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Field Observations and Chemical Analyses of Vegetation, Soils and Spoil Materials, Jarvis Creek Preference Coal Lease, Alaska

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editoral standards.

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FIELD OBSERVATIONS AND CHEMICAL ANALYSES OF VEGETATION, SOILS AND SPOIL MATERIALS, JARVIS CREEK PREFERENCE COAL LEASE, ALASKA

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INTRODUCTION

This report was prepared for the Fortmile Area Office of the Bureau of Land Management, Tok, Alaska, as a contribution toward the preparation of a feasibility and environmental assessment analysis of the potential development of a preference coal lease in the Jarvis Creek coal field. The preference lease is located within all of section 34 and parts of sections 33 and 35 (T. 14 S., R. 10 E.) and within all of section 3 and parts of sections 2 and 4 (T. 15 S., R. 10 E.) of the Mt. Hayes, Alaska C-4 quadrangle. This area is about 64 km south of Delta Junction and 14 km east of the Richardson Highway within the utility corridor of the trans-Alaska oil pipeline.

English units of measurement are occasionally used in the report at the suggestion of those who requested the study. Although most of the field work was completed between August 5-7, 1981, a part of the vegetational survey was conducted during a brief visit to the area on June 16, 1981. The results of the study, submitted as an Administrative Report, were communicated on October 6, 1981. We thank Janet L. Peard for her assistance in cataloging and identifying the plant collections.

FIELD OBSERVATIONS

The vegetation of the Jarvis Creek preference coal lease is classified as "birch and ericaceous shrub-sedge tundra" using the taxonomic system for Alaska vegetation that is proposed by Viereck and Dyrness (1980). The area is a broad plain of low relief at the extreme upper tree-limit that is bisected by the small channel formed by Ober Creek (fig. 1). The native (or undisturbed) area examined included a section of this broad plain north of Ober Creek that extended east along the gently sloping south-facing flank of a hill. We also examined the coal excavation trench and the spoil piles located adjacent to, and west of, the native site.

Native or Undisturbed Site

Vegetation--The vegetative cover of the native site at ground level consisted of a nearly uninterrupted mat of lichens and mosses. *Betula nana*, *Vaccinium uloginosum* subsp. *alpinum*, and *Empetrum nigrum* dominated the shrub layer and had a combined estimated cover of 50 to 60 percent. These shrubs seldom exceeded 30 cm in height and, where exposed, had an east-to-west orientation as a result of the influence of the prevailing winds. Scattered

Figure 1.--Map showing the Jarvis Creek preference lease study area and its location in Alaska relative to Fairbanks and Anchorage. The position of the three soil profile holes is plotted within the broad native or undisturbed study site. Native vegetation samples were collected throughout this general area. Explanation of the numbered sites follows: (1) gravelly spoil area; (2) clayey spoil area; (3) general location of the interburden and overburden sample sites within the excavated coal pit.

