species occurred in the adjacent forest. Three forbs were found in the burn. One forb known to be poisonous to some grazers, *Delphinium glaucum*, was found in the burn and forest. It may have been present but inconspicuous in the ROW, which had been mowed. (See Site #28 for more information on *D. glaucum*.) *Cornus canadensis* was the only forb common to all three habitats. Two indigenous weedy forbs, *Plantago major* var. *pilgeri* and *Potentilla hookeriana*, were found at this location. Three introduced weedy forbs (*Plantago major* var. *major*, *Taraxacum officinale* and *Thlaspi arvense*) occurred within the ROW and were probably introduced during revegetation or moved to the site later by vehicles and/or wind. An exotic clover (*Trifolium hybridum*) was also found in the ROW, bringing the total introduced forb species at this location to four. (See discussion in Site 28.) None of the exotic plant species occurred outside the ROW. All of these introduced species occur widely in Alaska, along roadsides, fields and settlements. All other forbs found at this location were indigenous. *Melilotus alba* was observed within the ROW near Globe Creek on 1 Aug 2001.

Six grass species were found at this location. Five occurred in the ROW and one in the adjacent forest and burn. Two indigenous grass species are often considered as weeds: *Agrostis scabra* and *Hordeum jubatum*. Two exotic species of grass, *Bromus inermis* and *Poa pratensis*, were recorded at this site. *Festuca rubra* is an indigenous species to Alaska; however, the species does not occur in forest communities and was clearly introduced to this portion of the ROW during revegetation. No introduced grass species had invaded the adjacent forest and communities. The only grass found in the two undisturbed habitats was *Festuca altaica*.

No sedge species was found at this location. It is believed that these habitats are too dry for sedges.

Moose was the main animal sign observed at this location.

Photo 31-3. East of the pipeline, the forest is intact. It consists of scattered spruce trees, with shrub birch occupying the openings.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #32

Date Examined:	22 July 1999
Location:	N65°02' 19.6"; W147°46' 15.7"; TAPS M.P. 438.7.
Pipeline:	Elevated
Slope:	Steep north
Drainage:	Inside - well-drained; Outside - perched over permafrost
Vegetation:	Open black spruce forest

Photo 32-1. Northward view of elevated section of pipeline. The ROW at this location is largely invaded with shrubs and trees. Recent brushing to control that woody growth allows herbaceous plants, grasses and forbs to temporarily predominate. However, the stumps are sprouting, and soon the canopy beneath the pipe will consist of woody plants. Grasses dominate along the margins of the roadway.

Site No. 32 is located on a northwest-facing slope on the southeast side of the Chatanika River. This site is approximately 13 mi north of Fox, Alaska and about 1 mi west of the Dalton Highway. The elevated pipeline is to the west of the ROW. The road is on the east side of the pipeline. Vegetation prior to construction was an open black spruce forest with large tussocks of cottongrass and low heath shrub understory. The forest floor consisted of lichens, moss, and litter. Wildfire is the most common type of natural disturbance in the area. The ROW vegetation was a mowed grass/shrub community. The ROW was vegetated except for the road; wheel tracks within the roadway were mostly barren soil. Seeded grasses dominated only along the margins of the roadway. Trees and shrubs dominated the ROW beyond the road and beneath the pipeline. A prominent moss and lichen stand had developed under the pipeline. Shrubs and trees invading the ROW had been cut during the 1998 growing season. This brushing action was keeping the trees and shrubs from developing, otherwise this section would be dominated by a mixed forest with shrub birch willow and heath shrubs.

Soil reaction was slightly acidic (pH 6.67) inside the ROW, and acidic outside (pH 5.10). Soil under the elevated pipe contained about 52% gravel, and that of the forest contained about 50% gravel. The similarity between soils indicated that the ROW soil was probably not altered by fill. Undoubtedly subsoil brought to the surface during VSM installation had affected the ROW soil under the pipeline. Soil moisture inside the ROW was about 12% and outside about 22%. Total soil C was 0.58% within the ROW and 2.84% in the adjacent soils, which translates to 1.3%

*Photo 32-2. The adjacent forest is black spruce on this north-facing slope. Large clumps of tufted cottongrass (*Eriophorum vaginatum*) appear among the trees.*

Site No. 32 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	51.9	49.5
Moisture %	11.5	21.9
Total C %	0.58	2.84
Total N %	0.03	0.09
C:N ratio	19.3	31.6
Organic matter %	1.3	6.3
pH	6.67	5.10
NH_4-N (ppm)	2	6
NO_3-N (ppm)	1	Not detectable
P (ppm)	4	6
K (ppm)	53	24
Organic mat thickness (cm)	1 - 3	26.7

and 6.3% organic matter, respectively. C content of both soils was low. Total soil N was low in both soils (0.03% within the ROW and 0.09% outside) at this location. C:N ratios for the ROW and forest soils were 19 and 32, respectively.

Available soil N was low at this location. Available ammonium N was 6 ppm outside the ROW and 2 ppm inside. Available nitrate N within the ROW was 1 ppm. No nitrate N was measured in the forest soil at this location. There was probably no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 4 ppm within the ROW soil and 6 ppm in the adjacent forest soil. These values are low for both soils. There was no carryover of P fertilizer from revegetation at this location. Available K was 53 ppm inside the ROW and 24 ppm outside. This indicated that K was marginally adequate in the ROW and probably less than adequate in the forest. The dissimilarity of available K levels between these two soils indicated either a possible carryover of K fertilizer applied during revegetation, or influence from subsoil left on the ROW surface.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 32.

Species Names	Inside	Outside
Trees		
Betula papyrifera	•	
Picea mariana	•	•
Populus balsamifera	•	
Populus tremuloides	•	
Total Trees	4	1
Shrubs		
Alnus crispa	•	•
Arctostaphylos uva-ursi	•	
Betula nana		•
Chamaedaphne calyculata		•
Ledum groenlandicum	•	•
Rosa acicularis	•	
Rubus chamaemorus		•
Salix alaxensis	•	
Salix arbusculoides	•	
Salix barclayi	•	
Salix glauca	•	
Salix planifolia ssp. pulchra	•	
Spirea beauverdiana		•
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea	•	•
Total Shrubs	11	8
Forbs		
Achillea sibirica	•	
Epilobium angustifolium	•	
Equisetum arvense	•	•
Geocaulon lividum	•	•
Polygonum alaskanum	•	•
Total Forbs	5	3
Grasses		
Agropyron spp.	•	
Alopecurus pratensis	•	
Arctagrostis latifolia	•	
Calamagrostis canadensis	•	
Festuca rubra	•	
Hordeum jubatum	•	
Poa pratensis	•	
Total Grasses	7	0
Sedges		
Eriophorum vaginatum		•
Total Sedges	0	1
Total Vascular Species	***27***	***13***

Within the ROW the organic mat consisted of mosses, lichens and plant debris up to 3 cm in thickness. The organic mat was well developed (26.7 cm) in the adjacent forest. The organic mat outside the ROW was indicative of poor drainage caused by permafrost perching soil.

Thirty-two plant species were recorded at this location. Twenty-seven were found within the ROW, and 13 in the adjacent forest habitat. Only one tree, four shrub, and three forb species were common to the ROW and outside habitats. No grass or sedge species was common to both habitats. Limited commonality of species between the two habitats resulted primarily from differences in disturbance, competition from seeded grasses, and stages of plant succession.

Four tree species were found at this site. All four occurred within the ROW, and one species (*Picea mariana*) was present in the adjacent forest. Fifteen shrub species were found at this location. Four species were common to both habitats: *Alnus crispa, Ledum groenlandicum, Vaccinium uliginosum,* and *Vaccinium vitis-idaea*. Eight shrub species were found only in the forest. Four shrub species occurred exclusively in the adjacent forest.

Five forb species were recorded at this location. All five occurred in the ROW. Three forb species occurred in the adjacent forest. *Equisetum arvense, Geocaulon lividum,* and *Polygonum alaskanum* were the forbs common to both habitats. All forbs found at this location were indigenous.

Seven grass species were found at this location. All seven occurred only in the ROW. One indigenous grass species at this site, *Hordeum jubatum*, is often considered a weed. Two exotic grass species, *Alopecurus pratensis* and *Poa pratensis*, were recorded at this site. (See Site #2, page A-5 for more about *P. pratensis*' origin.) Both of these species were included in the revegetation seed mixture. *Festuca rubra* is an indigenous species to Alaska; however, the species does not occur in black spruce forest communities and was clearly introduced to this portion of the ROW during revegetation. No introduced grass species had invaded the adjacent forest.

One sedge species (*Eriophorum vaginatum*) was a prominent forest floor herb at this location. This indigenous cottongrass is common in black spruce forests and its hummocks are the primary component of tussock tundra. Tussock sizes at this site were among the largest found during our survey (see Site #36). No sedges occurred in the ROW at this location. Presumably, competition and perhaps drier soil hydrology of the ROW were responsible for the absence of sedges in the disturbed habitat.

Wildlife were not sighted, but moose, bear, wolf, fox and beaver (in streams) are the most likely mammals present.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #33

Date Examined:	9 September 1999
Location:	N65°01' 28.1"; W147°44' 41.7"; TAPS M.P. 441.8.
Pipeline:	Elevated
Slope:	Flat surface, moderately sloped toward southeast
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Closed canopy, mixed spruce-birch forest

Site No. 33 is located on the north side of a northeast flowing tributary of the Chatanika River. This site is approximately 6 mi north of Fox, Alaska, and about 1 mi west of the Elliott Highway. The elevated pipeline is on the northeast side of the ROW. The road is on the southwest side of the pipeline. Vegetation prior to construction was a second growth birch forest that had formed following a fire. Birch regeneration was primarily from stump sprouting (coppice), as opposed to seedlings. The forest floor consists of litter, moss and lichens, while grasses and shrubs form the understory. Wildfire is the primary disturbance at this location, and second growth hardwoods are heavily browsed by moose. Fire not only burns the trees but also removes much of the organic mat on the soil surface. That reduces the soil insulation and causes the soil to thaw more deeply, lowering the permafrost surface.

Shrubs and trees invading the ROW had been cut in prior years. This brushing action was keeping the trees and shrubs from developing, otherwise this section of ROW would be dominated by shrubs and birch trees. The roadway within the ROW was mostly barren. Grasses dominated only along the margins of the roadway and were common beneath the pipeline. However, trees and shrubs dominated the plant community beyond the road and under the pipeline. Moss, lichen (*Stereocaulon*) were colonizing within the ROW. Mosses and a few lichens occurred on the forest floor.

Soil reaction was slightly alkaline outside the ROW (pH 7.17) and acidic inside (pH 6.21). Soil under the elevated pipe contained about 60% gravel, while that of the forest contained no gravel. The difference in gravel content dissimilarity indicated that stony fill had been hauled to this location. In fact, fill was being hauled to this site at the time we inspected it, to level the soil beneath the pipeline. Frost bulbs formed next to the VSMs had heaved the soil surface. That caused depressions between VSMs, and these were being filled with the stony soil. It is likely that the barren fill was seeded to grass and fertilized after the filling operation was completed.

Soil moisture inside the ROW was about 19% and outside about 36%. Total soil C was 0.60% within the ROW and 4.56% outside, translating to 1.3% and 10.1% organic matter, respectively. C content of the ROW was low, and that of the forest was moderate. Organic matter was calculated to be 1.3% and 10.1% for ROW and forest soils, respectively. Total soil N was 0.02% within the ROW and 0.22% outside, at this location. Total soil N is relatively low in the ROW and moderate in the forest soil. C:N ratios for the ROW and undisturbed soils were 30 and 20, respectively.

The amount of available soil N was low at this location. Ammonium N was the only form detected in both soils. Available ammonium N was 1 ppm in the forest and 5 ppm within the ROW. Nitrate N (1 ppm) was detected only in the ROW soil.

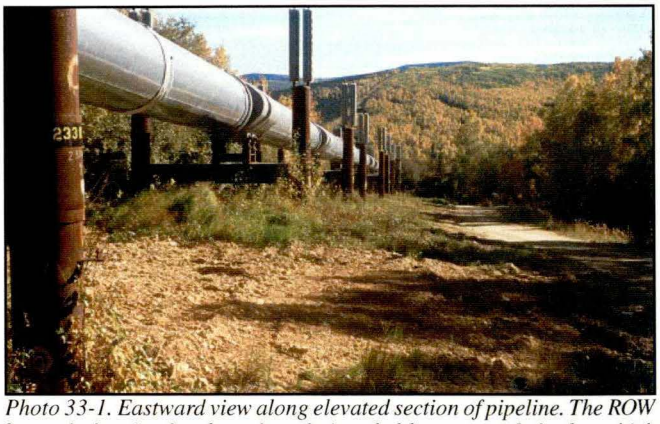


Photo 33-1. Eastward view along elevated section of pipeline. The ROW beneath the pipe has been largely invaded by trees and shrubs, which have been cut to control the growth. The roadway is largely barren. Fill has been placed between VSMs after frost bulbs raised the soil surface.

*Photo 33-2. The natural vegetation on this south-facing slope is a paper birch forest with an understory of rose (*Rosa acicularis*).*

Site No. 33 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	60.2	0
Moisture %	19.4	35.7
Total C %	0.60	4.56
Total N %	0.02	0.22
C:N ratio	30	20.7
Organic matter %	1.3	10.1
pH	6.21	7.17
NH_4-N (ppm)	5	1
NO_3-N (ppm)	1	Not detectable
P (ppm)	14	9
K (ppm)	38	95
Organic mat thickness (cm)	2 - 2.5	3 - 4

There was probably no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 14 ppm within the ROW soil and 9 ppm in the adjacent forest soil. These values are slightly adequate within the ROW soil and marginally limiting in the undisturbed soil. No significant carryover of P fertilizer from revegetation was indicated at this location. Available K was 38 ppm inside the ROW and 95 ppm outside. This indicated that K was adequate in the forest and moderately adequate in the ROW. Carryover of K fertilizer from revegetation was unlikely.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 33.

Species Names	Inside	Outside
Trees		
Betula papyrifera	•	•
Picea glauca	•	•
Populus balsamifera	•	
Populus tremuloides	•	
Total Trees	4	2
Shrubs		
Alnus sinuata	•	
Arctostaphylos uva-ursi	•	
Rosa acicularis		•
Salix alaxensis	•	
Salix arbusculoides	•	
Salix glauca	•	
Salix scouleriana		•
Vaccinium uliginosum	•	
Vaccinium vitis-idaea		•
Viburnum edule		•
Total Shrubs	6	4
Forbs		
Achillea sibirica	•	
Cornus canadensis		•
Crepis capillaris	•	
Epilobium angustifolium	•	•
Equisetum arvense	•	•
Matricaria matricarioides	•	
Mertensia paniculata	•	•
Plantago major var. peligre	•	
Polygonum aviculare	•	
Potentilla hookeriana	•	
Pyrola grandiflora		•
Stellaria longipes	•	
Taraxacum officinale	•	
Thalespi arvense	•	
Trifolium hybridum	•	
Total Forbs	13	5
Grasses		
Agropyron spp.	•	
Agrostis scabra	•	
Alopecurus pratensis	•	
Calamagrostis canadensis	•	•
Festuca altaica	•	
Poa pratensis	•	
Total Grasses	6	1
Sedges		
Total Sedges	0	0
Total Vascular Species	***29***	***12***

Within the ROW the organic mat consisted of plant debris up to 2.5 cm in thickness. The organic mat was poorly developed (3-4 cm) in the adjacent forest. The organic mat outside the ROW was typical of well-drained south-facing habitats.

Thirty-five plant species were recorded at this location. Twenty-nine were recorded within the ROW and 12 in the adjacent forest habitat. Only two tree, three forb, and one grass species were common to both habitats. Limited similarity of species between the ROW and adjacent natural plant communities resulted from revegetation, disturbances, competition, and stages of plant succession. The more advanced vegetation of the forest maintained a cooler, more moist soil than that within the ROW. Fill placed within the ROW created a drier habitat than that of the forest community.

Four tree species were found at this site. Two tree species were present in the adjacent forest, and four occurred within the ROW. *Betula papyrifera,* and *Picea glauca* were found in both habitats. *Populus balsamifera* and *Populus tremuloides* occurred only in the ROW. Ten shrub species were found at this location; four in the forest, and six in the ROW. None were common to both habitats.

Fifteen forb species were recorded at this location. Thirteen occurred in the ROW. Five forb species occurred in the adjacent forest community. *Epilobium angustifolium, Equisetum arvense,* and *Mertensia paniculata* were common to both habitats. One naturalized exotic weed, *Plantago major* var. *pilgeri*, was found at this location. Four introduced weedy forbs (*Crepis capillaris, Matricaria matricarioides, Taraxacum officinale* and *Thlaspi arvense*) occurred within the ROW and were probably either introduced during revegetation or moved to the site later by vehicles and/or wind. An exotic clover (*Trifolium hybridum*) was also found in the ROW, bringing the total introduced forb species at this location to five. (See discussion in Site 28.) None of the exotic plant species occurred outside the ROW. All of these introduced species are common in Alaska, along roadsides, fields and settlements. All other forbs found at this location were indigenous.

Six grass species were found at this location. All six occurred in the ROW and one in the adjacent forest. One indigenous grass species (*Agrostis scabra*) recorded at this location is considered a weed. Two exotic species of forage grass, *Alopecurus pratensis* and *Poa pratensis* occurred at this site. *Festuca rubra* is an indigenous species to Alaska; however, the species did not occur in the adjacent forest community and was most likely introduced to this portion of the ROW during revegetation. No introduced grass species had invaded the adjacent forest and communities. The only grass found in the undisturbed habitats was indigenous *Calamagrostis canadensis*. It occurred both in the forest and the ROW. It is a common colonizer in this habitat type, and often forms dense stands that interfere with tree seedling establishment following a fire.

No sedges occurred at this location. The absence of sedges indicates the habitat is relatively dry.

Wildlife signs observed were moose and bear. Fox and wolf are probably also users of this habitat.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #34

Date Examined:	10 September 1999
Location:	N64°49' 56.1"; W147°23' 28.2"; TAPS M.P. 461.
Pipeline:	Buried
Slope:	Flat surface, moderately sloped toward north and west
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Cleared spruce forest,regenerating as mixed spruce-birch forest

Site No. 34 is located on the south side of the Chena River. This site is outside the north fence of the Alyeska Pipeline Service Company's Nordale Yard, near Fairbanks, Alaska. The location is east of Badger Road. The buried pipeline is on the south side of the ROW. The road is on the north side of the pipeline. Vegetation prior to construction was a cleared second growth mixed birch-spruce forest. The forest had developed after the land had been cleared either by the military or by homesteaders. The forest regeneration was by seedlings, as opposed to coppice birch regeneration. The forest floor consists of litter and moss. The understory is shrubs and forbs. Wildfire and flooding are the primary natural disturbances at this location. The second growth hardwoods were browsed by moose. ATV traffic and other human activities are common this close to Fairbanks and the military reservation. Disturbances unrelated to the pipeline were probably more significant than the pipeline itself at this location.

Shrubs and trees invading the ROW had been cut in prior years. This brushing action was keeping the trees and shrubs from developing, otherwise this section of the ROW would be dominated by shrubs and birch trees. The roadway within the ROW was mostly barren. Grasses dominated only along the margins of the roadway and were common over the buried pipeline. However, trees and shrubs dominated the balance of the ROW. Moss, lichen (*Stereocaulon*) were colonizing within the ROW. Mosses and a few lichens occurred on the forest floor.

Soil reaction was alkaline inside the ROW (pH 7.42) and acidic outside (pH 5.34). Soil over the buried pipe contained about 32% gravel, while that of the forest contained no gravel. This dissimilarity in gravel content indicated stony subsoil had been placed on the surface during burial of the pipeline at this location. Gravel fill was hauled to build the road next to the pipeline. Soil moisture inside the ROW was about 13% and outside about 44%. Total soil C was 1.01% within the ROW and 3.51% outside, translating to 2.2% and 7.8% organic matter, respectively. C content of the ROW was low, and that of the forest was moderate. Total soil N was 0.09% within the ROW and 0.11% outside, at this location. Total soil N is relatively low in both soils. C:N ratios inside and outside the ROW were 11 and 32, respectively.

The amount of available soil N was low at this location. Ammonium N was the only form detected in both soils, at 3 ppm in both the forest and the ROW. Nitrate N was not detected in either soil. There was probably no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 5 ppm within the ROW soil and 3 ppm in the adjacent forest soil. These values are low and typical of soils in the region. No significant carryover of P fertilizer from revegetation at this location is indicated. Available K was 86 ppm inside the ROW and 45 ppm outside. This indicated that K was adequate in the ROW and moderately adequate in the forest. Carryover of K

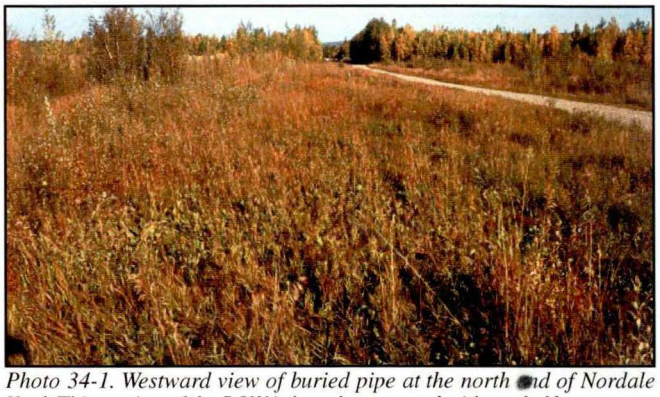


*Photo 34-1. Westward view of buried pipe at the north end of Nordale Yard. This section of the ROW is largely vegetated with seeded bromegrass (*Bromus inermis*) and weedy forbs. A fringe of willow appears at left.*

Photo 34-2. Vegetation to the north of the ROW is a cleared forest that is recolonizing through natural processes, and currently is dominated by shrubs and tree saplings.

Site No. 34 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	32.1	0
Moisture %	13.3	43.5
Total C %	1.01	3.51
Total N %	0.09	0.11
C:N ratio	11.2	32
Organic matter %	2.2	7.8
pH	7.42	5.34
NH_4-N (ppm)	3	3
NO_3-N (ppm)	Not detectable	Not detectable
P (ppm)	5	3
K (ppm)	86	45
Organic mat thickness (cm)	0 - 0.5	1 - 2

fertilizer from revegetation appears possible, although there is a greater likelihood that the higher K availability for the ROW soil resulted from subsoil placed on the surface.

Within the ROW the organic mat consisted of plant debris up to 0.5 cm in thickness. The organic mat was poorly developed (1-2 cm) in the adjacent (disturbed) forest habitat. The organic mat outside the ROW was typical for cleared forest habitats.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 34.

Species Names	Inside	Outside
Trees		
Larix laricina		•
Picea glauca		•
Picea mariana		•
Populus balsamifera	•	•
Populus tremuloides	•	•
Total Trees	2	5
Shrubs		
Arctostaphylos uva-ursi		•
Betula nana		•
Ledum groenlandicum		•
Myrica gale		•
Potentilla fruiticosa		•
Rosa acicularis	•	•
Rubus arcticus		•
Salix alaxensis	•	•
Salix arbusculoides	•	•
Salix bebbiana		•
Salix glauca	•	•
Salix myrtillifolia		•
Salix podaphylla (S. monticola)	•	
Vaccinium uliginosum		•
Vaccinium vitis-idaea		•
Total Shrubs	5	14
Forbs		
Achillea borealis		•
Cornus canadensis		•
Epilobium angustifolium	•	
Equisetum arvense	•	•
Parnassia palustris		•
Pyrola grandiflora		•
Taraxacum officinale	•	•
Trifolium hybridum	•	
Total Forbs	4	6
Grasses		
Agropyron spp.		•
Bromus inermis	•	
Calamagrostis canadensis		•
Festuca baffinensis	•	
Festuca rubra	•	
Poa pratensis	•	
Total Grasses	4	2
Sedges		
Carex bigelowii		•
Carex microglochin		•
Total Sedges	0	2
Total Vascular Species	**15**	**29**

Thirty-six vascular plant species were recorded at this location. Fifteen were recorded within the ROW and 29 in the adjacent forest habitat. Two tree, three shrub, and two forb species were common to both habitats. This limited commonality of species was caused by disturbances, competition from seeded grasses, and stages of plant succession. The slightly more advanced vegetation of the second growth forest appeared to maintain a more moist soil than within the ROW.

Five tree species were found at this site. All five were present in the adjacent forest, and two occurred within the ROW. *Betula papyrifera* and *Picea glauca* were found in both habitats. *Populus balsamifera* and *Populus tremuloides* were observed within the ROW. *Larix laricina* was found at three locations in this surgery (Sites 34, 35 and 36). This was our northernmost record. See Viereck and Little (1972) for more information on this species, its distribution and wood properties.

Fifteen shrub species were found at this location. Four shrub species (*Rosa acicularis, Salix alaxensis, Salix arbusculoides,* and *Salix glauca*) were common to both habitats. Fourteen shrub species were found in the disturbed forest, and five in the ROW. *Salix podaphylla (S. monticola?)* was the only shrub species unique to the ROW. Identification of this species is uncertain.

Eight forb species were recorded at this location. Four occurred in the ROW. Six forb species occurred in the adjacent second growth forest community. No forbs were common to both habitats. One exotic weed, *Taraxacum officinale* was found at this location. This exotic plant species occurred in the second growth forest. It probably occurred within the ROW, as a colonizer within the cleared forest, before construction of the pipeline. As previously stated, this plant is a common weed along roads, in yards, gardens, and fields in this vicinity. An exotic clover (*Trifolium hybridum*) was also found in the ROW, bringing the total introduced forb species at this location to two. (See discussion in Site 28.) All other forbs found at this location were indigenous.

Six grass species were found at this location. Four occurred in the ROW and two in the adjacent second growth forest. Two exotic species of forage grass, *Bromus inermis* and *Poa pratensis*, occurred at this site. These grasses were introduced at this location during revegetation of the ROW. *Festuca rubra* is an indigenous species to Alaska; however, the species did not occur in adjacent forest communities and was most likely introduced to this portion of the ROW during revegetation. No introduced grass species had invaded the adjacent second growth forest. The only grasses found in the adjacent second growth forest were indigenous *Agropyron* spp. and *Calamagrostis canadensis*. *Calamagrostis* is a common colonizer in this area, and often forms dense stands that interfere with tree seedling establishment following forest fires. *Agropyron* usually is found in relatively well-drained soils along streams and on south-facing slopes.

Two sedges occurred at this location, *Carex bigelowii* and *Carex microglochin*. These sedges are common in this vicinity and were natural components of the second growth forest. They had not colonized within the ROW, possibly because competition from seeded grasses was too great.

Animals and animal signs observed at this location included moose and bear.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #35

Date Examined:	10 September 1999
Location:	N64°33' 06.7"; W146°49' 47.2"; TAPS M.P. 489.2.
Pipeline:	Elevated
Slope:	Flat surface, moderately sloped toward north and west
Drainage:	Inside - well drained; Outside - drained
Vegetation:	Black spruce forest

Site No. 35 is located on the south side of the south fork of French Creek. This site is just north of Pump Station 8. The location is north of Johnson Road. The elevated pipeline is on the northeast side of the ROW. The road is on the northwest side of the pipeline. A cleared powerline right-of-way is situated to the west of the pipeline ROW. Our "outside" inventory was conducted in the undisturbed forest between the powerline and pipeline. Vegetation prior to construction was a closed black spruce forest. The forest next to the pipeline appeared to have been undisturbed for a considerable time. The forest floor consists of moss and the *Peltigera* lichen. The understory is relatively open with a few scattered shrubs and forbs. Wildfire would be the primary natural disturbance at this location. Mixed hardwood-spruce stands occur in this locale and are the result of forest regeneration after burning. ATV traffic and other human activities are common here.

Shrubs and trees invading the ROW had been cut in prior years. This brushing action was keeping the trees and shrubs from developing, otherwise they would dominate this section of ROW. The roadway within the ROW was mostly barren gravel. Grasses dominated only along the margins of the roadway. However, trees and shrubs dominated the plant community beyond the road and under the pipeline. The outer edges of the ROW were lined with tall shrubs, mostly alder. Many of these were 10 ft or taller. Moss and lichen (*Peltigera*) were colonizing within the ROW.

Soil reaction was acidic both inside and outside the ROW (pH 5.76 and pH 6.16, respectively). Soil under the elevated pipe contained about 63% gravel, while that of the forest contained no gravel. The difference in gravel content indicates that stony fill and subsurface material from VSM excavations had been placed on the surface during construction of the pipeline at this location. Soil moisture inside the ROW was about 11% and outside about 143%. Total soil C was 0.63% within the ROW and 6.16% outside, translating to 1.4% and 13.7% organic matter,

Site No. 35 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	62.7	0
Moisture %	11.3	143.4
Total C %	0.63	10.66
Total N %	0.05	0.46
C:N ratio	12.6	23.2
Organic matter %	1.4	23.7
pH	5.76	6.16
NH_4-N (ppm)	4	2
NO_3-N (ppm)	1	Not detectable
P (ppm)	6	9
K (ppm)	41	39
Organic mat thickness (cm)	0 - 1	3 - 4

Photo 35-1. Northward along elevated section of pipeline, south of Pump Station 8. The ROW margins are dominated by naturally recolonizing shrubs. Beneath the pipeline, shrubs and tree seedlings have been cut to control the woody canopy. Grasses line the margins of the road, and tall shrubs (alder) predominate the margins of fill.

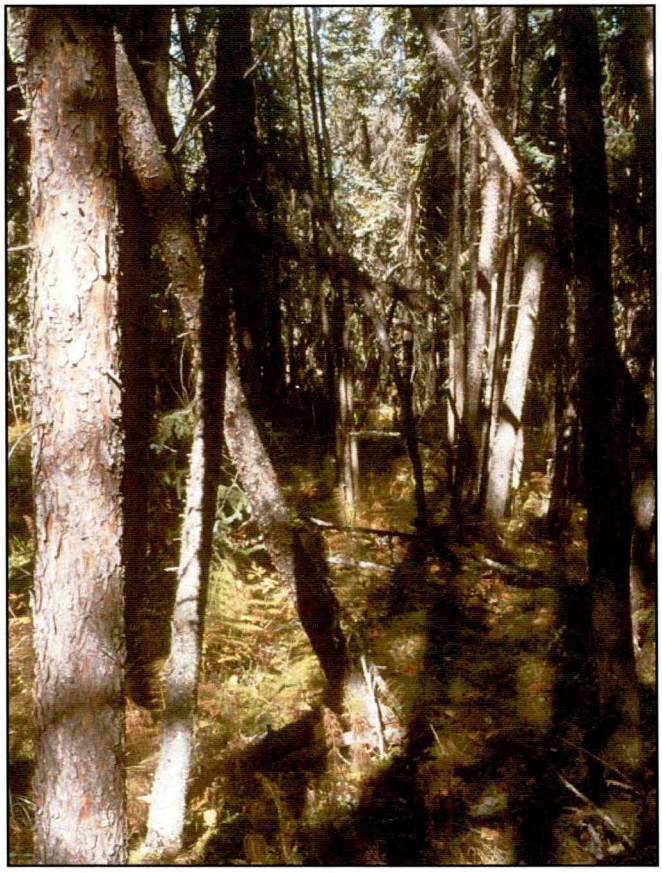


Photo 35-2. Northward view in the dense spruce forest west of the pipeline. The forest floor at this location is carpeted with moss.

respectively. C content of the ROW was low, and that of the forest was slightly above moderate. Organic matter was calculated as 1.4% and 24% for the ROW and forest soils, respectively. Total soil N was 0.05% within the ROW and 0.46% outside, at this location. Total soil N is relatively low within the ROW and moderate outside. C:N ratios for the ROW and forest soils were about 13 and 23, respectively.

The amount of available soil N was low at this location overall. Ammonium N was detected in both soils, at 4 ppm within the ROW and 2 ppm in the forest soil. Nitrate N was detected only in the ROW soil (1 ppm). There was probably no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 6 ppm within the ROW soil and 9 ppm in the adjacent forest soil. These low values are typical of soils in the region. The slightly lower available P in the ROW indicates no significant carryover of P fertilizer from revegetation at this location. Available K was 41 ppm inside the ROW and 39 ppm outside. This indicated that K was low in both soils and had not carried over from revegetation applications.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 35.

Species Names	Inside	Outside
Trees		
Betula papyrifera	•	
Larix laricina	•	
Picea glauca	•	
Picea mariana	•	•
Populus balsamifera	•	
Total Trees	5	1
Shrubs		
Alnus sinuata	•	
Ledum groenlandicum	•	•
Rosa acicularis		•
Rubus idaeus	•	
Salix lanata var richardsonii	•	
Vaccinium uliginosum	•	
Vaccinium vitis-idaea	•	•
Total Shrubs	6	3
Forbs		
Achillea sibirica	•	
Cornus canadensis	•	•
Crepis capillaris	•	
Epilobium angustifolium	•	
Epilobium palustre	•	
Equisetum arvense	•	•
Matricaria matricarioides	•	
Petasites frigidus		•
Plantago major var. major	•	
Polygonum alaskanum		•
Polygonum aviculare	•	
Potentilla hookeriana	•	
Pyrola grandiflora	•	
Stellaria longipes	•	
Taraxacum officinale	•	
Trifolium hybridum	•	
Total Forbs	14	4
Grasses		
Agrostis scabra	•	
Alopecurus pratensis	•	
Calamagrostis canadensis	•	•
Festuca rubra	•	
Poa pratensis	•	
Total Grasses	5	1
Sedges		
Total Sedges	0	0
Total Vascular Species	***30***	***9***

Within the ROW the organic mat consisted of plant debris, moss and lichen up to 1 cm in thickness. The organic mat (3 - 4 cm) in the adjacent undisturbed forest provided a complete cover, but it was not very thick, in contrast to other locations with vigorous moss growth.

Thirty-three plant species were recorded at this location. Thirty were recorded within the ROW and nine in the adjacent forest habitat. Only one tree, two shrub, two forb, and one grass species were common to both habitats. This difference of species between the ROW and adjacent natural plant communities resulted from disturbance and soil hydrological changes resulting from construction activities. Competition from seeded grasses may have been a minor factor. The advanced vegetation of the black spruce forest appeared to maintain a more moist soil than within the ROW.

Five tree species were found at this site. All five tree species were present within the ROW, and only one tree species (*Picea mariana*) was found in the adjacent forest. Seven shrub species were found at this location. Only two shrub species (*Rosa acicularis* and *Vaccinium vitis-idaea*) were common to both habitats. Three shrub species were found in the forest, and six in the ROW.

Seven forb species were recorded at this location. Six occurred in the ROW. Three forb species occurred in the adjacent forest community. Two forbs (*Cornus canadensis* and *Equisetum arvense*) were common to both habitats. Five exotic weeds were found at this site: *Crepis capillaris*, *Matricaria matricarioides*, *Plantago major* var. *major*, *Polygonum aviculare*, and *Taraxacum officinale*. These occurred only within the ROW. All are commonly found in the region and are associated with roadsides, fields, yards, and gardens. They were introduced to Alaska long before the pipeline was constructed. Their presence at this location may have been facilitated with revegetation treatments. An exotic clover (*Trifolium hybridum*) was also found in the ROW, bringing the total introduced forb species at this location to six. (See discussion in Site 28.) One indigenous forb, *Potentilla hookeriana*, is sometimes considered a weedy plant because of its tendency to occupy open ground.

Five grass species were found at this location. Three were indigenous to Alaska: *Agrostis scabra, Calamagrostis canadensis*, and *Festuca rubra*. All five grass species occurred within the ROW and one (*C. canadensis*) occurred in the adjacent black spruce forest. Two exotic species of grass, (*Alopecurus pratensis* and *Poa pratensis*) occurred at this site. These two grasses were introduced during revegetation of the ROW. *Festuca rubra* is an indigenous species to Alaska; however, this grass did not occur in black spruce forests and was most likely introduced during revegetation. No introduced grass species had invaded the adjacent second forest. *Agrostis scabra* is often considered a weedy grass, because it invades open ground and has no value for either indigenous wildlife or domestic livestock. It is unattractive, and its only apparent value is to occupy open areas with relatively infertile soil conditions. All other grass species are indigenous to Alaska

No sedges occurred at this location. The competition from the forest may have been too great for sedges to invade. Competition and soil dryness were probably the two factors against sedges in the ROW habitat.

Animals and animal signs observed at this location included moose, squirrel and hare.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #36

Date Examined:	10 September 1999
Location:	N64°15' 00.4"; W146°04' 03.4"; TAPS M.P. 521.1.
Pipeline:	Elevated
Slope:	Flat surface, subtle slope toward north and west
Drainage:	Inside - well drained; Outside - perched
Vegetation:	Shrub-herb bog

Site No. 36 is located on the south side of Shaw Creek in the Shaw Creek Flats. The location is east of the Richardson Highway. The elevated pipeline is on the northwest side of the ROW. The road is on the northeast side of the pipeline. A military products pipeline lies to the west of the pipeline ROW. Vegetation prior to construction was a shrub-herb bog. Trees within the bog were small and scattered, resembling a savannah. Fill had been placed across the bog within the ROW to provide support for pipeline construction, operation and maintenance. Fire is the main natural disturbance affecting this habitat type. Generally, the site is too wet to burn, except within the canopy during dry seasons.

Shrubs and trees invading the ROW had been cut earlier in 1999. This brushing action was keeping the trees and shrubs from developing, otherwise they would dominate this section of ROW. The roadway within the ROW was largely barren. Under the pipeline, vegetation provided complete cover. Moss and lichen (*Peltigera*) were colonizing within the ROW. Moss, *Peltigera*, and mushrooms were observed in the undisturbed habitat. Very large (knee-high) tussocks of *Eriophorum vaginatum* predominated in the bog, possibly larger than those found at Site #32.

Soil reaction was alkaline inside the ROW (pH 7.50) and acidic outside (pH 5.95). Soil under the elevated pipe contained about 66% gravel, while the bog soil contained no gravel. The difference in gravel content was consistent with stony fill placement at this location. Soil moisture inside the ROW was about 5.7%, and outside about 154%. Total soil C was 0.74% within the ROW and 8.17% outside, translating to 1.6% and 18.2% organic matter, respectively. C content of the ROW was low, and that of the bog was moderate to high. Total soil N was low (0.03%) within the ROW and moderate (0.49%) outside, at this location. C:N ratios for the ROW and adjacent soils were

Site No. 36 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	65.5	0
Moisture %	5.7	153.6
Total C %	0.74	8.17
Total N %	0.03	0.49
C:N ratio	24.7	16.7
Organic matter %	1.6	18.2
pH	7.50	5.95
NH_4-N (ppm)	3	5
NO_3-N (ppm)	Not detectable	Not detectable
P (ppm)	6	2
K (ppm)	32	28
Organic mat thickness (cm)	0 - 1	7 - 8

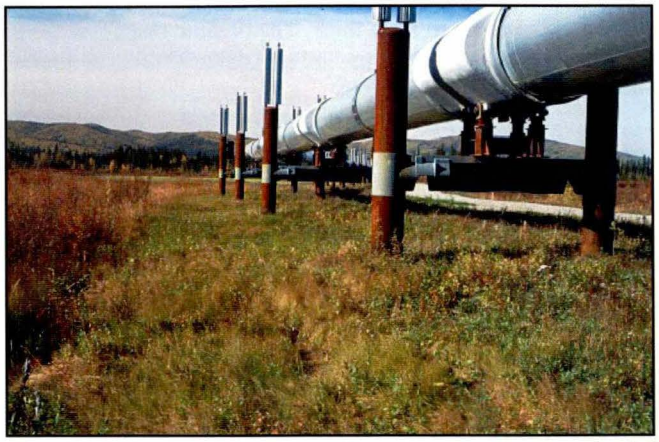


Photo 36-1. Northward view along elevated section of pipeline. Seeded grasses and indigenous shrubs provide a complete cover beneath the pipeline. This portion has been brushed to control woody plants.

Photo 36-2. Shrubs dominated the adjacent bog west of the pipeline.

about 25 and 17, respectively. The amount of available soil N was low in both areas. Ammonium N was detected in both soils, at 3 ppm within the ROW and 5 ppm in the bog. Nitrate N was detected in neither soil. There was no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 6 ppm within the ROW soil and 2 ppm in the adjacent bog soil. The available soil P in the bog is very low, and that within the ROW is moderately low. There does not appear to be significant carryover of P fertilizer from revegetation. Available K was 32 ppm inside the ROW and 28 ppm outside. This indicated that K was low in both soils and probably had not carried over from revegetation applications.

Within the ROW the organic mat consisted of plant debris, moss, and lichen up to 1 cm thick. The organic mat (7-8 cm) in the adjacent undisturbed bog was partially decomposed plant litter.

Forty-five plant species were recorded at this location. Thirty-one occurred within the ROW and nineteen in the adjacent bog habitat. Three tree, three shrub, one forb, one grass, and one sedge species were common to both habitats. Limited commonality of species between the ROW and adjacent natural plant communities was caused by the habitat changes associated with construction, which altered soil hydrology, and revegetation.

Six tree species were found at this site. Five tree species were present within the ROW, and four tree species were found in the adjacent bog. *Populus balsamifera* and *Populus tremuloides* were found only within the ROW. *Picea glauca* occurred only in the undisturbed bog. This tree may have been overlooked in the ROW because of recent mowing. Fifteen shrub species were found at this location. Only three shrub species (*Potentilla fruticosa*, *Salix arbusculoides*, and *Vaccinium uliginosum*) were common to both habitats. Ten shrub species were found in the undisturbed bog, and seven in the ROW.

Seventeen forb species were recorded at this location. Fifteen occurred in the ROW. Three forb species occurred in the adjacent shrub-herb community. There were several impressive colonies of *Astragalus* at this location. *Astragalus* is a N-fixing legume with smooth and relatively heavy seeds. Legumes shatter upon drying, scattering seeds next to the mother plant. This causes the species to occur in clumps. One forb (*Equisetum arvense*) was common to both habitats. One exotic weed, *Taraxacum officinale*, was found only within the ROW at this location. This is a common plant associated with roadsides, fields, yards, and gardens. One indigenous forb, *Dracocephalum parviflorum*, is sometimes considered a weedy plant because of its tendency to occupy open ground and waste places. All other forbs found at this location were indigenous.

Six grass species were found at this location. Four were indigenous to Alaska: *Agropyron* spp., *Calamagrostis canadensis*, *Festuca altaica,* and *Festuca rubra*. All four occurred within the ROW, and one (*C. canadensis*) grew in the adjacent shrub-herb bog. Two exotic species of grass, *Bromus inermis* and *Poa pratensis*, occurred only within the ROW at this site. These two grasses were introduced during revegetation. *Festuca rubra* did not occur in bogs and was most likely introduced to this portion of the ROW during revegetation. No introduced grass species had invaded the adjacent undisturbed habitat.

One sedge (*Eriophorum vaginatum*) occurred within the ROW and the adjacent bog at this location. This tussock-forming sedge is a predominant plant in the undisturbed bog.

Moose and hare were the major animals using this habitat.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 36.

Species Names	*Inside*	*Outside*
Trees		
Betula papyrifera	•	•
Larix laricina	•	•
Picea mariana	•	•
Populus balsamifera	•	
Populus tremuloides	•	
Picea glauca		•
Total Trees	5	4
Shrubs		
Potentilla fruiticosa	•	•
Salix alaxensis	•	
Salix arbusculoides	•	•
Salix bebbiana	•	
Salix monticola	•	
Shepherdia canadensis	•	
Vaccinium uliginosum	•	•
Andromeda polifolia		•
Betula nana		•
Chamaedaphne calyculata		•
Linnaea borealis		•
Myrica gale		•
Salix planifolia ssp. pulchra		•
Salix barclayi		•
Total Shrubs	7	10
Forbs		
Achillea sibirica	•	
Aster sibiricus	•	
Astragalus alpinus	•	
Astragalus eucosmus	•	
Castelleja elegans	•	
Dracocephalum parviflorum	•	
Epilobium palustre	•	
Equisetum arvense	•	•
Erigeron pulcherrima	•	
Oxytropis campestris	•	
Parnassia palustris	•	
Platanathera hyperborea	•	
Pyrola secunda	•	
Taraxacum officinale	•	
Tofieldia pusilla	•	
Iris setosa		•
Potentilla palustris		•
Total Forbs	15	3
Grasses		
Agropyron spp.	•	
Bromus inermis	•	
Calamagrostis canadensis	•	•
Festuca altaica	•	
Festuca rubra	•	
Poa pratensis	•	
Total Grasses	3	1
Sedges		
Eriophorum vaginatum	•	•
Total Sedges	1	1
Total Vascular Species	***31***	***19***

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #37

Date Examined:	10 September 1999
Location:	N64°01' 24.9"; W145°43' 04.1"; TAPS M.P. 542.
Pipeline:	Buried
Slope:	Flat surface, subtle slope toward west
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Spruce-cottonwood forest

Site No. 37 is located on the north side of Jarvis Creek just south of Delta Junction, Alaska. The location is east of the Richardson Highway. The buried pipeline is in the center of the ROW, and there is no road within the ROW at this location, which is on the bank of Jarvis Creek. A military road to the Buffalo Drop Zone crosses the ROW just north of this site. Vegetation prior to construction was a spruce-cottonwood forest. The forest experienced considerable natural and human disturbance prior to pipeline construction. Flooding, rechanneling the creek, and loess deposition had major effects on this site. Forest fires are another type of natural disturbance common to this habitat type. The vicinity was also impacted by military activities and local residents. No fill had been placed within the ROW at this location.

Shrubs and trees invading the ROW had not been recently cut, and some individuals were up to 6 ft in height. Brushing of the ROW in past years had kept these plants from overtaking the area. The entire ROW was vegetated to varying degrees. The east side was mainly grasses and forbs, and the west side was young trees and forbs. Moss was not important at this location in either habitat because of loess deposition.

Soil reaction was alkaline both inside the ROW (pH 7.96) and outside (pH 8.16). Soil over the buried pipe contained about 20% gravel, while soil of the adjacent forest contained no gravel. The dissimilarity in gravel content was consistent with stony subsoil remaining on the surface after pipeline burial. Soil moisture inside the ROW was about 7.5% and outside about 16%. Total soil C was 0.79% within the ROW and 1.86% outside, translating to 1.8% and 4.1% organic matter, respectively. C content of the ROW and the adjacent forest was low. Much of the reason for low organic C in these soils was from effects of continued loess deposition. During the summer months, the soil is relatively warm, causing the organic C to decompose relatively rapidly. Total soil N was very low in both areas; below detection limits within the ROW and 0.10% outside the ROW. C:N ratio for the forest soil was about 19.

The amount of available soil N was also low in both areas. Ammonium N was detected in both soils at the level of 2 ppm. Nitrate N was detected in neither soil. It was unusual to find ammonium N and no nitrate N in these alkaline soils. There was no carryover of N fertilizer from revegetation at this location. Measurable available soil P was 1 ppm within the ROW soil and 1 ppm in the adjacent forest soil. The available soil P in both soils is quite low and probably limiting plant growth. There was no carryover of P fertilizer from revegetation. Available K was 11 ppm inside the ROW and 12 ppm outside. This indicated that K was low in both soils and probably had not carried over from revegetation applications.

Within the ROW, the organic mat consisted of plant debris, moss, and lichen up to 0.5 cm in thickness. The organic mat (2-

Photo 37-1. Southward across buried pipeline on the outskirts of Delta Junction. Sandy soil was deposited from nearby Jarvis Creek. Cottonwood dominates a portion of the ROW, and seeded grasses elsewhere.

*Photo 37-2. The adjacent spruce/cottonwood forest has an understory of rose (*Rosa acicularis*). The forest floor is largely barren sand with a thin cover of plant debris.*

Site No. 37 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	19.8	0
Moisture %	7.5	15.9
Total %	0.79	1.86
Total N %	Not detectable	0.10
C:N ratio	Not applicable	18.6
Organic matter %	1.8	4.1
pH	7.96	8.16
NH_4-N (ppm)	2	2
NO_3-N (ppm)	Not detectable	Not detectable
P (ppm)	1	1
K (ppm)	11	12
Organic mat thickness (cm)	2 - 2.5	0 - 0.5

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 37.		
Species Names	Inside	Outside
Trees		
Picea glauca	•	•
Populus balsamifera	•	•
Total Trees	2	2
Shrubs		
Eleagnus commutata	•	•
Juniperus communis	•	•
Linnaea borealis		•
Potentilla fruiticosa	•	•
Rosa acicularis	•	•
Salix brachyophylla ssp nyphoclada	•	
Salix arbusculoides	•	
Salix alaxensis	•	
Salix glauca	•	
Shepherdia canadensis	•	
Vaccinium vitis-idaea		•
Viburnum edule		•
Total Shrubs	9	7
Forbs		
Achillea sibirica	•	
Achillea borealis	•	
Anemone richardsonii		•
Aster sibiricus	•	
Astragalus americanus	•	•
Castelleja elegans	•	
Chenopodium album	•	
Cnidium cnidiifolium	•	
Erigeron pulcherrima	•	
Fragaria virginiana	•	
Galium boreale	•	•
Geocaulon lividum		•
Geum macrophyllum	•	
Hedysarum alpinum	•	•
Hedysarum mackenzii	•	
Matricaria matricarioides	•	
Oxytropis campestris	•	
Sanguisorba stipulata	•	
Sanguisorba officinalis	•	
Solidago multiradiata	•	
Taraxacum officinale	•	
Trifolium hybridum	•	
Zygadenus elegans	•	
Total Forbs	21	5
Grasses		
Agropyron spp.	•	
Bromus inermis	•	
Calamagrostis purpurascens	•	•
Festuca rubra	•	
Poa pratensis	•	
Total Grasses	5	1
Sedges		
Carex microglochin	•	
Total Sedges	1	0
Total Vascular Species	**38**	**15**

2.5 cm) in the adjacent undisturbed bog consisted of plant litter and thin moss cover.

Forty-three plant species were recorded at this location. Thirty-eight were recorded within the ROW and 15 in the adjacent spruce-cottonwood habitat. Only two tree, four shrub, three forb, and one grass species were common to both habitats. This dissimilarity of species between the ROW and adjacent natural plant communities was caused by the disturbance and perhaps by competition from seeded grasses.

Two tree species (*Picea glauca* and *Populus balsamifera)* were found at this site. Both tree species were present within the ROW and in the adjacent forest. Twelve shrub species were found at this location; seven in the adjacent forest, and nine within the ROW. Four shrubs (*Elaeagnus commutata, Juniperus communis, Potentilla fruticosa*, and *Rosa acicularis*) were common to both habitats.

Twenty-three forb species were recorded at this location. Twenty-one occurred in the ROW. Five forb species occurred in the adjacent forest. Three forbs (*Astragalus americanus, Galium boreale, and Hedysarum alpinum*) were common to both habitats. Three exotic weeds (*Chenopodium album, Matricaria matricarioides,* and *Taraxacum officinale*) were found within the ROW at this location. These are common weeds associated with roadsides, fields, yards, and gardens. These species are all found in the vicinity, associated with human habitation, and were here long before the pipeline was constructed. An exotic clover (*Trifolium hybridum;* see discussion in Site 28) was also found in the ROW, bringing the total introduced forb species at this location to four. All other forbs found at this location were indigenous. One poisonous plant was recorded, *Zygadenus elegans*. See Site #21 for more about this species.

Five grass species were found at this location. Three were indigenous to Alaska: *Agropyron* spp., *Calamagrostis canadensis*, and *Festuca rubra*. All three occurred within the ROW and one (*C. canadensis*) in the adjacent forest. Two exotic species of grass, *Bromus inermis* and *Poa pratensis*, occurred only within the ROW. These two grasses were introduced during revegetation. *Festuca rubra* did not occur in the adjacent forests, but it does occur along stream channels such as Jarvis Creek. It may have been in the vicinity prior to the pipeline. Most likely its abundance at this location can be traced to revegetation of the ROW. No introduced grass species had invaded the adjacent undisturbed habitat.

One sedge (*Carex microglochin*) occurred within the ROW at this location. This rhizomatous sedge is reported to prefer calcareous (alkaline) soils, and apparently found a niche in the ROW at this location.

Moose, bison, and hare were the major animals using this habitat.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #38

Date Examined:	19 September 1999
Location:	N63°56' 46.6"; W145°45' 36.7"; TAPS M.P. 547.7.
Pipeline:	Elevated
Slope:	Flat surface sloping gently west and northward
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Black spruce forest with aspen, burned on east side of ROW, unburned on west

Site No. 38 is located approximately 0.5 mi north of Pump Station 9, south of Delta Junction, Alaska. The land is within the boundary of the Fort Greely military reserve and east of the Richardson Highway. The buried pipeline is in the middle of the ROW. There was no evidence that rocky fill had been placed within the ROW, and the vegetation over the pipe appeared similar to that throughout the ROW. Vehicle travel within the ROW is minimal, and a set of wheel tracks appears along the east edge of the ROW. These wheel tracks are vegetated, indicating relatively little vehicle use. The ROW is completely vegetated and regularly mowed. The site is within a drainage that flows into the Delta River. Vegetation prior to construction was dense black spruce and hardwood mixed forest. The forest is subjected to periodic wildfires. A 1999 fire burned the forest up to the east side of the ROW, leaving the area with a charred stand of dead trees, an ash-covered forest floor on the east, and unburned forest on the west.

Soil reaction was acidic both inside and outside the ROW (pH 6.44 and pH 5.76). Soil over the elevated pipe contained about 58% gravel, while the adjacent soil contained no gravel in the surface. This dissimilarity in gravel content indicates that the backfill over the pipeline consisted of subsoil, which was more rocky than the surface soil. Soil moisture inside the ROW was about 5.7% and outside about 24.5%. Total soil C was 0.78% within the ROW and 1.66% outside, translating to 1.7% and 3.7% organic matter, respectively. C content of the ROW and the adjacent tundra was low, but not unusual for this habitat. Total soil N was 0.10% within the ROW and 0.19% outside, at this location. Total soil N was moderate to low inside and outside the ROW. The C:N ratios were 7.8 and 15.1 for the ROW and adjacent forest soils, respectively.

Site No. 38 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	57.9	0
Moisture %	5.7	24.5
Total C %	0.78	1.66
Total N %	0.10	0.11
C:N ratio	7.8	15.1
Organic matter %	1.7	3.7
pH	6.44	5.76
NH_4-N (ppm)	1	Not detectable
NO_3-N (ppm)	Not detectable	2
P (ppm)	15	1
K (ppm)	58	43
Organic mat thickness (cm)	0 - 1	2 - 3

The amount of available soil N was low, at 1 ppm within and 2 ppm outside the ROW. There was no carryover of N fertilizer from revegetation at this location. Vegetation was probably using N as quickly as it was mineralized from organic matter. Measurable available soil P was 15 ppm within the ROW soil and 1 ppm in the adjacent forest soil. Soil P in the adjacent forest soil could be limiting plant growth. There may have been a

Photo 38-1. Southward view toward Pump Station 9. The pipeline is buried, and a mixture of seeded and natural plant species has overgrown the entire ROW, which was recently mowed to control woody plants.

Photo 38-2. A wildfire burned the spruce/aspen forest on the east side of the ROW earlier in the 1999 season. By September, stump sprouting and regrowth of grass and forbs had commenced.

Photo 38-3. View of the burned forest shown in Photo 38-2 after two growing seasons. Notice the regeneration of forest-floor plants, including stump sprouts of deciduous tree species. A number of the herbaceous plants were absent in the unburned community.

carryover of P fertilizer from revegetation. The greater available P inside the ROW may also indicate inherently more P in subsoils than surface soils. Available K was 58 ppm inside the ROW and 43 ppm outside, indicating that K was marginal to adequate both soils. There was probably no carryover of K from revegetation.

Within the ROW the organic mat (0-1 cm) consisted primarily of plant debris. The organic mat in the adjacent forest (2-3 cm) consisted primarily of moss and plant debris typical for this vegetation type.

Forty vascular plant species were recorded at this location, 31 within the ROW and 18 in the adjacent forest habitats (burned and unburned). Three tree species, four shrubs, and two forbs were common to both habitats. Limited commonality of species between the ROW and adjacent natural plant communities resulted from habitat changes associated with construction and mowing disturbances, and revegetation.

Five tree species were found at this site. All tree species occurred within the ROW. Three tree species (*Betula papyrifera, Picea mariana* and *Populus tremuloides*) were common to the ROW and forest habitats. *Populus balsamifera,* and *Picea glauca* occurred only within the ROW, indicating the construction disturbance permitted these trees to expand their local ranges to this site. Eight shrub species were found in the ROW, and six within the adjacent forest communities. Four shrubs (*Alnus crispa, Ledum groenlandicum, Salix glauca,* and *Vaccinium vitis-idaea*) were common to both habitats. Four shrubs (*Arctostaphylos uva-ursi, Empetrum nigrum, Salix monticola*, and *Vaccinium uliginosum*) were recorded only within the ROW. All tree and shrub species at this location were indigenous.

Twenty forb species were recorded at this location. Fifteen occurred in the ROW. Seven forbs were recorded for the adjacent forest. Two forb species (*Aster sibiricus* and *Galium boreale*) were common to both habitats. Four exotic forb species were recorded. Three of these introduced species (*Chenopodium album, Crepis tectorum,* and *Taraxacum officinale*) are weeds. The fourth, *Trifolium hybridum*, is an exotic clover (see discussion in Site 28). This was our southernmost record for *Zygadenus elegans*, a poisonous plant.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 38.

Species Names	*Inside*	*Outside Burned*	*Outside Unburned*
Trees			
Betula papyrifera	•	•	•
Picea mariana	•		•
Picea glauca	•		
Populus balsamifera	•		
Populus tremuloides	•	•	•
Total Trees	5	2	3
Shrubs			
Alnus crispa	•	•	
Arctostaphylos uva-ursi	•		
Empterum nigrum	•		
Ledum groenlandicum	•	•	•
Linnaea borealis		•	•
Salix glauca	•	•	
Salix monticola	•		
Salix myrtillifolia			•
Vaccinium uliginosum	•		
Vaccinium vitis-idaea	•	•	•
Total Shrubs	8	5	4
Forbs			
Achillea borealis	•		
Aster sibiricus	•	•	
Chenopodium album	•		
Chenopodium rubrum	•		
Corydylis sempervirens		•	
Crepis tectorum	•		
Epilobium angustifolium	•		
Erigeron pulcherrima	•		
Galium boreale	•	•	
Gentiana glauca	•		
Geocaulon lividum			•
Geum macrophyllum	•		
Lupinus arcticus		•	
Oxytropis campestris	•		
Potentilla hookeriana	•		
Silene repens		•	
Taraxacum officinale	•		
Taraxacum alaskanum	•		
Trifolium hybridum	•		
Zygadenus elegans		•	
Total Forbs	15	6	1
Grasses			
Agropyron spp.	•		
Festuca altaica		•	
Festuca rubra	•		
Total Grasses	2	1	0
Sedges			
Carex glacialis	•		
Carex tenuiflora		•	
Total Sedges	1	1	0
Total Vascular Species	***31***	***15***	***8***

Three grass species were found at this location. Two occurred within the ROW (*Agropyron* spp. and *Festuca rubra*). One (*Festuca altaica*) occurred only in the adjacent forest. During the 2000 and 2001 growing seasons, this grass developed large

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #38

Date Examined:	19 September 1999
Location:	N63°56' 46.6"; W145°45' 36.7"; TAPS M.P. 547.7.
Pipeline:	Elevated
Slope:	Flat surface sloping gently west and northward
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Black spruce forest with aspen, burned on east side of ROW, unburned on west

Continued

specimens in the burned area (Photo 38-4). No grass species was common to both habitats. *Agropyron* spp. is an indigenous grass that invaded this site through natural means. *F. rubra* is an indigenous grass but was introduced during ROW revegetation.

Two sedge species were found at this location One species occurred in the ROW and the other in the adjacent forest. No sedge was common to both habitats.

Moose, hare, and bison are common wildlife in this vicinity.

Photo 38-4. A vigorous Festuca altaica *plant growing within an area of black spruce forest burned in two years prior. This indigenous bunchgrass was found colonizing portions of the TAPS ROW and was often present in the adjacent undisturbed communities along the pipeline route.*

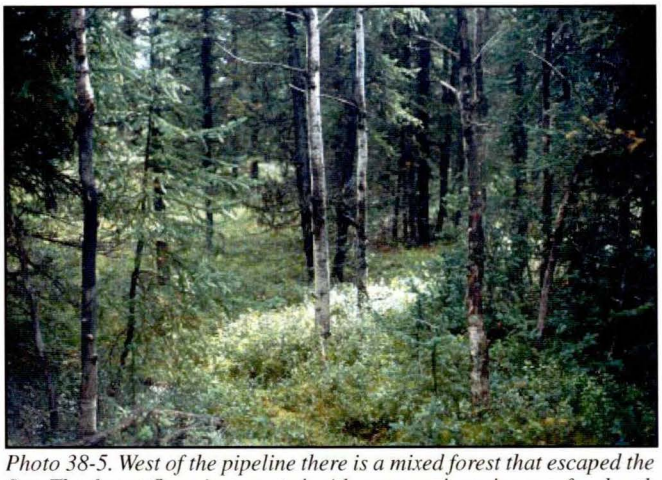


Photo 38-5. West of the pipeline there is a mixed forest that escaped the fire. The forest floor is carpeted with moss and produces a few heath shrubs.

This page deliberately left blank

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #39

Date Examined:	11 September 1999
Location:	N63°47' 59.0"; W145°49' 47.6"; TAPS M.P. 559.4.
Pipeline:	Elevated
Slope:	Flat surface sloping toward south and east
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Scattered trees within shrub tundra consisting of dwarf birch, willow and heath shrubs

Site No. 39 is located approximately 2 mi north of the pipeline crossing with the Richardson Highway on the south side of Donnelly Dome. The land is within the boundary of the Fort Greely military reserve. The location is west and north of the Richardson Highway. The elevated pipeline is on the west side of the ROW. Vehicle travel within the ROW occurs east of the pipeline. The ROW is vegetated except for wheel tracks of the roadway. Brush and young trees dominate beneath the pipeline, and an open stand of short grasses line the roadway margins. The site is within a drainage that flows southeast and eventually north into Jarvis Creek. Vegetation prior to construction was an open shrub tundra containing a scattering of white spruce trees. Undisturbed alpine tundra in this vicinity is pock marked with basins that seasonally fill with water. These basins seem to have been produced by frost boils. The tundra has experienced wildfires in this vicinity after the pipeline was constructed. About 20 years ago, a fire was caused by a stray rocket from a U.S. Air Force plane during a practice mission. The area actually burned was north and west of this site. Fill was placed within the ROW during pipeline construction at this location.

Shrubs and trees invading the ROW have been cut regularly, including the 1999 growing season. Moss and lichen (*Stereocaulon*) were important ground colonizers at this location beneath the pipeline. Moss and *Cetraria* spp. (lichen) were common outside the ROW.

Soil reaction was neutral inside the ROW (pH 7.00) and acidic outside (pH 6.26). Soil under the elevated pipe contained about 40% gravel, and that of the adjacent shrub land contained about 34% gravel. The dissimilarity in gravel content may indicate the fill material contained more stones than the natural material on site, and subsoil removed during VSM placement was deposited on the surface. Soil moisture was about 10.8% inside the ROW and about 48% outside. Total soil C was 0.49% within the ROW and 1.07% outside, translating to 1.08% and 2.4% organic matter, respectively. C content of the ROW and the adjacent tundra was low, but not unusual for these low production habitats. Calculated organic matter contents were 1.1% and 2.4% for the ROW and outside soils, respectively. Total soil N was 0.04% within the ROW and 0.09% outside, at this location. Total soil N is extremely low inside and outside the ROW. C:N ratios for the ROW and adjacent soils were about 12.

The amount of available soil N was also low in both soils, at 2 ppm in the ROW and 3 ppm outside. The neutral ROW soil N was in the ammonium form, and that in the acidic tundra soil was split between nitrate and ammonium. There was no carryover of N fertilizer from revegetation at this location. Vegetation was probably using N as quickly as it was mineralized from organic matter. Measurable available soil P was 6 ppm within the ROW soil and 1 ppm in the adjacent soil. The available soil P in both

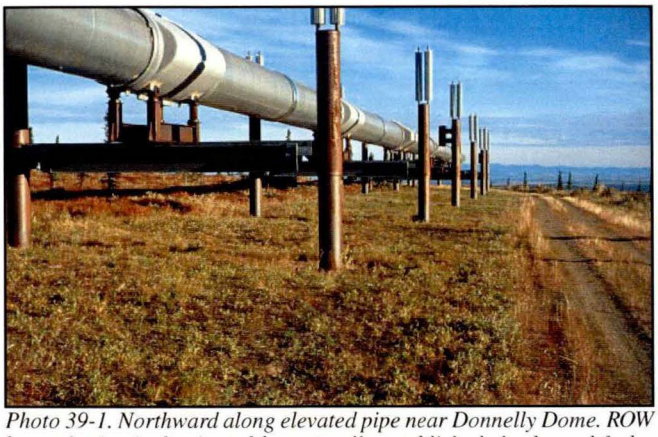


Photo 39-1. Northward along elevated pipe near Donnelly Dome. ROW beneath pipe is dominated by naturally established shrubs and forbs. Seeded grasses line the roadway except for wheel tracks.

Photo 39-2. Southwest across a mixture of alpine shrub tundra and scattered savannah of spruce trees. Alaska Range is in the background.

Site No. 39 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	40.4	33.7
Moisture %	10.8	48.4
Total C %	0.49	1.07
Total N %	0.04	0.09
C:N ratio	12.3	11.9
Organic matter %	1.1	2.4
pH	7.00	6.26
NH_4-N (ppm)	2	1
NO_3-N (ppm)	Not detectable	2
P (ppm)	6	1
K (ppm)	29	31
Organic mat thickness (cm)	1-2	4-6

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 39.		
Species Names	*Inside*	*Outside*
Trees		
Picea glauca	•	•
Populus tremuloides	•	
Populus balsamifera	•	
Total Trees	3	1
Shrubs		
Alnus crispa	•	
Betula nana	•	•
Dryas drummondii		•
Empetrum nigrum		•
Ledum decumbens		•
Salix reticulata	•	•
Salix monticola	•	
Salix lanata var richardsonii	•	•
Salix glauca	•	•
Salix myrtillifolia	•	•
Salix planifolia ssp. pulchra		•
Vaccinium vitis-idaea		•
Vaccinium uliginosum	•	•
Total Shrubs	8	11
Forbs		
Achillea borealis	•	
Artemisia borealis		•
Astragalus americanus		•
Delphinium glaucum		•
Epilobium angustifolium	•	
Equisetum arvense		•
Geocaulon lividum		•
Oxytropis campestris	•	
Parnassia palustris	•	
Pedicularis verticillata		•
Petasites frigidus		•
Platanthera hyperborea	•	
Polemonium acutiflorum		•
Pyrola secunda		•
Saxifraga hieracifolia		•
Valeriana capitata		•
Viola epipsila		•
Total Forbs	5	12
Grasses		
Arctagrostis latifolia	•	•
Festuca rubra	•	
Festuca altaica		•
Poa paucispicula		•
Total Grasses	2	3
Sedges		
Carex lugens	•	
Carex aquatilis		•
Carex spp.?		•
Eriophorum vaginatum		•
Total Sedges	1	3
Total Vascular Species	***19***	***30***

soils is quite low and could be limiting plant growth. There may have been a slight carryover of P fertilizer from revegetation. However, it is important to note that different extractions were used to measure available P at this site. Based on other Bray P-1 extractions, the tundra soil at this site is quite low in available P. Available K was 29 ppm inside the ROW and 31 ppm outside, marginally low in both soils. Values from both soils are within sampling and testing error limits and are equivalents.

Within the ROW the 1 to 2-cm thick organic mat consisted of plant debris, moss, mushrooms, and crustose lichen. The organic mat (4 cm) in the adjacent tundra consisted of plant debris and moss/lichen accumulations among the frost boils. Frost boils were barren.

Forty-two vascular plant species were recorded at this location. Nineteen were recorded within the ROW and 30 in the adjacent shrub habitat. Only one tree, six shrub, and one grass species were common to both habitats. No forbs or sedges were in common. This difference in species between the ROW and adjacent natural plant communities was caused by the habitat changes associated with construction, ROW mowing, and revegetation treatments.

Three tree species were found at this site. All three species occurred within the ROW. One tree species (*Picea glauca*) was common to both habitats. *Populus balsamifera* and *Populus tremuloides* occurred only within the ROW, indicating that construction disturbance permitted these trees to expand their local ranges to this site. Thirteen shrub species were found at this location; eight of these occurred in the ROW, and eleven within the adjacent shrub community. Six shrubs (*Betula nana, Salix reticulata, Salix lanata* var. *richardsonii, Salix glauca, Salix myrtillifolia* and *Vaccinium uliginosum*) were common to both habitats. Two species of shrubs (*Alnus crispa* and *Salix monticola*) were recorded only within the ROW.

Seventeen forb species were recorded at this location. Five occurred in the ROW. Only 12 forbs were recorded for the adjacent shrub tundra. No forb species was common to both habitats. No exotic forb species were found at this location.

Four grass species were found at this location. Two occurred within the ROW. Three occurred in the adjacent shrub tundra. One indigenous grass, *Agrostis latifolia*, was common to both habitats. *Festuca rubra*'s presence can be attributed to seed applications following pipeline construction. Two indigenous grass species, *Festuca altaica* and *Poa paucispicula*, were found only in the adjacent shrub community at this site.

One sedge (*Carex lugens*) occurred only within the ROW at this location. Three sedges (*Carex aquatilis, Eriophorum vaginatum,* and an unidentified species) were found in the adjacent undisturbed habitat. This was our southernmost record for *E. vaginatum*, which is close to the range Hultén (1968) presented for this plant.

Hare, moose, and occasionally bison are main wildlife species in this vicinity.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #40

Date Examined:	20 July 1999
Location:	N63°23' 13.8"; W145°43' 54.6"; TAPS M.P. 587.5.
Pipeline:	Elevated
Slope:	Flat surface sloping steeply toward south and east
Drainage:	Inside - well drained; Outside - perched over permafrost
Vegetation:	Scattered trees within shrub tundra consisting of dwarf birch, willow and heath shrubs

Site No. 40 is located approximately 23 mi south of Donnelly Dome, along the Delta River at the Denali Fault. The location is west of the Richardson Highway. The pipeline is on the west side of the ROW. South of the sample site, the pipeline is placed on specially constructed supports to allow for pipe movement in case of an earthquake (Photo 40-1). Vehicle travel within the ROW occurs east of the pipeline. The ROW is vegetated except for the roadway. Brush and young trees dominate beneath the pipeline, and an open stand of short grasses line the roadway margins. The site is within a drainage that flows northward and eventually into the Delta River. Vegetation prior to construction was an open shrub tundra containing a scattering of white spruce trees. Undisturbed tundra in this vicinity lacks the frost boil basins found at the Donnelly Dome site. Undisturbed vegetation at this location has a significant grass component. It is likely that wildfires have occurred in the area, but there were no evident signs of this. Fill was not placed within the ROW during pipeline construction at this location. Instead a cut was made into the gravel deposit, and the natural gravel exposed provided support for the road and pipeline.

Shrubs and trees invading the ROW may have been cut in prior years; however, site notes taken during this survey contained no information on that practice. Moss was colonizing the soil surface at this location beneath the pipeline. Moss and lichens (*Cladonia* and *Cetraria* spp.) were common outside the ROW.

Soil reaction was alkaline (pH 8.29)inside the ROW, and acidic outside (pH 5.27). Soil under the elevated pipe contained about 59% gravel, while that of the adjacent shrub land contained no gravel. Absence of gravel in the undisturbed area indicates that the natural gravel deposit at this location was capped with fine materials, which probably consisted of silts and fine sands originating from glacial outwash and volcanic ash. The

Site No. 40 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	59.1	0
Moisture %	8.4	82.8
Total C %	1.17	9.60
Total N %	0.01	0.36
C:N ratio	117	26.7
Organic matter %	2.6	21.3
pH	8.29	5.27
NH_4-N (ppm)	Not detectable	1
NO_3-N (ppm)	1	Not detectable
P (ppm)	2	7
K (ppm)	54	37
Organic mat thickness (cm)	0 - 2.5	22

Photo 40-1. Southward view of pipeline at the Denali Fault. Gravel fill at this location is poorly vegetated, supporting only a few grasses. Wheel tracks are barren in the well-used roadway. Shrubs and trees have invaded portions of the ROW without traffic and gravel fill. Mowing is probably used to control these woody plants.

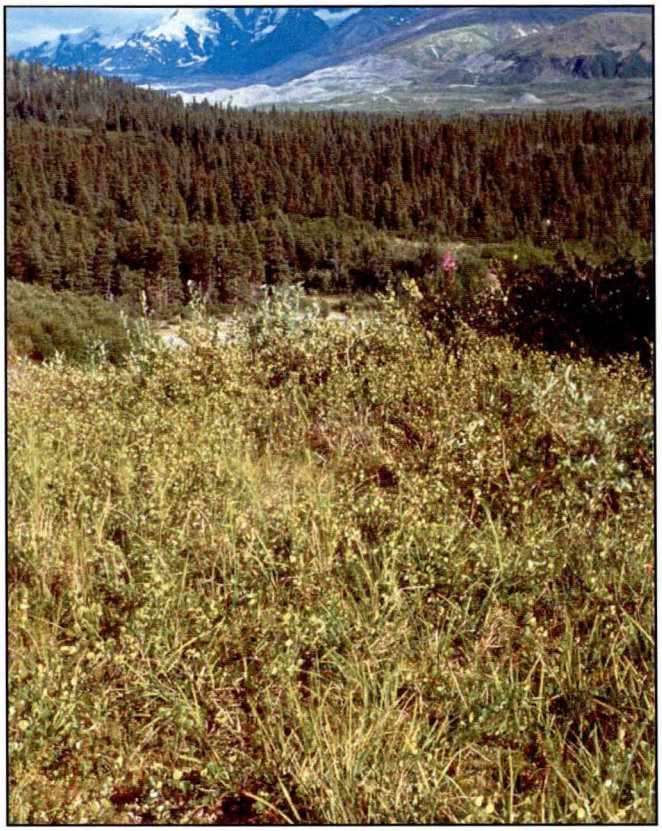


Photo 40-2. Adjacent vegetation on the hill to the north of the Denali Fault turnout is alpine shrub/cottongrass tundra. Spruce forest dominates the valley floor outside the ROW.

dissimilarity in gravel content between the ROW and adjacent forest soil does not indicate fill at this location, but rather removal of surface materials. Soil moisture inside the ROW was about 8.4% and outside about 83%. Total soil C within the ROW and outside was 1.17% and 9.60%, respectively, translating to organic matter values of 2.6% and 21.3%. C content of the ROW was moderately low, but that of the adjacent tundra was high and representative of tundra soils. Total soil N was extremely low inside (0.01%) and moderate (0.36%) outside the ROW. C:N ratios of the ROW and tundra soils were 117 and 27, respectively.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 40.

Species Names	*Inside*	*Outside*
Trees		
Picea glauca	•	•
Populus balsamifera	•	
Total Trees	2	1
Shrubs		
Alnus crispa	•	
Betula nana		•
Empetrum nigrum		•
Ledum decumbens		•
Rubus chamaemorus		•
Salix glauca	•	•
Salix brachyophylla ssp nyphoclada	•	
Salix planifolia ssp. pulchra		•
Salix alaxensis	•	•
Salix barclayi		•
Shepherdia canadensis	•	
Vaccinium vitis-idaea		•
Vaccinium uliginosum		•
Total Shrubs	5	10
Forbs		
Aster sibiricus	•	
Epilobium latifolium	•	
Epilobium angustifolium	•	
Gentiana propinqua	•	
Hedysarum alpinum	•	
Parnassia palustris	•	
Pedicularis labradorica		•
Polygonum bistora subsp. plumosum		•
Pyrola secunda	•	
Tofieldia pusilla	•	
Total Forbs	8	2
Grasses		
Calamagrostis canadensis		•
Festuca rubra	•	
Heirochloe alpina		•
Poa arctica		•
Poa pratensis	•	
Total Grasses	2	3
Sedges		
Carex bigelowii		•
Total Sedges	0	1
Total Vascular Species	***17***	***17***

The amount of total available soil N was low (1 ppm) in both soils. The alkaline ROW soil N was in the nitrate form, and that in the acidic tundra soil was as ammonium. There was no carryover of N fertilizer from revegetation at this location. Vegetation was probably using N as quickly as it was mineralized from soil organic matter. Measurable available soil P was 2 ppm within the ROW soil and 7 ppm in the adjacent tundra soil. P is low in both soils and could be limiting plant growth. There was no carryover of P fertilizer from revegetation. It is important to note that different extractions were used to measure available P at this site. Available K was 54 ppm inside the ROW and 37 ppm outside. This indicated that K was marginally low in undisturbed habitat and possibly adequate in the ROW soil. Difference in available K between these two soils could be interpreted as an indication of carryover of fertilizer from revegetation. However, it is suspected that it simply reflects inherent differences in K contents of the two geologic materials.

Within the ROW the organic mat consisted of plant debris and moss up to 2.5 cm in thickness. The organic mat (22 cm) in the adjacent tundra consisted of plant debris (peat) typical for tundra vegetation.

Thirty-one vascular plant species were recorded at this location. Seventeen were recorded within the ROW and the adjacent shrub habitat. One tree and two shrub species were common to both habitats; there were no forbs, grasses, or sedges in common. This disparity of species between the ROW and adjacent natural plant communities was caused by the habitat changes associated with construction, which created a drier habitat with a less acidic soil and introduced competitive grasses. In time, the vegetation of the ROW will tend toward a shrub forest type, similar to those found along Richardson Highway in the valley floor.

Two tree species were found at this site. Both tree species occurred within the ROW. One tree species (*Picea glauca*) was common to both habitats. *Populus balsamifera* occurred only within the ROW, indicating that construction disturbance permitted this tree to expand its local range to this site. Thirteen shrub species were found at this location. Five shrub species were found in the ROW, and ten within the adjacent shrub community. Two shrubs (*Salix glauca, Salix alaxensis*) were common to both habitats. Three species of shrubs (*Alnus crispa, Salix brachyophylla* ssp. *nyphoclada*, and *Shepherdia canadensis*) were recorded only within the ROW.

Ten forb species were recorded at this location. Eight occurred in the ROW. Two forbs occurred in the adjacent shrub tundra. No forb species was common to both habitats. No exotic forb species were found at this location.

Five grass species were found at this location. Two occurred within the ROW. Three occurred in the adjacent shrub tundra. No grass was common to both habitats. The presence of *Festuca rubra* and *Poa pratensis* can be attributed to seed applications following pipeline construction. Three indigenous grass species (*Calamagrostis canadensis*, *Heirochloe alpina,* and *Poa arctica*) were found only in the adjacent shrub community at this site.

One sedge (*Carex bigelowii*) occurred only in the adjacent undisturbed habitat. No sedges occurred in the ROW, probably because it was too dry for those species.

Moose appeared to be the main wildlife species in this vicinity. In some years, hares are very common along this stretch of highway, and fox and beaver are also observed on occasion.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #41
Date Examined:	20 July 1999
Location:	N63°15' 18.4"; W145°41' 55.7"; TAPS M.P. 599.
Pipeline:	Elevated
Slope:	Flat surface sloping steeply toward south and east
Drainage:	Inside - well drained; Outside - perched over permafrost
Vegetation:	Open shrub tundra, tall alder, occasional white spruce

Site No. 41 is located approximately 13-14 mi north of Summit Lake, along Phelan Creek, near Rainbow Mountain. The location is west of the Richardson Highway. The pipeline is on the west side of the ROW. The site lies west of Phelan Creek, on the slope immediately above the creek and north of the bridge. Vehicle travel within the ROW occurs east of the pipeline. The ROW is vegetated except for the roadway. A scattering of brush and young trees occur beneath the pipeline. Stands of short grasses line margins of the roadway and occupy spaces among the shrubs and trees under the pipeline. The site is within a drainage that flows northward and eventually north into the Delta River. Vegetation prior to construction was an open alpine shrub tundra with a very sparse scattering of white spruce trees. Undisturbed vegetation at this location has significant grass and tussock sedge components. Fill was placed within the ROW during pipeline construction at this location. A ravine cloaked with tall shrub lies just west of the pipeline.

Shrubs and trees invading the ROW may have been cut in prior years; however, site notes taken during this survey contained no information on that practice. Brush and tree invasion of the ROW is not extensive at this location. Without brushing, this section of ROW would still remain relatively open for some time. Moss was colonizing the ground surface at this location beneath the pipeline. Moss and lichens (*Stereocaulon, Cladonia,* and *Cetraria* spp.) were recorded within the ROW. Moss and lichens (*Peltigera, Cetraria,* and *Cladonia*) were common on the tundra surface outside the ROW.

Soil reaction was alkaline inside the ROW (pH 8.28) and acidic outside (pH 5.62). Soil under the elevated pipe contained about 67% gravel, while that of the adjacent shrub land contained about 20% gravel. Difference in the gravel between the two habitats resulted from rocky fill deposited in the ROW at this location. Soil moisture inside the ROW was about 7% and outside about 30%. Total soil C was 0.44% and 2.45%, respectively, translating to 0.98% and 5.44% organic matter for the ROW and the adjacent soils. C content of the ROW was low, but that of the adjacent tundra was moderate. These values probably reflected the effects of a south-facing slope on decomposition. Total soil N was extremely low inside and moderate outside the ROW. C:N ratio for the tundra soil was 27.2.

The amount of available soil N was 2 ppm within the ROW, and below detection limits outside the ROW. The alkaline ROW soil N was in the ammonium and nitrate forms. There was no carryover of N fertilizer from revegetation at this location. Vegetation was probably using N as quickly as it was mineralized from soil organic matter, especially in the undisturbed tundra. Measurable available soil P was 4 ppm within the ROW soil and 2 ppm in the adjacent tundra soil. The available soil P in both soils is quite low and could be limiting plant growth. There was no carryover of P fertilizer from revegetation. It is important to note that different extractions were used to measure available P at this site. The alkaline soil was extracted with sodium bicarbonate, and the acidic soil was extracted with Bray P-1 (an acid mixture). Based on other Bray P-1 extractions, the tundra soil results are quite low in available P. Available K was low (22 ppm in both habitats), possibly restricting plant production. There was probably no carryover of K fertilizer from revegetation treatments at this location.

Photo 41-1. Northwest view up slope above Phelan Creek. Seeded fescue grass and indigenous shrubs appear in the ROW.

Site No. 41 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	66.8	20.0
Moisture %	7.0	30.4
Total C %	0.44	2.45
Total N %	Not detectable	0.09
C:N ratio	Not applicable	27.2
Organic matter %	1	5.4
pH	8.28	5.62
NH_4-N (ppm)	1	Not detectable
NO_3-N (ppm)	1	Not detectable
P (ppm)	4	2
K (ppm)	22	22
Organic mat thickness (cm)	0 - 1.5	14

Within the ROW the organic mat consisted of plant debris, lichens, and moss up to 1.5 cm in thickness. The organic mat (14 cm) in the adjacent tundra consisted of plant debris (peat) typical for this vegetation. The tundra organic mat was thinner than that found on north-facing slopes.

Thirty vascular plant species were recorded at this location. Nineteen were recorded within the ROW and 15 in the adjacent shrub tundra habitat. Four shrub species were common to both habitats. There were no tree, forb, grass, or sedge species in common. This disparity of species was caused by habitat changes associated with construction, and with revegetation which introduced competitive grasses. In time, the vegetation of the ROW will trend toward a shrub forest type, similar to those found along Phelan Creek in the valley floor.

Two tree species were found at this site, neither species common to both habitats. *Populus balsamifera* occurred only within the ROW, indicating the construction disturbance permitted this tree to expand its local range to this site. *Picea glauca* occurred only in the adjacent tundra habitat.

Thirteen shrub species were found at this location. Nine of these were found in the ROW, and eight within the adjacent shrub community. Four shrubs (*Arctostaphylos alpine, Betula nana, Salix planifolia* ssp. *pulchra,* and *Vaccinium uliginosum*) were common to both habitats. Five species of shrubs (*Alnus crispa, Rosa acicularis, Salix alaxensis, Salix barclayi,* and *Salix glauca*) were recorded only within the ROW. Four shrub species were found only in the undisturbed habitat (*Empetrum nigrum, Ledum decumbens, Rubus chamaemorus,* and *Vaccinium vitis-idaea*). All of these tundra shrubs are members of the heath family and characteristically occur in moist, acidic habitats.

Eleven forb species were recorded at this location. Seven occurred in the ROW. Four forb species were recorded in the adjacent shrub tundra. No forb species was common to both habitats. All forb species found at this location were indigenous.

Three grass species were observed at this location. Two occurred only within the ROW. One occurred only in the adjacent shrub tundra. No grass was common to both habitats. *Festuca rubra*'s presence in the ROW can be attributed to seed applications following pipeline construction. The two reedgrasses (*Calamagrostis canadensis* and *C. lapponica*) were natural colonizers.

One sedge (*Carex bigelowii*) occurred only in the adjacent undisturbed habitat. No sedges occurred in the ROW, probably because it was too dry for those species.

Browsed *Salix alaxensis* indicated that moose are an important wildlife species in this vicinity. In some years, hares are very common along this stretch of highway, and fox and beaver are also observed on occasion.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 41.

Species Names	Inside	Outside
Trees		
Picea glauca		•
Populus balsamifera	•	
Total Trees	1	1
Shrubs		
Alnus crispa	•	
Arctostaphylos alpina	•	•
Betula nana	•	•
Empetrum nigrum		•
Ledum decumbens		•
Rosa acicularis	•	
Rubus chamaemorus		•
Salix alaxensis	•	
Salix barclayi	•	
Salix glauca	•	
Salix planifolia ssp. pulchra	•	•
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea		•
Total Shrubs	9	8
Forbs		
Astragalus alpinus	•	
Cornus canadensis	•	
Epilobium angustifolium	•	
Epilobium latifolium	•	
Equisetum arvense	•	
Oxytropis campestris	•	
Pedicularis labradorica		•
Polygonum bistora subsp. plumosum		•
Saussurea angustifolia		•
Saxifraga tricuspidata	•	
Stellaria laeta		•
Total Forbs	7	4
Grasses		
Calamagrostis canadensis	•	
Calamagrostis lapponica		•
Festuca rubra	•	
Total Grasses	2	1
Sedges		
Carex bigelowii		•
Total Sedges	0	1
Total Vascular Species	**19**	**15**

Photo 41-2. Undisturbed vegetation adjacent to the ROW is alpine shrub/ sedge with incursions of tall shrubs and occasional spruce.

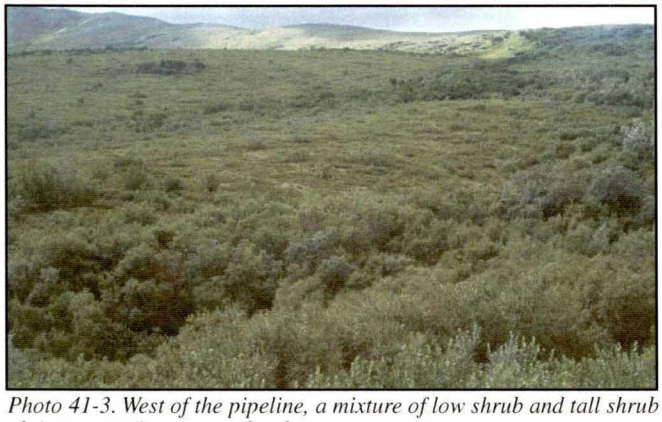


Photo 41-3. West of the pipeline, a mixture of low shrub and tall shrub alpine vegetation covers the slope.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #42

Date Examined:	20 July 1999
Location:	N63°12' 4.02"; W145°30' 42.9"; TAPS M.P. 606.5.
Pipeline:	Buried
Slope:	Flat surface sloping gently toward south and west
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Open willow-herb-lichen on glacial outwash; occasional cottonwood

Site No. 42 is located at the Isabel Camp site near Summit Lake, on the glacial outwash from the Gulkana Glacier. This is the only site in our survey that was not on the TAPS ROW. The location is east of the Richardson Highway. The pipeline is buried west of the camp site. Vehicle travel within the camp is predominantly on the trail that leads up the valley, beyond the camp. The camp site is gradually becoming vegetated with indigenous species except for the roadway, which remains relatively free of plants due to continuous vehicle traffic. Camping and other recreational uses continually disturb the site. Generally it is the repeated vehicle traffic that is the greatest human deterrent to plant colonization.

The site is near the divide between the Delta and Gulkana drainages. Vegetation prior to construction was an open scrub with a very sparse scattering of cottonwood trees. Willow shrubs were much more common than the cottonwood. A thin, patchy layer of organic matter occurred on the surface of the gravel outwash. This and the live vegetation trapped dust and sand blowing across the site, allowing for limited soil development to occur. What little soil and organic mat that had formed was removed from the camp site. The process of primary succession is underway at this site. The rate at which that process occurs could be a study in itself and is beyond the scope of this survey.

Undisturbed vegetation at this location includes an interesting array of primary succession species, including lichens, moss, herbs, shrubs and one tree species. This makes the site ecologically informative for understanding which indigenous species are important to colonizing open gravel in this region. Such information should be useful in selecting revegetation approaches and goals for gravel habitats in the region, i.e. McCallum Creek. The Isabel Camp site did not appear to have been either seeded or fertilized and was undergoing colonization strictly by natural processes. Evidence along the access road indicated Festuca rubra had been seeded to the area. Fertilizer was likely applied. The fact that a trail existed to this site from the Richardson Highway may or may not have been associated with the pipeline. The trail may have predated the pipeline; however, trail improvements occurred because of the camp.

Laboratory soil data for samples from this location exhibited values such as might be expected from raw glacial outwash, upon which minimal vegetation establishment had occurred. Soil reaction was slightly alkaline inside and outside the camp area (pH 7.55 and pH 7, respectively). Soil on the camp site contained about 64% gravel, and that of the adjacent shrub community about 77% gravel. Variations in gravel content between these two locations represented sampling error. The gravel contents of glacial outwash in both locations ought to be the same. Soil moisture inside the camp was about 9% and outside about 3%. This difference may be legitimate, reflecting differences in plant

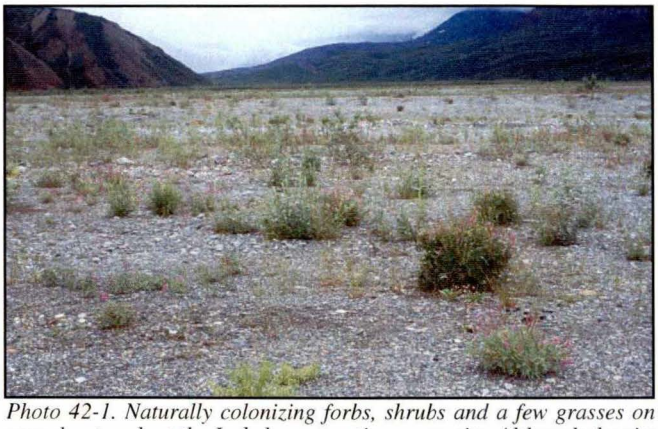


Photo 42-1. Naturally colonizing forbs, shrubs and a few grasses on gravel outwash at the Isabel construction camp site. Although the site was seeded and fertilized, no evidence of revegetation was found.

Photo 42-2. South of the camp site, a complex of tall willow, cottonwood, herb and lichen vegetation covered the gravel.

Site No. 42 soil data inside and outside Isabel Camp site.

Characteristic	*Inside*	*Outside*
Gravel %	64.2	77.3
Moisture %	8.9	3.2
Total Carbon %	0.50	0.80
Total Nitrogen %	0.01	0.03
C:N ratio	50	26.7
Organic matter %	1.1	1.8
pH	7.55	7.41
NH_4-N (ppm)	1	Not detectable
NO_3-N (ppm)	1	Not detectable
P (ppm)	1	1
K (ppm)	19	17
Organic mat thickness (cm)	0	0 - 2

populations. There was considerably more vascular vegetation outside the camp site, which would be expected to transpire more soil water than would the sparse vegetation within the abandoned camp. Limited capacity to hold moisture is undoubtedly an important factor affecting plant establishment on this gravel outwash.

Total soil C was 0.50% within the camp site and 0.80% outside, translating to 1.11% and 1.78% organic matter, respectively. Inorganic carbonate C would have been included in this laboratory analysis. Thus, the actual organic matter contents of these samples could be lower than calculated. C contents of both locations were low, as would be expected from such habitats. Total soil N is extremely low both inside and outside the camp site (0.01% and 0.03%, respectively).

The amount of available soil N was low within the camp site and below detection limits outside. Total available N was 2 ppm for soils within the camp site. The soil N was in the ammonium and nitrate forms. Vegetation outside the camp site was probably using N as quickly as it was mineralized from the limited supply of soil organic matter. Measurable available soil P was quite low (1 ppm in both soils), probably limiting plant growth. Available K was 19 ppm inside and 17 ppm outside the camp site. That indicated that K was low in both habitats and possibly restricting plant production. These 'soils' would be expected to have low nutrient holding capacities, from lack of organic matter, low silt, and low clay contents. Therefore, mineral nutrition in general would constrain the amount of plants either site might support, until a sufficient accumulation of organic matter had formed.

Within the camp site no organic mat had developed. The organic mat outside the camp site varied from none to 2 cm. The photos and plant discussion explain this more fully.

Twenty-seven vascular plant species were recorded at this location. Eighteen were recorded within the camp site and 18 in the adjacent habitat. Nine species were common to both habitats: one tree, three shrub, three forb, and two grasses. No sedges were found at this location.

Commonality of species between the camp site and adjacent natural plant community reflected similarities in habitats. Dissimilarities are the product of age differences. In time, the vegetation of the camp site should tend toward a lichen-herb-

Vascular plant species observed inside and outside the Isabel Camp location, Site No. 42.

Species Names	Inside	Outside
Trees		
Populus balsamifera	•	•
Total Trees	1	1
Shrubs		
Dryas drummondii	•	•
Rubus arcticus	•	
Salix alaxensis	•	•
Salix barclayi	•	
Salix planifolia ssp. pulchra		•
Shepherdia canadensis	•	•
Total Shrubs	5	4
Forbs		
Achillea borealis	•	
Arnica frigida	•	
Aster sibiricus		•
Astragalus alpinus		•
Epilobium angustifolium	•	
Epilobium latifolium	•	•
Epilobium palustre		•
Erigeron acris	•	•
Hedysarum alpinum	•	•
Hedysarum mackenzii		•
Lupinus arcticus		•
Potentilla multifida	•	
Senecio lugens		•
Taraxacum alaskanum	•	
Total Forbs	8	9
Grasses		
Agropyron spp.	•	•
Arctagrostis latifolia	•	
Calamagrostis canadensis	•	
Poa alpina		•
Poa glauca		•
Trisetum spicatum	•	•
Total Grasses	4	4
Sedges		
Total Sedges	0	0
Total Vascular Species	**18**	**18**

Photo 42-3. Pioneering Hedysarum mackenzii *and* H. alpinum *establish on open gravel. These plants trap soil fines carried in by the wind. Mosses and lichens establish around the plants and continue to accumulate fines, adding organic matter to the soil. Eventually the herb dies, leaving a ring of decayed moss and lichen on the gravel surface as in this image.*

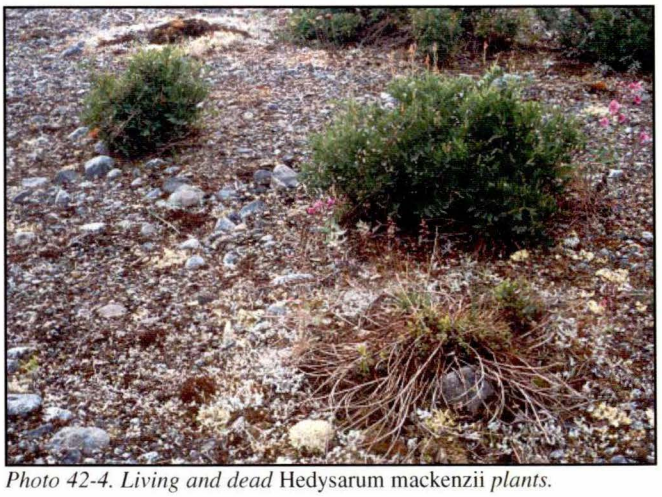


Photo 42-4. Living and dead Hedysarum mackenzii *plants.*

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #42

Date Examined:	20 July 1999
Location:	N63°12' 4.02"; W145°30' 42.9"; TAPS M.P. 606.5.
Pipeline:	Buried
Slope:	Flat surface sloping gently toward south and west
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Open willow-herb-lichen on glacial outwash; occasional cottonwood

Continued

shrub scrub, similar to that found in the adjacent undisturbed plant community.

One tree species was found at this site (cottonwood). That tree species occurred within the camp site as seedlings and in the adjacent habitat as stunted trees. Six shrub species were found at this location, five within the camp site and four within the adjacent community. Three shrubs (*Dryas drummondii, Salix alaxensis,* and *Shepherdia canadensis*) were common to both habitats. *D. drummondii* and perhaps *S. canadensis* are N-fixing higher plants. Two species of shrubs (*Rubus arcticus* and *Salix barclayi*) were recorded only within the camp site. One shrub species (*Salix planifolia* ssp. *pulchra*) was found only in the undisturbed habitat. All tree and shrub species at this location are indigenous.

Fourteen forb species were recorded at this location. Eight occurred in the camp site, and nine in the adjacent habitat. Three forb species (*Epilobium latifolium, rigeron acris,* and *Hedysarum alpinum*) were common to both habitats. *Achillea borealis, Arnica frigidus, Epilobium angustifolium, Potentilla multifida,* and *Taraxacum alaskanum* were found only in the disturbed camp site habitat. *Aster sibiricus, Astragalus alpinus, Epilobium paulstre, Hedysarum mackenzii, Lupinus arcticus,* and *Senecio lugens* were found only in the undisturbed habitat. All forb species found at this location are indigenous to Alaska. *A. alpinus, H. alpinum, H. mackenzii,* and *L. arcticus* are all N-fixing species and significant to building soil N supplies for other plant species.

Six grass species were found at this location. Four occurred within the camp site and four in the adjacent community. Two grass species (*Agropyron* spp. and *Trisetum spicatum*) were common to both habitats. *Arctagrostis latifolia* and *Calamagrostis canadensis* were found only within the camp site. *Poa alpina* and *Poa glauca* were found only in the undisturbed habitat.

Of particular interest at this location was the association between *Hedysarum*, lichens and mosses. Three photos illustrate this mutualism. As previously stated, *Hedysarum* plants are N fixing legumes. They are capable of establishing on this gravel outwash without assistance. Around these individual plants, a colony of lichens (primarily *Stereocaulon* spp) develop just beyond the drip line of the *Hedysarum* canopy. *Stereocaulon* lichens contain a blue-green algae, which is capable of fixing atmospheric N. Beneath the *Hedysarum* canopy, moss apparently colonize, living within the influence of the higher plant. Undoubtedly the shelter and N supplied by the *Hedysarum* as well as the *Stereocaulon* lichen are important factors in forming these colonies that dot the surface of the landscape. An accumulation of organic matter occurs within these rings of lichen and *Hedysarum.* The organic accumulation persists even after the legume plant dies, leaving a dark center (partially decomposed organic matter) ringed with a light-colored lichen community. Our observations were time-constrained at this site, but it was clear that interesting ecological processes related to soil and plant community development were occurring at this location. This site demonstrates the importance of N-fixing plant species for vegetating open gravel.

Moose browse intensely on *Salix alaxensis* at this location. Beaver have been observed near the Richardson Highway here, and caribou, red fox, and other species are common in the area.

Photo 42-5. H. alpinum *surrounded by* Stereocaulon *and other lichen. Buffalo berry,* Shepherdia canadensis, *can be seen in the upper left center of this photo. Buffalo berry is a pioneer that probably fixes atmospheric N.*

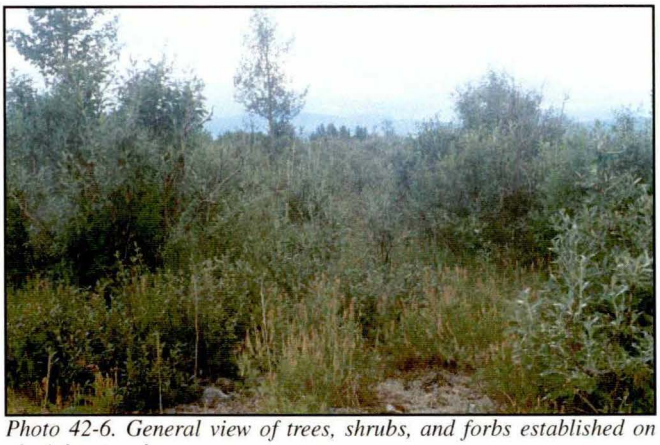


Photo 42-6. General view of trees, shrubs, and forbs established on glacial outwash.

This page deliberately left blank

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #43

Date Examined:	20 July 1999
Location:	N63°05' 22.7"; W145°29' 25.1"; TAPS M.P. 613.4.
Pipeline:	Buried
Slope:	Rolling surface sloping northward toward Fish Creek
Drainage:	Inside - well drained; Outside - laterally drained, probably over permafrost
Vegetation:	Open shrub tundra, wet sedge in drainage valleys, occasional white spruce

Site No. 43 is located east of the southern end of Summit Lake. The site is east of the Richardson Highway. The pipeline is on the east side of the ROW, and the roadway is on the west side. The site lies north of Fish Creek and drains northward to the creek. Vehicle travel within the ROW appears to be relatively intense, depriving the roadway of plant cover. The remainder of the ROW is vegetated with seeded grasses and indigenous shrubs. Tall willow and young trees predominate over the buried pipeline. Stands of short grasses line margins of the roadway and occupy spaces among the shrubs and trees over the pipeline. The site is within a drainage that flows southward and eventually into the Gulkana River. Vegetation prior to construction was an open alpine shrub tundra (about 50% shrub cover) containing a very sparse scattering of white spruce trees. Undisturbed vegetation at this location varies markedly with the rolling topography. Heath shrub with a lichen-moss understory dominates slopes and elevated ground. Valleys are wet and generally covered with wet sedge meadow species. Gravel was either placed within the ROW or exposed by grading during pipeline construction at this location. Summer and winter (snowmachining) recreation are popular at this location.

Evidence of cutting shrubs and trees invading the ROW was not recorded for this site. This section of ROW is gradually being overtaken by tall shrubs, particularly over the pipeline. Left unchecked. this brush will eventually form a tall shrub mixture with a few trees. Moss was not colonizing the ground surface at this location over the pipeline, as dry soil conditions prevented its invasion. Moss and lichens (*Peltigera, Cetraria,* and *Cladonia*) were common on the tundra surface outside the ROW.

Soil reaction was acidic both inside and outside the ROW (pH 6.24 and pH 5.72, respectively). Soil over the buried pipe

Site No. 43 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	66.2	10.5
Moisture %	12.2	69.2
Total C %	1.08	6.81
Total N %	0.08	0.24
C:N ratio	13.5	28.4
Organic matter %	2.4	15.1
pH	6.24	5.72
NH_4-N (ppm)	1	1
NO_3-N (ppm)	Not detectable	Not detectable
P (ppm)	10	5
K (ppm)	47	15
Organic mat thickness (cm)	1 - 4	20 - 23

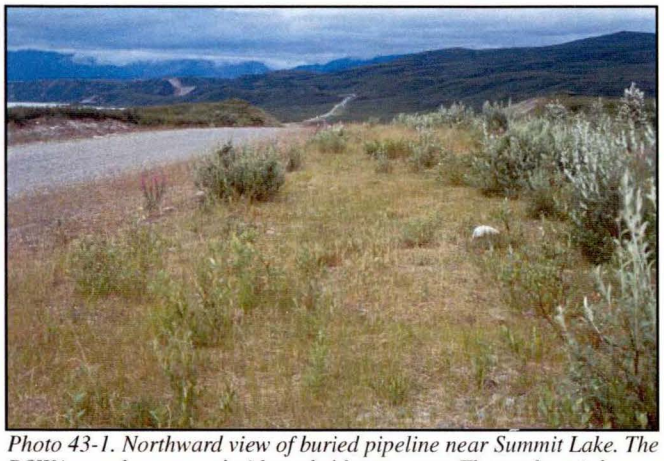


Photo 43-1. Northward view of buried pipeline near Summit Lake. The ROW is mostly vegetated with seeded fescue grass. The roadway is barren gravel. Shrubs are invading over the buried pipeline and outside the roadway.

Photo 43-2. Adjacent vegetation is open shrub with lichen and heath species covering the ground. A few spruce trees appear on the landscape.

contained about 66% gravel, while that of the adjacent shrub land was about 11% gravel. This difference between the two habitats was due to disturbances from construction activities. Soil moisture inside the ROW was about 12% and outside about 69%. Total soil C was 1.08% in the ROW and 6.84% outside, translating to 2.4% and 15.2% organic matter, respectively. C content of the ROW was low, but that of the adjacent tundra was moderate. Total soil N is low (0.08%) inside and moderate (0.24%) outside the ROW. C:N ratios for the ROW and tundra soils were about 14 and 28, respectively.

The amount of available soil N was low at 1 ppm for both soils. These acidic soils held N in the ammonium form. There was no carryover of N fertilizer from revegetation at this location. Vegetation was probably using N as quickly as it was mineralized from soil organic matter, especially in the undisturbed tundra. Measurable available soil P was 10 ppm within the ROW soil and 5 ppm in the adjacent shrub tundra soil. The available soil P in both soils is marginally adequate and may not be limiting plant growth. There may have been carryover of P fertilizer from revegetation. Available K was 47 ppm inside and 15 ppm outside the ROW. That indicated that K was marginally adequate within the ROW and possibly limiting outside. There may have been a carryover of K fertilizer from revegetation treatments at this location.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 43.

Species Names	Inside	Outside
Trees		
Picea glauca	•	•
Populus balsamifera	•	
Populus tremuloides	•	
Total Trees	3	1
Shrubs		
Arctostaphylos alpina		•
Betula nana		•
Cassiope tetragona	•	
Empetrum nigrum	•	
Ledum decumbens	•	•
Rubus chamaemorus		•
Salix alaxensis	•	
Salix barclayi	•	
Salix glauca	•	•
Salix planifolia ssp. pulchra	•	•
Spirea beauverdiana	•	
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea	•	•
Total Shrubs	10	8
Forbs		
Achillea borealis	•	
Artemisia borealis		•
Castelleja elegans		•
Cornus canadensis		•
Epilobium angustifolium	•	
Epilobium latifolium	•	
Erigeron acris	•	
Gentiana algida	•	
Oxytropis campestris	•	
Pedicularis labradorica		•
Potentilla hookeriana	•	•
Senecio lugens	•	
Taraxacum officinale	•	
Veronica americana	•	
Viola epipsila		•
Total Forbs	10	6
Grasses		
Alopecurus pratensis	•	
Festuca rubra	•	
Heirochloe alpina		•
Total Grasses	2	1
Sedges		
Carex bigelowii		•
Total Sedges	0	1
Total Vascular Species	**25**	**17**

Within the ROW the organic mat consisted of plant debris up to 4 cm in thickness. The organic mat (20-23 cm) in the adjacent shrub tundra consisted of mosses, lichens, and plant debris (peat) typical for this vegetation. The organic mat was thicker here than on the south-facing slope above Phelan Creek, Site No. 41.

Thirty-five vascular plant species were recorded at this location. Twenty-five were recorded within the ROW and 17 in the adjacent shrub tundra habitat. Only one tree, five shrubs, and one forb species were common to both habitats. No grass or sedge were common to these habitats. This disparity of species between the ROW and adjacent natural plant communities was caused by habitat changes associated with construction and revegetation, which created a drier habitat and introduced competitive grasses.

Three tree species were found at this site. All three species occurred within the ROW. One tree species (*Picea glauca*) was common to both habitats. *Populus balsamifera* and *Populus tremuloides* occurred only within the ROW, indicating that construction disturbance permitted these trees to expand their local ranges to this site. Thirteen shrub species were found at this location. Ten shrub species were found in the ROW, and eight within the adjacent shrub community. Five shrubs (*Ledum decumbens, Salix glauca, Salix planifolia* ssp. *pulchra, Vaccinium uliginosum,* and *Vaccinium vitis-idaea*) were common to both habitats. Five shrub species were found only in the disturbed habitat (*Cassiope tetragona, Empetrum nigrum, S. alaxensis, S. barclayi,* and *Spirea beauverdiana*). Three shrubs were found only in the undisturbed community (*Arctostaphylos alpina, Betula nana,* and *Rubus chamaemorus*). Slightly less than half of the shrubs at this location are members of the heath family.

Fifteen forb species were recorded at this location. Ten occurred in the ROW, and six in the adjacent shrub tundra. One forb species, *Potentilla hookeriana,* was common to both habitats. *Taraxacum officinale* found at this location is an introduced weed.

Three grass species were found at this location. Two (*Alopecurus pratensis* and *Festuca rubra*) occurred only within the ROW. One (*Heirochloe alpina*) occurred only in the adjacent shrub tundra. No grass was common to both habitats. *Festuca rubra*'s presence here can be attributed to seed applications following pipeline construction. *A. pratensis* is an introduced forage grass and was seeded during revegetation of this portion of the ROW.

One sedge (*Carex bigelowii*) occurred only in the adjacent undisturbed habitat. No sedges occurred in the ROW, probably because it was too dry for those species.

Browsed *Salix alaxensis* indicated that moose are an important wildlife species in this vicinity. In some years, hares are very common along this stretch of highway, and fox and caribou are observed on occasion.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #44

Date Examined:	20 July 1999
Location:	N62°43' 44.5"; W145°25' 56.3"; TAPS M.P. 639.8.
Pipeline:	Elevated
Slope:	Flat to slightly rolling surface sloping gently eastward
Drainage:	Inside - well drained; Outside - perched over permafrost
Vegetation:	Black spruce-shrub forest (50-60% closed)

Site No. 44 is located about 6 miles north of Hogan Hill along the Richardson Highway. The ROW is east of the Richardson Highway. The pipeline is on the west side of the ROW, and the roadway on the east. The ROW is vegetated with seeded grasses and indigenous forbs and shrubs. The roadway is barren gravel. Stands of short grasses line the roadway margins and occupy spaces among the shrubs and trees under the pipeline. The site drains into Haggard Creek. Vegetation prior to construction was a spruce forest. Heath shrub with lichens and moss typifies the understory. Gravel fill was placed in the ROW during pipeline construction.

Evidence of cutting shrubs and trees invading the ROW was not recorded for this site. Shrubs at this location were shorter than at many other locations in the boreal forest zone. This section of ROW is gradually being overtaken by shrubs and trees, particularly under the pipeline. If left unchecked this brush will eventually form a forest with a shrub understory. Moss was colonizing patches of the surface under the pipeline, as were *Stereocaulon* and *Peltigera* lichens. Moss and lichens (*Peltigera, Cetraria,* and *Cladonia*) were common on the tundra surface outside the ROW.

Soil reaction was alkaline inside the ROW (pH 7.87) and acidic outside (pH 5.37). Soil under the elevated pipe contained about 63% gravel, and that of the adjacent shrub land contained about 21% gravel. Difference in the gravel between the two habitats was due to disturbances from construction activities. Soil moisture inside the ROW was about 6% and outside about 45%. Total soil C was 0.67% within the ROW and 4.66% outside, translating to 1.5% and 10.3% organic matter, respectively. C content of the ROW was low (0.67%), but that of the adjacent

Site No. 44 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	63.3	21.1
Moisture %	6.4	44.5
Total C %	0.67	4.66
Total N %	0.01	0.14
C:N ratio	67	33.3
Organic matter %	1.5	10.4
pH	7.87	5.37
NH_4-N (ppm)	1	Not detectable
NO_3-N (ppm)	1	Not detectable
P (ppm)	3	6
K (ppm)	28	24
Organic mat thickness (cm)	0 - 2	18

Photo 44-1. Gravel fill in this location is being invaded by shrubs and trees, except in the roadway, which remains barren gravel. Fireweed, horsetail and a few grasses predominate among the shrubs and trees.

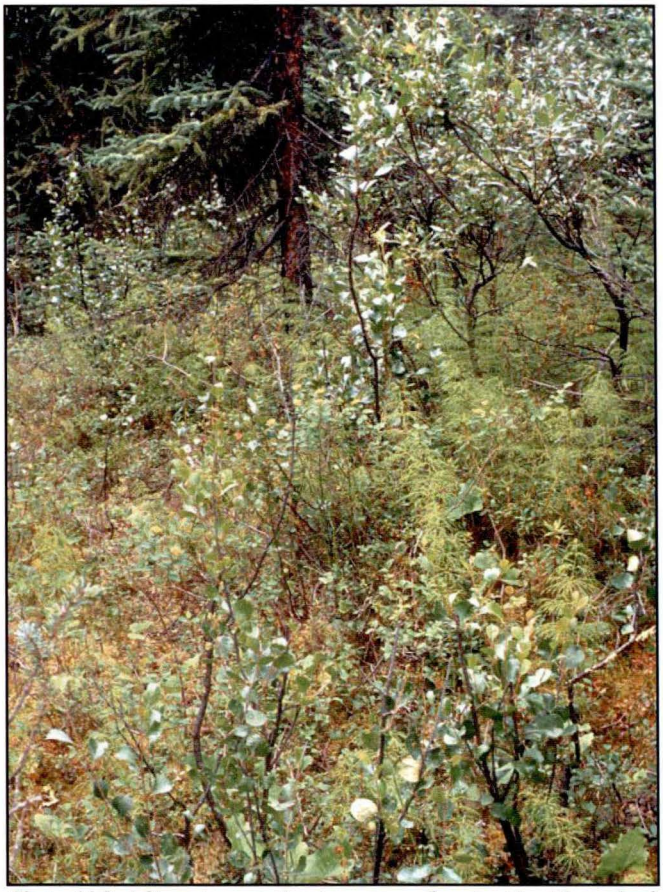


Photo 44-2. Adjacent vegetation is a spruce forest with willow, shrub birch, and horsetail in the understory. The soil surface is carpeted with lichens and mosses.

tundra was moderate (4.66%). This translated to 1.5% and 10.4$ organic matter for ROW and forest soils. Total soil N is quite low (0.01%) inside and low (0.14%) outside the ROW. C:N ratios were 67 and 33 for ROW and forest soils at this site.

The amount of available soil N was low within and outside the ROW. Total available N was 2 ppm for ROW soil, and below lab detection limits for the forest soil. The alkaline soil held N in the ammonium and nitrate forms. There was no carryover of N fertilizer from revegetation at this location. The forest vegetation was probably using N as quickly as it was mineralized from soil organic matter. Measurable available soil P was 3 ppm within the ROW soil and 6 ppm in the adjacent shrub tundra soil. The available soil P in both soils is probably limiting plant growth. It is important to note that two different extraction methods were used for these soils. There was no carryover of P fertilizer from revegetation. Available K was 28 ppm inside and 24 ppm outside the ROW. That indicated that K was possibly limiting in both soils. There was no carryover of K fertilizer from revegetation treatments at this location.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 44.

Species Names	Inside	Outside
Trees		
Picea glauca	•	
Picea mariana		•
Populus balsamifera	•	
Populus tremuloides	•	
Total Trees	3	1
Shrubs		
Betula nana		•
Empetrum nigrum	•	•
Ledum groenlandicum	•	•
Rubus chamaemorus		•
Salix barclayi	•	•
Salix bebbiana	•	
Salix brachyophylla ssp nyphoclada	•	
Salix glauca	•	
Salix planifolia ssp. pulchra	•	•
Spirea beauverdiana		•
Vaccinium uliginosum	•	•
Vaccinium vitis-idaea		•
Total Shrubs	8	9
Forbs		
Achillea borealis	•	
Aster sibiricus	•	
Cornus canadensis	•	
Epilobium angustifolium	•	
Equisetum arvense	•	•
Petasites frigidus		•
Total Forbs	5	2
Grasses		
Alopecurus pratensis	•	
Bromus inermis	•	
Calamagrostis canadensis	•	
Festuca altaica		•
Festuca rubra	•	
Total Grasses	4	1
Sedges		
Total Sedges	0	0
Total Vascular Species	**20**	**13**

Within the ROW the organic mat consisted of mosses, lichens, and plant debris up to 2 cm in thickness. The organic mat (18 cm) in the adjacent forest consisted of mosses, lichens, and plant debris (peat) typical for this vegetation.

Twenty-seven vascular plant species were recorded at this location. Twenty were recorded within the ROW and 13 in the adjacent shrub tundra habitat. Six species were common to both habitats, five shrubs and one forb. No trees or grass species were common, and no sedges at all were found at this location. Limited commonality of species between the ROW and adjacent natural plant communities resulted from habitat changes associated with construction and revegetation, which created a drier habitat and introduced competitive grasses.

Four tree species were found at this site. *Picea glauca, Populus balsamifera* and *Populus tremuloides* occurred only within the ROW, indicating that construction disturbances permitted the hardwoods to expand their local ranges to this site. *Picea mariana* was found only in the adjacent forest. A more intensive search could possibly reveal *P. mariana* colonizing the ROW.

Twelve shrub species were found at this location. Eight shrub species were found in the ROW, and nine within the adjacent forest community. Five shrubs (*Empetrum nigrum, Ledum groenlandicum, Salix barclayi, Salix planifolia ssp. pulchra*, and *Vaccinium uliginosum*) were common to both habitats. Three willow species (*Salix bebbiana, Salix brachyophylla* ssp. *nyphoclada*, and *Salix glauca*) were found only within the ROW. Four shrub species were found only in the undisturbed habitat (*Betula nana, Rubus chamaemorus, Spirea beauverdiana* and *Vaccinium vitis-idaea*). Four species of shrubs at this location were members of the heath family.

Forb numbers were limited at this site, with only six species recorded. Five forb species were recorded within the ROW. One forb species, *Equisetum arvense,* was common to both habitats. All forbs at this location were indigenous species.

Five grass species were found at this location. Four (*Alopecurus pratensis, Bromus inermis, Calamagrostis canadensis,* and *Festuca rubra*) occurred only within the ROW. One (*Festuca altaica*) occurred only in the adjacent spruce forest. No grass was common to both habitats. *A. pratensis, B. inermis* and *F. rubra* were introduced during revegetation of the ROW following construction.

No sedges were found at this location; the site may be too dry for them.

Moose bones indicated that hunters had dressed a kill at this location. Caribou and fox have also been observed in this vicinity. In some years, hares are very common along this stretch of highway. Trails indicated that the area is popular for recreational uses.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #45

Date Examined:	19 July 1999
Location:	N62°31' 29.8"; W145°32' 36.4"; TAPS M.P. 654.8.
Pipeline:	Elevated
Slope:	Flat to slightly rolling surface sloping eastward
Drainage:	Inside - well drained; Outside - perched over permafrost
Vegetation:	Open Black spruce-shrub forest

Site No. 45 is located near Sourdough along the Richardson Highway. The ROW is west of the Richardson Highway and Gulkana River, and is accessed by crossing the Gulkana River Bridge. The pipeline is on the northwest side of the ROW, and the roadway on the southeast. The ROW was vegetated primarily with indigenous forbs and shrubs. Seeded and indigenous grasses were prominent along the roadway margins and among invading shrubs and trees. The relatively steep roadway is barren gravel. The site drains into the Gulkana River. Vegetation prior to construction was an open black spruce forest with a prominence of shrubs. Heath shrubs with lichens and moss typifies the understory. Gravel fill was probably placed within the ROW during pipeline construction.

Evidence of cutting shrubs and trees invading the ROW was not recorded for this site; however, site photos suggest that has occurred. This section of ROW is gradually being overtaken by shrubs and trees, particularly under the pipeline. Tall willow and alder occur along the margin of the gravel fill, between the pipeline and adjacent forest. These tall specimens have escaped ROW brushing. Young shrub seedlings within the ROW indicated persistent recolonization; if unchecked, this woody plant invasion would eventually form a forest with a shrub understory. Patches of *Hylocomium* moss were colonizing the surface under the pipeline. Moss (*Hylocomium* and other species) and lichens (*Peltigera, Cetraria,* and *Cladonia*) were common on the tundra surface outside the ROW.

Soil reaction was alkaline inside the ROW (pH 7.82) and acidic outside (pH 6.28). Soil under the elevated pipe contained about 80% gravel, while that of the adjacent shrub land contained only about 23% gravel. Difference in gravel between the two habitats resulted from disturbances during construction and from fill added to the site. Soil moisture inside the ROW was 6.6%

Site No. 45 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	79.7	23.1
Moisture %	6.6	27.4
Total C %	0.83	9.08
Total N %	0.12	0.38
C:N ratio	6.9	23.9
Organic matter %	1.8	20.2
pH	7.82	6.28
NH_4-N (ppm)	1	1
NO_3-N (ppm)	8	Not detectable
P (ppm)	3	2
K (ppm)	54	59
Organic mat thickness (cm)	0 - 2	15

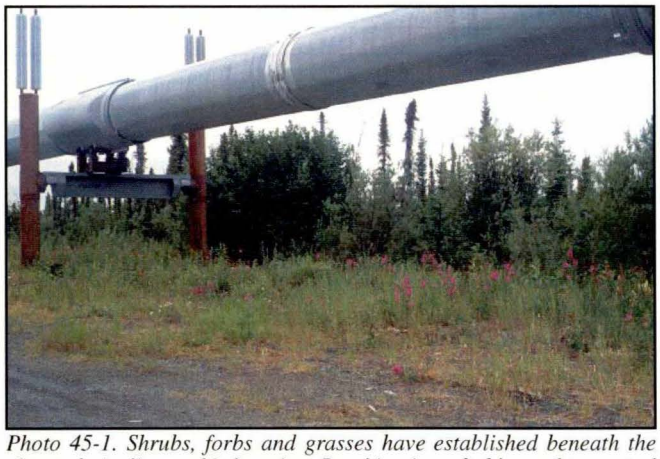


Photo 45-1. Shrubs, forbs and grasses have established beneath the elevated pipeline at this location. Brushing is probably used to control the woody plant growth.

Photo 45-2. Undisturbed vegetation at this location is a black spruce forest with a shrub understory of willow, shrub birch, and heath species.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 45.		
Species Names	*Inside*	*Outside*
Trees		
Picea mariana	•	•
Populus balsamifera	•	
Populus tremuloides	•	
Total Trees	3	1
Shrubs		
Alnus sinuata	•	
Arctostaphylos alpina	•	•
Betula nana		•
Empetrum nigrum		•
Ledum groenlandicum	•	•
Potentilla fruticosa	•	•
Rosa acicularis		•
Rubus chamaemorus		•
Salix barclayi	•	
Salix bebbiana	•	
Salix glauca	•	•
Salix myrtillifolia		•
Salix planifolia ssp. pulchra		•
Shepherdia canadensis	•	
Vaccinium uliginosum		•
Vaccinium vitis-idaea	•	•
Total Shrubs	9	12
Forbs		
Artemisia tilesii	•	
Astragalus alpinus	•	
Castelleja elegans	•	
Descurainia sophioides	•	
Epilobium angustifolium	•	
Epilobium latifolium	•	
Equisetum scirpoides	•	
Erigeron acris	•	
Geocaulon lividum		•
Hedysarum alpinum	•	
Matricaria matricarioides	•	
Oxytropis campestris	•	
Oxytropis deflexa	•	
Parnassia palustris	•	•
Petasites frigidus		•
Platanthera hyperborea	•	
Potentilla hookeriana	•	
Saussurea angustifolia		•
Taraxacum officinale	•	
Thlaspi arvense	•	
Total Forbs	17	4
Grasses		
Agropyron spp.	•	
Agrostis scabra	•	
Bromus inermis	•	
Calamagrostis canadensis	•	•
Festuca altaica	•	•
Hordeum jubatum	•	
Puccinellia arctica	•	
Total Grasses	7	2
Sedges		
Carex lugens		•
Total Sedges	0	1
Total Vascular Species	***36***	***20***

and outside 27.4%. Total soil C was low within the ROW (0.83%) and moderate in the adjacent tundra (9.08%), translating to 1.8% and 20.2% organic matter, respectively. Total soil N is low both inside (0.12%) and outside (0.38%) the ROW. The C:N ratios for the ROW and forest soils were 6.9 and 23.9, respectively, well within the desired ratio for supplying N to vascular plants.

The amount of available soil N was moderate in ROW soils (9 ppm) and quite low in the adjacent forest soil (1 ppm). The alkaline soil held N mostly as nitrate and a small portion as ammonium. Available N in the adjacent forest soil was detected only as ammonium. There was probably no carryover of N fertilizer from revegetation at this location. The forest vegetation seemed to be using N as quickly as it was mineralized from soil organic matter. Measurable available soil P was 3 ppm within the ROW soil and 2 ppm in the adjacent forest soil. The available soil P in both soils is probably limiting plant growth. It is important to note that two different extraction methods were used for these soils. There was no carryover of P fertilizer from revegetation. Available K was 54 ppm inside and 59 ppm outside the ROW. There was no carryover of K fertilizer from revegetation treatments at this location.

Within the ROW the organic mat consisted of mosses, lichens, and plant debris up to 2 cm in thickness. The organic mat (15 cm) in the adjacent forest consisted of mosses, lichens, and plant debris (peat) typical for this vegetation.

Forty-seven vascular plant species were recorded at this location. Thirty-six were recorded within the ROW and 20 in the adjacent forest. Nine species were common to both habitats (one tree species, five shrubs, one forb, and two grasses). Only one sedge was recorded at this location. Limited commonality of species between the ROW and adjacent natural plant communities resulted from habitat changes associated with construction which created a drier habitat, and from revegetation which introduced competitive grasses.

Three tree species were found at this site. All three species occurred within the ROW. *Populus balsamifera* and *Populus tremuloides* occurred only within the ROW, indicating that construction disturbance permitted these two hardwoods to expand their local ranges to this site. *Picea mariana* was found both in the ROW and in the adjacent forest. Sixteen shrub species were found at this location, nine in the ROW and twelve within the adjacent forest community. Five shrubs (*Arctostaphylos alpina, Ledum groenlandicum, Potentilla fruticosa, Salix glauca,* and *Vaccinium vitis-idaea*) were common to both habitats. Four shrub species (*Alnus sinuata, Salix barclayi, Salix bebbiana,* and *Shepherdia canadensis*) were found only within the ROW. Seven shrub species were found only in the undisturbed habitat (*Betula nana, Empetrum nigrum, Rosa acicularis, Rubus chamaemorus, Salix myrtillifolia, S. planifolia* ssp. *pulchra,* and *Vaccinium uliginosum*).

Forbs were more abundant here compared to Site No. 44. Twenty forbs were found at this location, seventeen in the ROW and four in the adjacent forest. *Parnassia palustris* was the only forb common to both habitats. One indigenous forb (*Saussurea angustifolia*) in the forest was of particular interest. This species occurs widely in Alaska, and this site was its southernmost occurrence in our survey. It is a member of the sunflower family and has purple flowers. Specimens in the Arctic usually grow low to the ground, 0.5-1.5 dm. Those have been designated as

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory	Site #45
Date Examined:	19 July 1999
Location:	N62°31' 29.8"; W145°32' 36.4"; TAPS M.P. 654.8.
Pipeline:	Elevated
Slope:	Flat to slightly rolling surface sloping eastward
Drainage:	Inside - well drained; Outside - perched over permafrost
Vegetation:	Open Black spruce-shrub forest

Continued

Saussurea angustifolia var. *angustifolia* (Welsh, 1974). The plants at this location attained heights of 3-4 dm and were probably also the variety *angustifolia*. The greater stem length at this location might be attributed to warm weather during the growing season.

Three forbs at this location were introduced weeds: *Matricaria matricarioides, Taraxacum officinale,* and *Thlaspi arvense.* All of these exotic species are commonly found in lawns, fields, and waste places around human settlements in Alaska's boreal zone.

Seven grass species were found at this location. All seven were found in the ROW, and two (*Calamagrostis canadensis* and *Festuca altaica*) occurred in both habitats. *Bromus inermis* and *Festuca rubra* were introduced during ROW revegetation. Two of the indigenous grasses (*Agrostis scabra* and *Hordeum jubatum*) are considered weeds, because they usually occur in waste places, fields, and lawns. Neither species is palatable to grazers. *H. jubatum* has been sold as an ornamental grass, because for a brief period its inflorescences display a silky display of long reddish awns.

One sedge species, *Carex lugens*, was found in the adjacent forest. No sedges were observed within the ROW.

In the undisturbed forest we observed frogs and owls. There were signs of hare, fox, and moose. Caribou are common in the area. Trails indicated the locale was popular for recreational uses. Rafting was observed on the nearby Gulkana River at the time of this survey, and a campground has been constructed below this site. Access to the river and to the Sourdough stop on the old stage trail to Valdez make this area attractive for recreation.

This page deliberately left blank

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #46

Date Examined:	20 July 1999
Location:	N62°29' 06.1"; W145°29' 38.4"; TAPS M.P. 685.2.
Pipeline:	Elevated
Slope:	Flat surface sloping southeast
Drainage:	Inside - well drained; Outside - possibly perched over permafrost
Vegetation:	Closed spruce forest

Site No. 46 is located near Glennallen along the Richardson and Glenn highways. The ROW crosses the Glenn Highway and is west of the Richardson Highway. Accessing this location requires driving along the ROW roadway from the Glenn Highway toward the location for Pump Station 11. The pipeline is on the east side of the ROW, and the roadway on the west. The ROW is vegetated with seeded grasses and forbs and shrubs. Seeded and indigenous grasses are also prominent along the roadway margins and among invading shrubs and trees. The roadway is well traveled, barren gravel. The site drains into Moose Creek then to the Tazlina River and finally the Copper River. Vegetation prior to construction was a closed spruce forest with low shrubs forming an understory. Heath shrubs and willows were common. *Peltigera* lichen and sphagnum moss were the dominant surface plants. Gravel fill was placed in the ROW during pipeline construction.

There was evidence that invading shrubs and trees had been cut at this site. This section of ROW is being overtaken by these species, particularly under the pipeline. Young tree and shrub seedlings within the ROW indicated persistent recolonization. Left unchecked, this woody plant invasion would eventually form a forest with a shrub understory.

Soil reaction was alkaline inside the ROW (pH 7.92) and acidic outside (pH 5.84). Soil under the elevated pipe contained about 70% gravel, while that of the adjacent forest contained only about 8% gravel. Difference in the gravel between the two habitats was due to disturbances from construction activities, and from fill added to the site. Soil moisture inside the ROW was about 4% and outside about 79%. Total soil C was 1.36% inside the ROW and 13.18% outside, translating to 3.0% and 29.3% organic matter, respectively. C content was low inside the ROW but moderate in the adjacent forest. Total soil N is low in both soils (0.06% inside and 0.48% outside the ROW). The C:N ratios for the ROW and forest soils were 22.7 and 27.5,

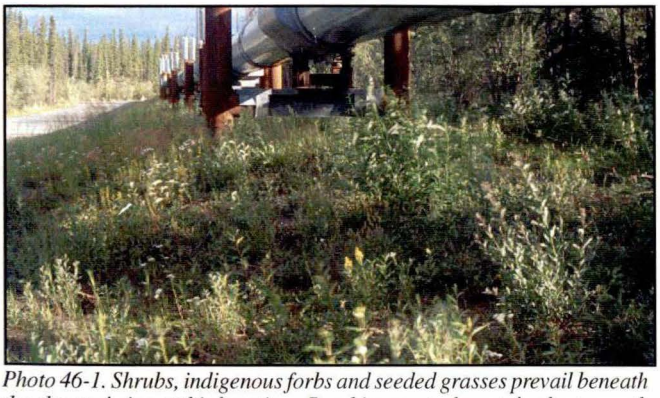


Photo 46-1. Shrubs, indigenous forbs and seeded grasses prevail beneath the elevated pipe at this location. Brushing controls woody plant growth beneath the pipeline. The roadway is well-used barren gravel.

Site No. 46 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	70.2	7.7
Moisture %	3.6	78.8
Total C %	1.36	13.18
Total N %	0.06	0.48
C:N ratio	22.7	27.5
Organic matter %	3	29.3
pH	7.92	5.84
NH_4-N (ppm)	3	1
NO_3-N (ppm)	1	Not detectable
P (ppm)	4	9
K (ppm)	70	87
Organic mat thickness (cm)	0 - 2	15.2

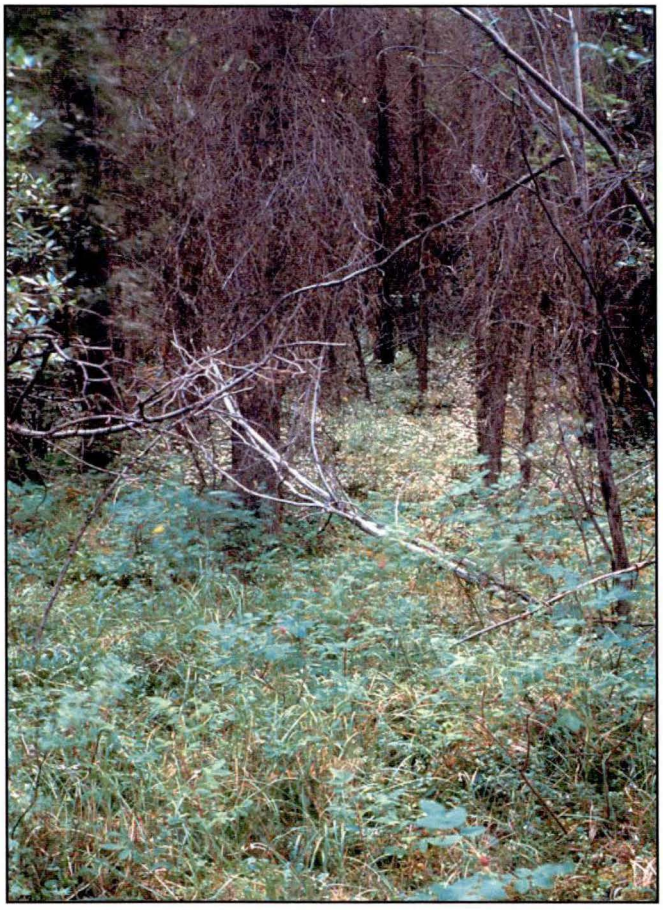


Photo 46-2. The adjacent spruce forest has an understory dominated by rose shrubs.

respectively, within the desired ratio for supplying N to vascular plants.

The amount of available soil N within the ROW was low (4 ppm) and quite low (1 ppm) in the adjacent forest soil. The alkaline soil held N mostly as ammonium and a small portion as nitrate. Available N in the adjacent forest soil was detected only as ammonium. There was probably no carryover of N fertilizer from revegetation at this location. The forest vegetation seemed to be using N as quickly as it was mineralized from soil organic matter. Measurable available soil P was 4 ppm within the ROW soil and 9 ppm in the adjacent forest soil. The available soil P in both soils is probably limiting plant growth. It is important to note that two different extraction methods were used for these soils. There was no carryover of P fertilizer from revegetation. Available K was 70 ppm inside and 87 ppm outside the ROW. That indicated that K was probably not limiting in either soil. There was no carryover of K fertilizer from revegetation treatments at this location.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 46.

Species Names	Inside	Outside
Trees		
Picea glauca	•	•
Picea mariana		•
Populus balsamifera	•	
Total Trees	2	2
Shrubs		
Arctostaphylos alpina	•	•
Arctostaphylos uva-ursi	•	
Empetrum nigrum		•
Linnaea borealis		•
Potentilla fruticosa		•
Rosa acicularis		•
Salix alaxensis	•	
Salix arbusculoides	•	
Salix brachyophylla ssp nyphoclada	•	
Salix glauca	•	•
Salix myrtillifolia	•	•
Salix scouleriana		•
Shepherdia canadensis	•	•
Vaccinium uliginosum		•
Vaccinium vitis-idaea		•
Total Shrubs	8	11
Forbs		
Achillea borealis	•	•
Aster sibiricus	•	•
Astragalus americanus	•	
Barbarea orthoceras	•	
Castelleja elegans	•	
Chenopodium rubrum	•	
Descurainia sophioides	•	
Dracocephalum parviflorum	•	
Epilobium angustifolium	•	•
Equisetum scirpoides		•
Gentiana propinqua		•
Geocaulon lividum	•	•
Hedysarum alpinum		•
Lepidium densiflora	•	
Lesquerella arctica	•	
Lupinus arcticus	•	•
Matricaria matricarioides	•	
Oxytropis campestris	•	
Oxytropis deflexa	•	
Potentilla uniflora	•	
Pyrola grandiflora		•
Senecio lugens	•	•
Total Forbs	18	10
Grasses		
Agropyron spp.	•	
Bromus inermis	•	
Festuca altaica		•
Hordeum jubatum	•	
Phleum pratense	•	
Total Grasses	4	1
Sedges		
Total Sedges	0	0
Total Vascular Species	**32**	**24**

Within the ROW the organic mat consisted of plant debris and mosses up to 2 cm in thickness. The organic mat (15 cm) in the adjacent forest consisted of mosses, lichens, and plant debris typical for this vegetation.

Forty-five vascular plant species were recorded at this location. Thirty-two were found within the ROW and 24 in the adjacent forest habitat. Eleven species (one tree, four shrubs, and six forbs) were common to both habitats. There were no grass species in common, and no sedges were recorded at this location. Limited commonality of species between the ROW and adjacent natural forest resulted from changes associated with construction, which created a drier habitat with introduced competitive grasses.

Three tree species were found at this site. Two tree species occurred within the ROW, and two occurred in the forest. *Populus balsamifera* was found only within the ROW, indicating the construction disturbance permitted this hardwood to expand its local range to this site. *Picea glauca* was recorded for the adjacent forest and the ROW, while *Picea mariana* occurred only in the forest.

Fifteen shrub species were found at this location; eight in the ROW and eleven within the adjacent forest community. Four shrubs (*Arctostaphylos alpina, Salix glauca, Salix myrtillifolia,* and *Shepherdia canadensis*) were common to both habitats. Four shrub species (*Arctostaphylos uva-ursi, Salix alaxensis, Salix arbusculoides,* and *Salix brachyophylla* ssp. *nyphoclada*) were found only within the ROW. Seven shrub species were found only in the undisturbed habitat (*Empetrum nigrum, Linnaea borealis, Potentilla fruticosa, Rosa acicularis, Salix scouleriana, Vaccinium uliginosum,* and *Vaccinium vitis-idaea*).

Twenty-two forbs were found at this location. Eighteen occurred in the ROW, and ten in the adjacent forest. Six forb species (*Achillea borealis, Achillea sibiricus, Epilobium angustifolium, Geocaulon lividum, Lupinus arcticus,* and *Senecio lugens*) were common to both habitats. Eleven forb species occurred only within the ROW, and four species were found only in the forest.

Two forb species at this location were introduced weeds: *Lepidium densiflora* and *Matricaria matricarioides. L. densiflora* is a common weed in waste places of southern Alaska. *M. matricarioides* occurs in lawns, fields, waste places around human settlements in Alaska's boreal zone. These species were possibly introduced to this location with revegetation seed mixtures. They may have spread from the nearby community of Glennallen. None of the exotic species were found in the undisturbed forest.

Five grass species were found at this location. Four were found in the ROW, and one (*Festuca altaica*) occurred only in the undisturbed habitat. Two, *Bromus inermis* and *Phleum pratense* are exotic forage grasses that were introduced during ROW revegetation. *Festuca rubra* was conspicuously absent. One indigenous grass (*Agrostis scabra*) is considered a weed.

No sedges were found at this location.

There were signs of hare, squirrel, and moose. Because of the proximity to Glennallen, there is potential for considerable human use of the area, but evidences of this were few.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #47

Date Examined:	19 July 1999
Location:	N62°02' 30.9"; W145°28' 50.3"; TAPS M.P. 688.9.
Pipeline:	Elevated
Slope:	Flat surface sloping slightly eastward
Drainage:	Inside - well drained; Outside - perched over permafrost
Vegetation:	Closed mixed forest dominated by spruce mixed with aspen and cottonwood

Site No. 47 is located south of Glennallen across Willow Creek. Accessing this location requires leaving the Richardson Highway just south of the Tazlina River Bridge and traveling west on the pipeline access road. The pipeline is on the west side of the ROW, and the roadway on the east. The ROW is vegetated with seeded grasses, forbs, shrubs, and young trees. Seeded and indigenous grasses are prominent along margins of the roadway, which is largely barren gravel. The roadway is well traveled. The site is on a terrace and drains into the Tazlina River and finally the Copper River. Vegetation prior to construction was a closed mixed forest with an understory of predominantly *Shepherdia canadensis*. Heath shrubs were absent in the forest, but two heath species were colonizing in combination with willows beneath the pipeline. Gravel fill was placed within the ROW during pipeline construction. This site and Site 46 are mixed forest habitats south of the black spruce-muskeg complex of Interior Alaska. Typical black spruce muskeg vegetation began disappearing between Sites 45 and 46.

Shrubs and trees invading the ROW had been cut at this site. This section of ROW is being overtaken by shrubs and trees, particularly under the pipeline. Young tree and shrub seedlings within the ROW indicated persistent recolonization was occurring. Left unchecked, this woody plant invasion would eventually form a forest with a shrub understory.

Soil reaction was alkaline inside and outside the ROW (pH 8.04 and pH 7.35). Soil under the elevated pipe contained about 64% gravel, and while that of the adjacent shrub land contained no gravel. Difference in the gravel between the two habitats resulted from disturbances related to construction activities and fill added to the site. Soil moisture inside the ROW was about 7% and outside about 63%. Total soil C was 0.46% within the ROW and 5.27% outside the ROW, translating to 1.02% and 11.7% organic matter for the ROW and adjacent soils, respectively. C content of the ROW was very low. Total soil N was low (0.01%) inside and low (0.19%) outside the ROW. The C:N ratios for the ROW and forest soils were 46 and 27.7, respectively. The ROW C:N ratio was greater than the desired ratio. C:N of the forest was just within the desired ratio for plant growth, based on agricultural standards.

The amount of available soil N was very low (below detection limits) within the ROW, and low (2 ppm) in the adjacent forest soil. The alkaline forest soil held N evenly between the ammonium and nitrate forms. There was clearly no carryover of N fertilizer from revegetation at this location. Both the ROW and forest vegetation seemed to be using N as quickly as it was mineralized from soil organic matter. Measurable available soil P was 3 ppm within the ROW soil and 5 ppm in the adjacent forest soil. The available soil P in the ROW soil was probably limiting plant growth. Available P in the forest soil was marginally

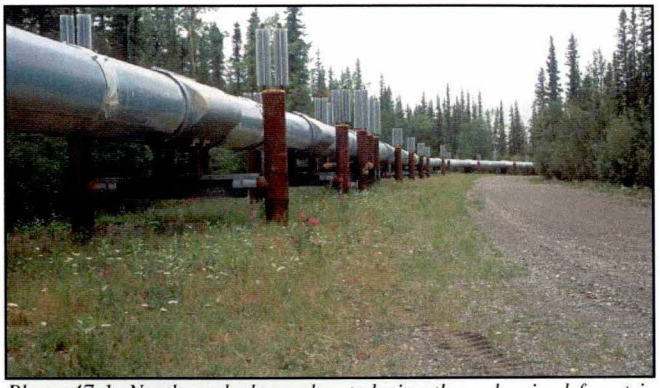


Photo 47-1. Northward along elevated pipe through mixed forest in Copper Basin. Vegetation under the pipe is a mixture of naturally-established tree, forbs, and shrubs, with some seeded grasses. Grasses line the edges of the roadway.

Photo 47-2. Second growth mixed forest adjacent to the ROW.

Site No. 47 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	63.6	0
Moisture %	7.4	63.4
Total C %	0.46	5.27
Total N %	0.01	0.19
C:N ratio	46	27.7
Organic matter %	1	11.7
pH	8.04	7.35
NH_4-N (ppm)	Not detectable	1
NO_3-N (ppm)	Not detectable	1
P (ppm)	3	5
K (ppm)	29	55
Organic mat (cm)	0 - 1	6

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 47.		
Species Names	*Inside*	*Outside*
Trees		
Picea glauca	•	•
Picea mariana		•
Populus balsamifera	•	•
Populus tremuloides	•	•
Total Trees	3	4
Shrubs		
Arctostaphylos alpina	•	
Arctostaphylos uva-ursi	•	
Salix arbusculoides	•	
Salix bebbiana	•	
Salix scouleriana	•	•
Shepherdia canadensis	•	•
Total Shrubs	6	2
Forbs		
Achillea borealis	•	
Aster sibiricus	•	
Epilobium angustifolium	•	
Equisetum arvense	•	•
Erigeron acris	•	
Hedysarum alpinum	•	
Oxytropis deflexa	•	
Pyrola minor		•
Senecio lugens	•	
Total Forbs	8	2
Grasses		
Agropyron spp.	•	
Bromus inermis	•	
Calamagrostis canadensis	•	
Festuca altaica	•	•
Festuca rubra	•	
Poa pratensis	•	
Total Grasses	6	1
Sedges		
Carex tenuiflora		•
Total Sedges	0	1
Total Vascular Species	***23***	***10***

adequate. There was no carryover of P fertilizer from revegetation. Available K was 29 ppm inside and 55 ppm outside the ROW, indicating K was possibly limiting within the ROW. Available K was marginally adequate in the adjacent forest soil. There was no carryover of K fertilizer from revegetation treatments at this location.

Within the ROW the organic mat consisted of plant debris and mosses up to 1 cm in thickness. The organic mat (6 cm) in the adjacent forest consisted of mosses, lichens, and plant debris.

Twenty-six vascular plant species were recorded at this location, 23 within the ROW and 10 in the adjacent forest habitat. Three tree species, two shrubs, one forb and one grass were common to both habitats. Limited commonality of species between the ROW and adjacent natural forest resulted from habitat changes associated with construction and revegetation with grasses. Soil fertility was an additional limiting factor of the ROW habitat.

Four tree species were found at this site. Three tree species occurred within the ROW, and four occurred in the forest. *Picea mariana* was found only within the forest, suggesting that construction disturbance had excluded this softwood from the ROW. *Picea glauca* was recorded in the adjacent forest and the ROW. The presence of hardwoods in the undisturbed forest suggests that the area was probably recovering from a previous disturbance, such as logging or fire.

Six shrub species were found at this location. All six were found in the ROW, and two within the adjacent forest community. Two shrubs (*Salix scouleriana,* and *Shepherdia canadensis*) were common to both habitats. Four shrub species (*Arctostaphylos alpina, Arctostaphylos uva-ursi, Salix arbusculoides,* and *Salix bebbiana*) were found only within the ROW. No shrub species were found only in the undisturbed forest.

Nine forb species were found at this location. Eight occurred in the ROW, and two species within the adjacent forest. One forb species, *Equisetum arvense,* was common to both habitats. Seven forb species occurred only within the ROW, and one species (*Pyrola minor*) found only in the forest. All forb species recorded at this location are indigenous to Alaska.

Six grass species were found at this location. All six species occupied the ROW, and one (*Festuca altaica*) was common to both habitats. This was the southernmost location in which we found *F. altaica* in either the ROW or adjacent habitat. *Bromus inermis* and *Poa pratensis* are exotic species introduced at this location during revegetation of the ROW. *Festuca rubra* is indigenous to Alaska; however, its presence resulted from revegetation following construction.

One sedge species (*Carex tenuiflora*) was found at this location. The sedge was found only in the forest habitat. The ROW soil may have been too dry for sedges.

There were signs of hare and moose. Because the location is near Glennallen, there is potential for considerable human use of the area, but evidences of such were few.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #48

Date Examined:	18 July 1999
Location:	N61°47' 22.5"; W145°11' 54.7" (Forest) TAPS M.P. 709.7. N61°47' 18.6"; W145°11' 39.9" (ROW)
Pipeline:	Elevated
Slope:	Flat surface sloping eastward
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Closed mixed forest dominated by spruce mixed with alder and cottonwood

Site No. 48 is located south of Glennallen beyond Willow Creek. Accessing this location requires leaving the Richardson Highway at the second turnout south of the Willow Creek bridge. The ROW is west of the Richardson Highway. The pipeline is on the east side of the ROW, and the roadway on the west. A powerline right-of-way parallels the ROW on the west. Our forest site sampling was up slope from the powerline. The ROW is vegetated with forbs, shrubs, and young trees. Seeded and indigenous grasses were not prominent components of the ROW vegetation at the time of our inspection. The site drains into Willow Creek and finally the Copper River. Vegetation prior to construction was a closed mixed forest with alder. An understory of *Ledum groenlandicum* and *Empetrum nigrum* occurred under the spruce. Beneath the alder, organic debris predominated with scattered clumps of *Festuca altaica* and *Calamagrostis canadensis*. *Vaccinium uliginosum* were absent in the forest, but two heath species were colonizing in conjunction with willows beneath the pipeline. Gravel fill was placed within the ROW during pipeline construction.

The ROW had not been recently brushed at this location at the time of the survey. This section of ROW was being overtaken by shrubs and trees, particularly under the pipeline. Young tree and shrub seedlings within the ROW indicated persistent recolonization, particularly by spruce trees. Left unchecked, this woody plant invasion would eventually form a forest with a shrub understory.

Soil reaction was acidic inside the ROW, pH 6.23 and acidic outside, pH 6.11. Soil under the elevated pipe contained about 68% gravel, and that of the adjacent shrub land contained 26% gravel. Difference in the gravel between the two habitats resulted from disturbances related to construction activities and fill added to the site. Soil moisture inside the ROW was about 2.9% and outside about 47%. Total soil C was 1.18% inside and 7.41% outside the ROW, translating to 2.6% and 16.5% organic matter, respectively. C contents of the ROW and forest soils were above average for their respective mid-range habitats. Total soil N was 0.11% inside and 0.34% outside the ROW. The C:N ratios for the ROW and forest soils were 10.7 and 21.8, respectively. The ROW C:N ratio was well within the desired ratio. C:N of the forest was within the desired ratio for plant growth, based on agricultural standards.

The amount of available soil N was typical within and adequate outside the ROW. Total available N was 4 ppm for ROW soils and 16 ppm for the adjacent forest soil. These acidic soils held N predominantly as nitrates. There was no apparent carryover of N fertilizer from revegetation at this location. The ROW and forest vegetation seemed to have adequate reserve supply of N at the time of our sampling. Measurable available soil P was 2 ppm within the ROW soil and 3 ppm in the adjacent

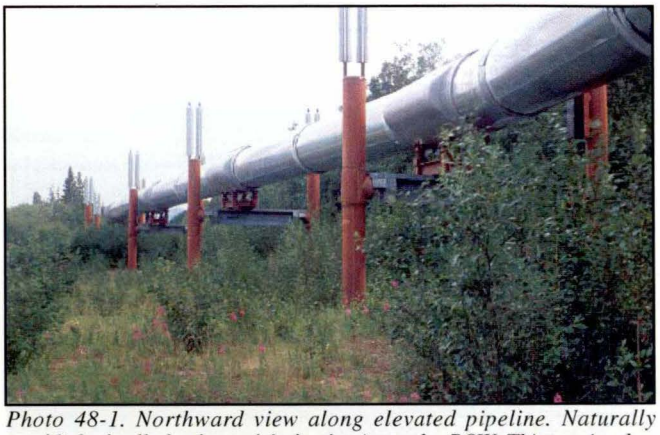


Photo 48-1. Northward view along elevated pipeline. Naturally established tall shrubs and forbs dominate the ROW. This section has not been brushed recently.

Photo 48-2. Second growth mixed forest east of the ROW.

Site No. 48 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	67.6	25.7
Moisture %	2.9	47.3
Total C %	1.18	7.41
Total N %	0.11	0.34
C:N ratio	10.7	21.8
Organic matter %	2.6	16.5
pH	6.23	6.11
NH_4-N (ppm)	1	2
NO_3-N (ppm)	3	14
P (ppm)	2	3
K (ppm)	22	26
Organic mat thickness (cm)	0 - 1.5	15.3

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 48.		
Species Names	*Inside*	*Outside*
Trees		
Betula papyrifera	•	
Picea glauca	•	•
Populus balsamifera	•	•
Total Trees	3	2
Shrubs		
Alnus crispa	•	•
Arctostaphylos alpina	•	
Arctostaphylos uva-ursi	•	
Dryas drummondii	•	
Empetrum nigrum		•
Ledum groenlandicum		•
Potentilla fruticosa	•	•
Ribies triste		•
Rosa acicularis	•	•
Rubus arcticus		•
Rubus spectabilis		•
Salix arbusculoides	•	•
Salix barclayi	•	
Salix glauca	•	
Salix monticola	•	
Salix scouleriana		•
Shepherdia canadensis	•	
Vaccinium vitis-idaea		•
Total Shrubs	11	11
Forbs		
Achillea borealis	•	
Astragalus alpinus	•	
Castelleja elegans	•	
Crepis nana	•	
Epilobium angustifolium	•	
Epilobium latifolium		•
Erigeron acris	•	
Lepidium densiflora	•	
Oxytropis deflexa	•	
Potentilla uniflora	•	
Pyrola minor	•	
Senecio lugens	•	
Total Forbs	11	1
Grasses		
Agropyron spp.	•	
Agrostis scabra	•	
Calamagrostis canadensis	•	•
Festuca altaica	•	•
Festuca rubra	•	
Hordeum jubatum	•	
Poa pratensis	•	
Puccinellia borealis	•	
Total Grasses	8	2
Sedges		
Carex tenuiflora		•
Juncus spp.	•	
Total Sedges	1	1
Total Vascular Species	***34***	***17***

forest soil. The available soil P in the ROW and forest soils could be limiting plant growth. There was no carryover of P fertilizer from revegetation. Available K was 22 ppm inside and 56 ppm outside the ROW. That indicated that K was potentially limiting plants within the ROW. There was no carryover of K fertilizer from revegetation treatments at this location.

Within the ROW the organic mat consisted of plant debris and mosses (dried on the date of our inspection) up to 1.5 cm in thickness. The organic mat (15.3 cm) in the adjacent forest consisted mostly of plant debris, with a few mosses.

Forty-four vascular plant species were recorded at this location. Thirty-four were recorded within the ROW and 17 in the adjacent forest habitat. Two tree species, four shrubs, and two grasses were common to both habitats. No forbs or sedge/rush species were common. This disparity of species between the ROW and adjacent natural forest was caused by habitat changes associated with construction, which created a drier habitat, and revegetation which introduced competitive grasses.

Three tree species were found at this site. All three tree species occurred within the ROW, and two occurred in the forest. *Betula papyrifera* was found only within the ROW, indicating the construction disturbance had extended the local range for this species into the ROW. *Picea glauca* and *Populus balsamifera* occurred in both habitats at this location. Nineteen shrub species were found at this site. Eleven shrub species were found in the ROW, and eleven within the adjacent forest community. Four shrub species (*Alnus crispa, Potentilla fruticosa, Rosa acicularis,* and *Salix arbusculoides*) were common to both habitats.

Twelve forb species were found at this location. Eleven occurred in the ROW, and one species was recorded within the adjacent forest. No forbs were common to both habitats. *Epilobium latifolium* was the only forb recorded in the forest habitat. *Lepidium densiflora* was the only introduced weed species observed at this location.

Eight grass species were found at this location. All eight species occurred in the ROW, and two (*Calamagrosits canadensis* and *Festuca altaica*) were common to both habitats. *Poa pratensis* is an exotic grass introduced at this location during ROW revegetation. *Festuca rubra* is indigenous to Alaska, but its presence here can be attributed to revegetation of the ROW.

One sedge species (*Carex tenuiflora*) was found at this location. The sedge was found only in the forest habitat. The ROW soil may have been too dry for sedges. One *Juncus* spp. was found at this location only in the ROW.

There were many well-used hare trails in the adjacent forest, and moose were also apparent. Because the location is not far from Copper Center and Glennallen, there is potential for considerable human use of the area. This site is near a pullout on the Richardson Highway, and tourists frequently stop here. There were evidences of human uses on the site in the form of tracks and trash.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #49

Date Examined:	11 September 1999
Location:	N61°35' 20.6"; W145°13' 55.5"; TAPS M.P. 724.6.
Pipeline:	Buried
Slope:	Flat surface, sloping eastward
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Closed mixed forest dominated by aspen, with scattered young spruce

Site No. 49 is located about 5 mi south of the bridge over the Tonsina River on the Richardson Highway. Accessing this location requires leaving the Richardson Highway and ascending a ridge to the west. The pipeline is on the west side of the ROW, and the roadway on the east. Remnants of pavement in the vicinity indicate this location was formerly a portion of the Richardson Highway. The area is recovering from a fire, and the forest is predominantly aspen. The ROW is vegetated with forbs and grasses. Seeded grasses were prominent components of the ROW vegetation at the time of our survey. The site drains into the Tonsina River and finally the Copper River. Vegetation prior to construction was a poorly vegetated disturbed forest. The rocky substrate provided a poor growing medium for vegetation, possibly because of the prior road construction. The site was dry and rocky, and gravel fill was probably not hauled in for the ROW.

The ROW appears to have been brush-cut regularly at this location. This section is not developing vigorous vegetation, likely because of poor soil. If left unchecked, herbaceous vegetation would eventually be replaced by shrubs and hardwood trees (mostly aspen and willow).

Soil reaction was acidic inside (pH 6.80) and outside (pH 5.46) the ROW. Soil over the buried pipe contained about 25% gravel, and that of the adjacent forest land contained 29% gravel. This similarity indicated that the two soils were probably from the same glacial till. Soil moisture inside the ROW was about 5% and outside about 6%. Total soil C was very low (0.37%) within the ROW and moderate (5.19%) in the adjacent soils, translating to 0.8% and 13.4% organic matter, respectively. Total soil N was mid-range (0.03%) inside and moderate (0.15%) outside the ROW. The C:N ratios for the ROW and forest soils were 12.3 and 34.6, respectively. The ROW C:N ratio was well

Site No. 49 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	25.3	28.7
Moisture %	4.9	6.6
Total C %	0.37	5.19
Total N %	0.03	0.15
C:N ratio	12.3	34.6
Organic matter %	0.8	11.5
pH	6.80	5.46
NH_4-N (ppm)	1	Not detectable
NO_3-N (ppm)	Not detectable	2
P (ppm)	50	59
K (ppm)	32	118
Organic mat thickness (cm)	0 - 0.5	1-2

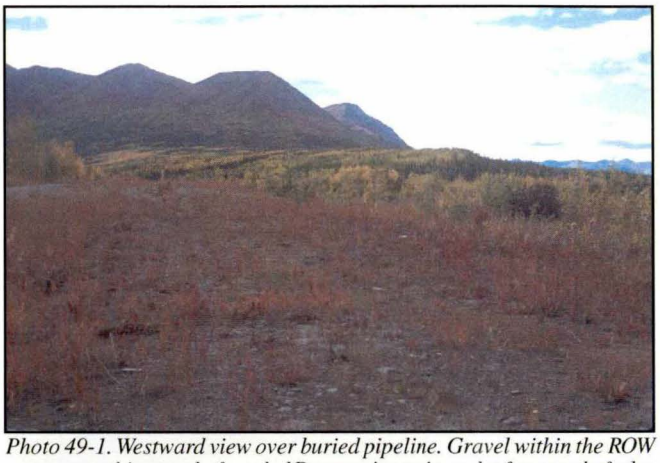


Photo 49-1. Westward view over buried pipeline. Gravel within the ROW supports a thin stand of seeded Bromus inermis *and a few weedy forbs. This is a poor, dry habitat for plants.*

Photo 49-2. Second growth aspen-spruce forest north of ROW.

within the desired ratio. C:N of the forest was above that desired for plant growth, based on agricultural standards.

The amount of available soil N was low in both soils. Total available N was 1 ppm for ROW soils and 2 ppm for the adjacent forest soil. The ROW soil available N was in the ammonium form, while that of the forest was nitrate. There was no apparent carryover of N fertilizer from revegetation at this location. Measurable available soil P was 50 ppm within the ROW soil and 59 ppm in the adjacent forest soil. The available soil P in the ROW and forest soils is more than adequate for plant growth. There was no carryover of P fertilizer from revegetation. Available soil P was unusually high in the ROW and forest soils at this site and Site #50. Samples were submitted to the laboratory so the ROW and adjacent habitat samples were not paired. Because the four samples from these two sites all tested high in soil available P, there is reason to believe the parent material in this region is unusually rich in P.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 49.

Species Names	Inside	Outside
Trees		
Picea sitchensis		•
Populus tremuloides	•	•
Total Trees	1	2
Shrubs		
Arctostaphylos rubra		•
Arctostaphylos uva-ursi	•	•
Empetrum nigrum	•	
Ledum groenlandicum		•
Rosa acicularis		•
Salix barclayi	•	•
Vaccinium vitis-idaea		•
Total Shrubs	3	6
Forbs		
Achillea borealis		•
Arabis holboellii	•	
Crepis capillaris	•	
Epilobium angustifolium	•	•
Epilobium palustre	•	
Erigeron pulcherrima	•	
Lepidium densiflora	•	
Lupinus arcticus		•
Pedicularis verticillata		•
Taraxacum officinale	•	
Trifolium hybridum	•	
Total Forbs	8	4
Grasses		
Bromus inermis	•	
Festuca rubra	•	
Total Grasses	2	0
Sedges		
Total Sedges	0	0
Total Vascular Species	**14**	**12**

Available K was 32 ppm inside and 118 ppm outside the ROW. That indicated that K was potentially limiting plants in the ROW, but quite adequate in the forest. There was no carryover of K fertilizer from revegetation treatments at this location.

The organic mat was poorly developed in both habitats, consisting primarily of plant debris up to 0.5 cm in thickness within the ROW and 2 cm in the forest. *Stereocaulon* and crustose lichens were scattered on the surface of the ROW soil. The organic mat in the adjacent forest consisted mostly of plant debris, with a few mosses and *Cetraria* lichen.

Twenty vascular plant species were recorded at this location. Fourteen were recorded within the ROW and 12 in the adjacent forest habitat. Only one tree species, two shrubs, and one forb were common to both habitats. This disparity of species between the ROW and adjacent forest was caused by habitat soil changes associated with construction and revegetation. Differences in the elapsed time since construction affected the ROW and fire disturbed the forest was also a factor influencing vegetation.

Two tree species were found at this site. One tree species, *Populus tremuloides*, occurred both in the ROW and in the forest. *Picea sitchensis* was found only within the forest. The dryness of this site made it more suited to the aspen than the spruce. Seven shrub species were found at this site. Three shrub species were found in the ROW, and six within the adjacent forest community. Two shrub species (*Arctostaphylos uva-ursi,* and *Salix barclayi*) were common to both habitats. One shrub species (*Empetrum nigrum*) was found only within the ROW. Four shrub species were found only in the undisturbed habitat.

Eleven forb species were found at this location. Eight occurred in the ROW, and four species were recorded within the adjacent forest. One forb (*Epilobium angustifolium*) was common to both habitats. Four introduced forbs were identified at this site. Three were weeds: *Crepis capillaris, Lepidium densiflora,* and *Taraxacum officinale*. During this survey, we recorded *C. capillaris* at nine locations within the ROW from M.P. 190 to MP 745. It was never found outside the ROW. It was collected by Alyeska employees at Pump Station No. 12 and sent to the University Agricultural and Forestry Experiment Station for identification. This weed was introduced to Alaska prior to construction of the pipeline, and occurs in disturbed sites in central and southeastern Alaska (Welsh, 1974). One introduced forb, *Trifolium hybridum,* is a common forage legume (see discussion in Site 28).

Two grass species were found at this location. Both species were found in the ROW. One, *Bromus inermis,* is an exotic forage grass that was introduced during revegetation. *Festuca rubra* was the other grass at this site. It is indigenous to Alaska; however, its presence here resulted from revegetation.

No sedge species were found at this location. The habitat is probably too dry for those plants.

Signs of wildlife were scarce. Moose and hare were probably the most common mammals in the area. There were evidences of human uses on the site in the form of tracks and trash. The site is readily accessible from the highway, and indeed vehicles passed by as we examined the site.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #50

Date Examined:	11 September 1999
Location:	N61°22' 04.0"; W145°10' 35.8"; TAPS M.P. 745.2.
Pipeline:	Buried
Slope:	Flat surface, sloping southeastward
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Closed mixed forest dominated by aspen, with scattered spruce

Site No. 50 is located just north of Squaw Creek, south of Tiekel River Lodge on Richardson Highway. Accessing this location requires leaving the Richardson Highway toward the west. The pipeline is on the west side of the ROW, and the roadway on the east. The site is at the base of a ridge. The substrate is rocky glacial outwash. Grasses and forbs were prominent components of the ROW vegetation, and hardwood trees were colonizing. The site drains into the Tsiana River and finally the Copper River. Vegetation prior to construction was a well-vegetated disturbed forest. The site is rocky, and gravel fill was probably not hauled in for the ROW.

Evidence of brushing the ROW was not readily apparent. This section of ROW is not developing a vigorous vegetation, most likely because of poor rocky soil. Left unchecked, herbaceous vegetation would eventually be replaced by shrubs and hardwood trees (mostly aspen and cottonwood).

Soil reaction was acidic inside and outside the ROW (pH 5.94 and pH 5.20). Soil over the buried pipe contained about 49% gravel, while that of the adjacent forest land contained 69% gravel. Similarly in the gravel between the two habitats indicated soils were probably from the same glacial deposit. Soil moisture inside the ROW was about 7% and outside about 5%. Total soil C was low within the ROW (0.95%) and in the adjacent forest (3.34%), translating to 2.1% and 7.4% organic matter, respectively. Total soil N was moderately low (0.12%) inside and low (0.09%) outside the ROW. The C:N ratios for the ROW and forest soils were 7.9 and 37.1, respectively. The ROW C:N ratio was well within the desired ratio. C:N of the forest was above the desired ratio for plant growth, based on agricultural standards.

The amount of available soil N was low both inside and outside the ROW (2 ppm in both soils). The ROW soil available N was in the ammonium form, and that of the forest was as nitrate. There was no apparent carryover of N fertilizer from revegetation at this location. Measurable available soil P was 107 ppm within the ROW soil and 157 ppm in the adjacent forest soil. The available soil P is more than adequate for plant growth in both soils. There may have been a carryover of P fertilizer from revegetation. These were the highest soil P values encountered for TAPS. (See discussion of soil P for Site No. 49.) Available K was 40 ppm inside and 39 ppm outside the ROW. That indicated that K was marginally adequate for plants in both habitats. There was no carryover of K fertilizer from revegetation treatments at this location.

Within the ROW the organic mat was poorly developed in both habitats, consisting primarily of plant debris up to 0.25 cm in thickness within the ROW. Moss and a few lichens were present on the surface of the ROW in places. The organic mat (1-2.5 cm) in the adjacent forest consisted mostly of plant debris, a few mosses, and *Cladonia* lichen.

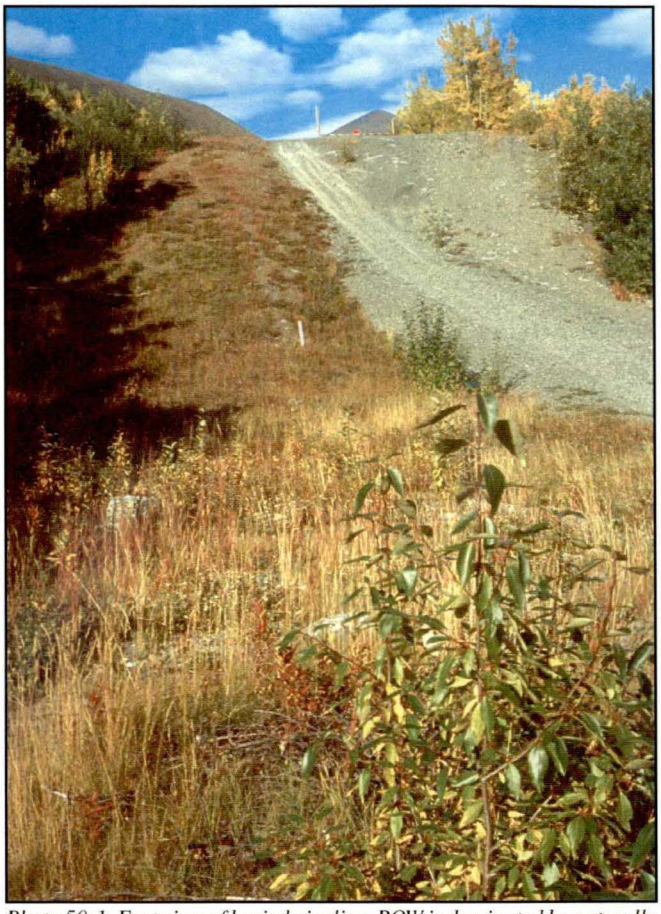


Photo 50-1. East view of buried pipeline. ROW is dominated by naturally colonizing trees, shrubs and forbs; gravel roadway is mostly barren.

Site No. 50 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	48.8	68.9
Moisture %	6.8	5.0
Total C %	0.95	3.34
Total Nn %	0.12	0.09
C:N ratio	7.9	37.1
Organic matter %	2.1	7.4
pH	5.94	5.20
NH_4-N (ppm)	2	Not detectable
NO_3-N (ppm)	Not detectable	2
P (ppm)	107	157
K (ppm)	40	39
Organic mat thickness (cm)	0 - 0.25	1 - 2.5

Twenty-six vascular plant species were recorded at this location. Eighteen were recorded within the ROW and 14 in the adjacent forest habitat. Two tree species, one shrub, and three forbs were common to both habitats. There were no grasses in common. This disparity of species between the ROW and adjacent natural forest was caused by habitat changes (primarily soil) associated with construction, and to some extent by revegetation with grasses.

Three tree species were found at this site. Two tree species, *Picea* glauca and *Populus balsamifera*, occurred within the ROW, and in the forest. Eight shrub species were found at this site. Three species were found in the ROW and six within the adjacent forest community. One shrub species (*Shepherdia canadensis*) was common to both habitats. One shrub species (*Arctostaphylos uva-ursi*) was found only within the ROW. *Amelanchier alnifolia*, northern serviceberry, was found only at this site in our survey. All trees and shrubs were indigenous.

Twelve forb species were found at this location. Ten occurred in the ROW, and five species were recorded within the adjacent forest. Three forb species (*Lupinus arcticus, Lycopodium annotinum,* and *Pyrola secunda*) were common to both habitats. Three introduced forbs were identified at this site. Two were weeds *Crepis capillaris* and *Taraxacum officinale*. One introduced forb, *Trifolium hybridum,* is a common forage legume (see discussion in Site 28).

Three grass species were found at this location. All three species were found only within the ROW. Two (*Alopecurus pratensis* and *Bromus inermis*), are exotic forage grasses that were introduced at this location during revegetation of the ROW. *Festuca rubra* was the other grass at this site. It is indigenous to Alaska; however, its presence here can be attributed to revegetation of the ROW following construction.

No sedge species were found at this location. The habitat is probably too dry for those plants.

Signs of wildlife were scarce. Moose and hare were probably the most common mammalian species in the area. There were evidences of human uses on the site in the form of ATV tracks and trash. The site is readily accessible from the highway, and there were vehicles parked in the vicinity of the site during our survey.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 50.

Species Names	Inside	Outside
Trees		
Picea glauca	•	•
Populus balsamifera	•	•
Populus tremuloides		•
Total Trees	2	3
Shrubs		
Alnus sinuata	•	
Amelanchier alnifolia		•
Arctostaphylos uva-ursi	•	
Linnaea borealis		•
Salix scouleriana		•
Shepherdia canadensis	•	•
Vaccinium vitis-idaea		•
Viburnum edule		•
Total Shrubs	3	6
Forbs		
Achillea borealis	•	
Antennaria rosea	•	
Cornus canadensis		•
Crepis capillaris	•	
Epilobium angustifolium	•	
Epilobium palustre	•	
Lupinus arcticus	•	•
Lycopodium annotinum	•	•
Pedicularis verticillata		•
Pyrola secunda	•	•
Taraxacum officinale	•	
Trifolium hybridum	•	
Total Forbs	10	5
Grasses		
Alopecurus pratensis	•	
Bromus inermis	•	
Festuca rubra	•	
Total Grasses	3	0
Sedges		
Total Sedges	0	0
Total Vascular Species	**18**	**14**

Photo 50-2. Second growth aspen forest north of pipeline.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #51

Date Examined:	11 September 1999
Location:	N61°11' 28.7"; W145°39' 28.6"; TAPS M.P. 769.
Pipeline:	Buried
Slope:	Flat surface, sloping eastward
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Closed mixed forest dominated by cottonwood, with scattered spruce

Site No. 51 is located about 2 mi north of Worthington Glacier, in the Tsiana River Valley. Accessing this location requires leaving the Richardson Highway toward the north at the second road past the bridge over Small Creek. The pipeline is on the west side of the ROW, and the roadway on the east. The site is bordered by the river. The substrate is very rocky glacial outwash. Grasses and forbs were prominent components of the ROW vegetation. A few hardwood trees were colonizing the ROW. The site drains into the Tsiana River and finally the Copper River. Vegetation prior to construction was a well vegetated disturbed cottonwood forest. Many of the small trees had been deformed from heavy snow loads. The site is rocky with coarse stones. The road was barren and consisted of stones smaller and more uniform than in the forest. This suggests that gravel fill (crushed rock) was probably used to construct the ROW roadway.

Evidence of recent brushcutting in the ROW was not readily apparent. This section of ROW is developing vigorous vegetation, in spite of the rocky soil. In time, it is expected that herbaceous vegetation would be replaced by hardwood trees.

Soil reaction was acidic inside and outside the ROW (pH 5.97 and pH 5.74). Soil over the buried pipe contained about 50% gravel, while that of the adjacent forest land contained 17% gravel. The two soils were from the same glacial till, but the greater content of stones in the soil over the buried pipe resulted from subsoil backfill. Soil moisture inside the ROW was about 8% and outside about 12%. Total soil C was low within the ROW (1.00%) and very low (0.73%) in the adjacent forest, translating to 2.2% and 1.2% organic matter, respectively. Total soil N was moderate (0.06%) inside and outside the ROW, and low outside with respect to other locations. The C:N ratios for the ROW and forest soils were 16.7 and 12.2, respectively. These ratios were within the range desirable for supplying N to vegetation.

Site No. 51 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	49.7	16.6
Moisture %	7.7	11.7
Total C %	1.00	0.73
Total N %	0.06	0.06
C:N ratio	16.7	12.2
Organic matter %	2.2	1.6
pH	5.97	5.74
NH_4-N (ppm)	1	Not detectable
NO_3-N (ppm)	Not detectable	2
P (ppm)	8	4
K (ppm)	12	23
Organic mat thickness (cm)	0 - 0.5	2 - 3

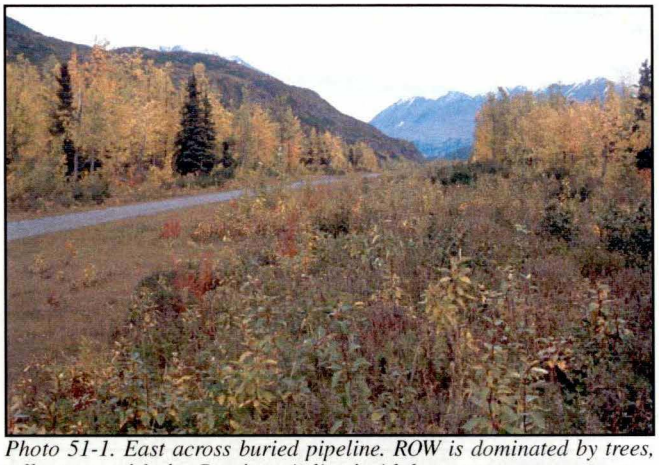


Photo 51-1. East across buried pipeline. ROW is dominated by trees, tall grass and forbs. Roadway is lined with low grasses.

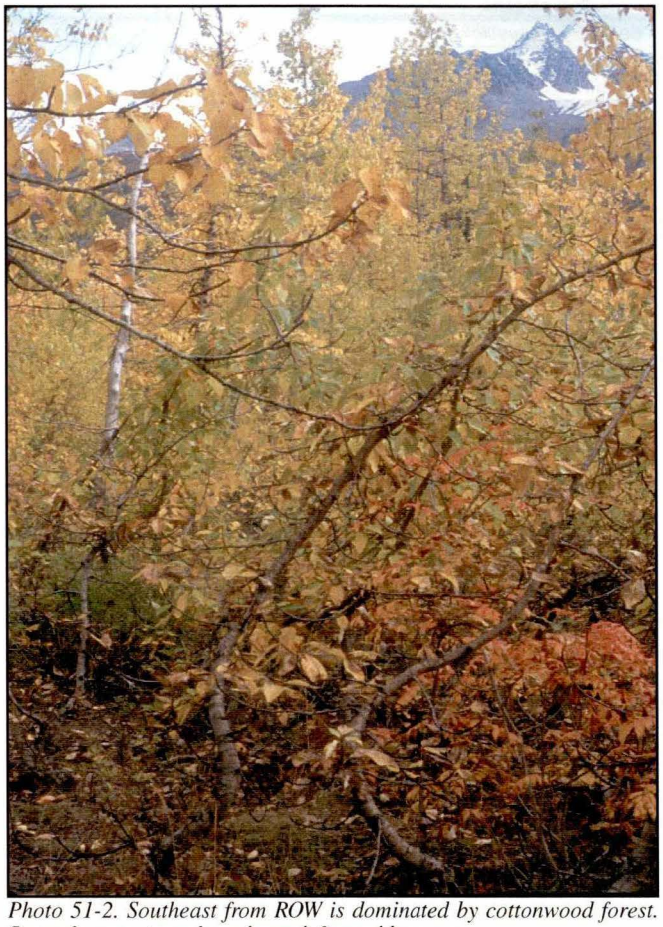


Photo 51-2. Southeast from ROW is dominated by cottonwood forest. Several young trees have been deformed by snow.

The amount of available soil N was low at 1 ppm for ROW soils and 2 ppm for the adjacent forest soil. The ROW soil available N was in the ammonium form, and that of the forest was as nitrate. There was no apparent carryover of N fertilizer from revegetation at this location. Measurable available soil P was 8 ppm within the ROW soil and 4 ppm in the adjacent forest soil. The available soil P in the ROW and forest soils is moderately low for plant growth. There was no significant carryover of P fertilizer from revegetation. Available K was 12 ppm inside and 23 ppm outside the ROW. That indicated that K was marginally adequate for plants in both habitats. There was no carryover of K fertilizer from revegetation treatments at this location.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 51.

Species Names	Inside	Outside
Trees		
Picea sitchensis		•
Populus balsamifera	•	•
Total Trees	1	2
Shrubs		
Alnus crispa	•	•
Arctostaphylos uva-ursi	•	•
Rubus arcticus		•
Salix alaxensis		•
Salix barclayi		•
Salix glauca		•
Salix lanata var richardsonii		•
Salix novae-angliae		•
Sorbus scopulina		•
Total Shrubs	2	9
Forbs		
Achillea borealis	•	
Botrychium boreale		•
Castelleja elegans	•	•
Epilobium angustifolium	•	
Epilobium palustre	•	
Lupinus arcticus	•	•
Lycopodium annotinum		•
Orchidaceae (?)	•	
Pyrola asarifolia	•	•
Pyrola secunda	•	•
Solidago multiradiata		
Total Forbs	9	6
Grasses		
Agropyron spp.		•
Agrostis scabra		•
Alopecurus pratensis	•	
Festuca rubra	•	
Phleum communtatum		•
Phleum pratense	•	
Poa paucispicula		•
Trisetum spicatum		•
Total Grasses	3	5
Sedges		
Carex spp.		•
Luzula spp.		•
Total Sedges	0	2
Total Vascular Species	***15***	***24***

The organic mat was poorly developed in both habitats, consisting primarily of plant debris up to 0.5 cm in thickness within the ROW. Moss, mushrooms and a few lichens (*Cladonia*) were present on the surface of the ROW in places. The organic mat (2-3 cm) in the adjacent forest consisted mostly of plant debris, a few mosses, and very large mushrooms.

Thirty-two vascular plant species were recorded at this location. Fifteen occurred within the ROW and 24 in the adjacent forest habitat. However, only one tree species, two shrubs, and four forbs were common to both habitats. No grasses were in common. This disparity of species between the ROW and adjacent natural forest was caused by competition from revegetation grasses and habitat changes (primarily soil) associated with construction.

Two tree species were found at this site, *Picea sitchensis* and *Populus balsamifera*. *Populus balsamifera* occurred in both habitats. Nine shrub species were found at this site. Two species were found in the ROW and all nine within the adjacent forest community. *Alnus crispa* (probably *sinuata*) and *Arctostaphylos uva-ursi* were common to both habitats. All trees and shrubs were indigenous.

Eleven forb species were found at this location. Nine occurred in the ROW, and six species in the adjacent forest. Four forb species (*Castelleja elegans, Lupinus arcticus, Pyrola asarifolia,* and *Pyrola secunda*) were common to both habitats. All forbs at this location were indigenous. An interesting forb, northern grapefern (*Botrychium boreale*), was found in the forest at this site. It was our only record for this plant during this survey.

Eight grass species were found at this location. Three species were found only within the ROW. Two exotic forage grasses, *Alopecurus pratensis* and *Phleum pratense* were introduced during revegetation of the ROW. *Festuca rubra* was the third grass species found within the ROW at this site. It is indigenous to Alaska; however, its presence here can be attributed to revegetation of the ROW following construction.

All grass species in the adjacent forest were indigenous to Alaska. *Agrostis scabra* is a weedy indigenous species. *Phleum commutatum* is an indigenous timothy grass, and it was found only at this location during our survey of the pipeline corridor. The *Trisetum spicatum* recorded at this location is a tall strain compared to those observed northward along the pipeline. Hultén (1968) considered it to be a subspecies, *alaskanum*. Welsh (1974) referred to it as a polymorphic variation of the species, not qualifying for subspecies status.

One sedge species and one rush were found at this location within the forest habitat. None were found in the ROW.

Signs of wildlife were scarce. Moose and bear were probably the most common mammalian species in the area. There were evidences of human uses on the site in the form of ATV tracks and trash. The site is readily accessible from the highway, and vehicles were parked outside the locked gate during our survey.

Trans-Alaska Pipeline Right-of-Way Vegetation Inventory

Site #52

Date Examined:	11 September 1999
Location:	N61°06' 41.1"; W145°48' 09.3"; TAPS M.P. 777.5.
Pipeline:	Buried
Slope:	Flat surface, sloping southwest
Drainage:	Inside - well drained; Outside - well drained
Vegetation:	Closed spruce forest

Site No. 52 is located about 5 mi south from Thompson Pass, in the Lowe River Valley. Accessing this location requires leaving the Richardson Highway toward the south at the first side road past the summit. The pipeline is on the south side of the ROW, and the roadway on the north. The site is just east of Sheep Creek. The substrate is silt over glacial outwash. Shrubs and invading trees were prominent components of the ROW vegetation. The site drains into the Lowe River and finally Valdez harbor. Vegetation prior to construction was a well vegetated forest. The area has been disturbed by natural stream processes and to some extent by humans. A power line is situated just south of the ROW. The wheel tracks of the roadway were barren and grasses predominated next to the road. Gravel may have been hauled to build the road during pipeline construction.

Evidence of recent brushcutting in the ROW was not readily apparent. Without periodic brushing, this section of the ROW would soon be overgrown with trees and shrubs.

Soil reaction was acidic inside and outside the ROW (pH 6.35 and pH 6.03). Soil over the buried pipe contained about 60% gravel, while that of the adjacent forest land contained 44% gravel. The two soils probably were from the same parent material, but subsoil backfill over the buried pipe contained more stones than the original surface soil. Soil moisture inside the ROW was about 6% and outside about 13%. Total soil C was 1.23% inside the ROW and 2.40% in the adjacent soil, translating to 4.9% and 5.3% organic matter, respectively. C content was moderately low in both soils. Total soil N was very low (0.04%) inside and low (0.11%) outside the ROW. The C:N ratios for the ROW and forest soils were 30.8 and 21.8, respectively. The ROW C:N ratio is slightly high, while that of the forest is within the desirable range for providing N to vegetation.

The amount of available soil N was moderately low at 8

Site No. 52 soil data inside and outside TAPS right-of-way.

Characteristic	*Inside*	*Outside*
Gravel %	60.2	43.7
Moisture %	6.4	12.7
Total C %	1.23	2.40
Total N %	0.04	0.11
C:N ratio	30.8	21.8
Organic matter %	2.7	30.8
pH	6.35	6.03
NH_4-N (ppm)	5	3
NO_3-N (ppm)	3	2
P (ppm)	7	10
K (ppm)	19	57
Organic mat thickness (cm)	2	2 - 4

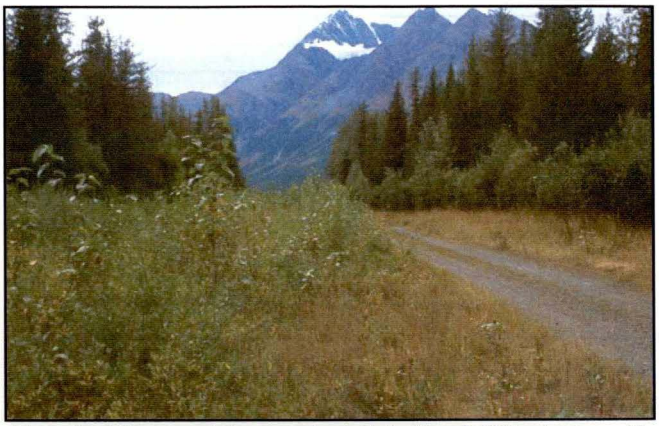


Photo 52-1. Westward view over buried pipeline. ROW is dominated by naturally-established cottonwood trees and shrubs. Grasses line margins of the roadway.

Photo 52-2. View of the coastal spruce forest south of the ROW.

ppm for ROW soils, and low at 5 ppm for the adjacent forest soil. The ROW and forest soil available N was predominantly ammonium, although both soils contained nitrate N. There was no apparent carryover of N fertilizer from revegetation at this location. Measurable available soil P was 7 ppm within the ROW soil and 10 ppm in the adjacent forest soil, both moderately low for plant growth. There was no carryover of P fertilizer from revegetation. Available K was 19 ppm inside and 57 ppm outside the ROW. That indicated that K was marginally adequate for plants in the forest habitat and probably limiting in the ROW soil. There was no carryover of K fertilizer from revegetation treatments at this location.

Vascular plant species observed inside and outside TAPS right-of-way at Site No. 52.

Species Names	Inside	Outside
Trees		
Betula papyrifera	•	
Picea sitchensis	•	•
Populus balsamifera	•	•
Total Trees	3	2
Shrubs		
Alnus crispa	•	•
Salix alaxensis		•
Salix barclayi	•	
Salix scouleriana		•
Salix sitchensis	•	•
Viburnum edule		•
Total Shrubs	3	5
Forbs		
Achillea borealis	•	
Artemisia tilesii	•	
Athyrium felix-femina		•
Galeopsis bifida	•	
Dryopteris dilatata		•
Epilobium angustifolium	•	•
Equisetum arvense		•
Erigeron acris	•	
Galium boreale		•
Heracleum lanatum	•	
Lupinus arcticus	•	
Plantago major var. major	•	
Pyrola asarifolia	•	
Pyrola secunda	•	
Ranunculus bongardi		•
Sanguisorba officinalis	•	
Taraxacum officinale	•	
Thalictrum sparsiflorum		•
Trifolium hybridum	•	
Total Forbs	13	7
Grasses		
Agrostis scabra	•	
Calamagrostis canadensis		•
Festuca rubra	•	
Phleum pratense	•	
Poa pratensis	•	
Total Grasses	4	1
Sedges		
Total Sedges	0	0
Total Vascular Species	**23**	**15**

The organic mat was minimally developed in both habitats, up to 2 cm thick in the ROW and 2-4 cm in the forest. Moss, mushrooms and plant litter were present on the surface of both soils.

Thirty-three vascular plant species were recorded at this location. Twenty-three occurred within the ROW and 15 in the adjacent forest habitat. However, only two trees, two shrubs, and one forb species were common to both habitats. The disparity of species between the ROW and adjacent natural forest was caused by competition from revegetation grasses and habitat changes (primarily soil) associated with construction.

Three tree species were found at this site, *Betula papyrifera, Picea sitchensis* and *Populus balsamifera*. *P. sitchensis* and *P. balsamifera* occurred in both habitats, while *B. papyrifera* was found only within the ROW. Apparently, the adjacent forest had not been disturbed recently enough to create opportunities for this tree species to establish. Six shrub species were found at this site. Three species were found in the ROW and five within the adjacent forest community. *Salix barclayi* occurred only within the ROW. *Salix alaxensis, Salix scouleriana*, and *Viburnum edule* were recorded only in the adjacent forest. Two shrub species (*Alnus crispa* probably *sinuata* and *Salix sitchensis*) were common to both habitats. All trees and shrubs were indigenous.

Nineteen forb species were found at this location, thirteen in the ROW, and seven within the adjacent forest. One forb (*Epilobium angustifolium*) was common to both habitats. Four exotic plant species occurred at this location. Three are common weeds: *Galeopsis bifida, Plantago major* var. *major,* and *Taraxacum officinale*. These may have come with revegetation seed mixtures and/or were in the vicinity as roadside plants prior to pipeline construction. One was an introduced species of clover, *Trifolium hybridum* (see discussion in Site 28).

Five grass species were found at this location. Four species (*Agrostis scabra, Festuca rubra, Phleum pratense,* and *Poa pratensis*) were found only within the ROW, and one (*Calamagrostis canadensis*) was found only in the forest habitat. *Phleum pratense*, a forage grass, and *Poa pratensis*, a forage and turfgrass, are introductions to Alaska, and were introduced during ROW revegetation. *Festuca rubra* found within the ROW was also introduced during revegetation. No exotic species of grass occurred in the adjacent forest. *Agrostis scabra* is a weedy indigenous species.

No sedges or rushes were found at this location in either habitat.

Bear signs were present in the vicinity. Moose and bear were probably the most common mammalian species in the area. There were evidences of human uses on the site. New flagged stakes indicated recent surveying activity. The site is readily accessible from the highway, and probably used by recreationists regularly.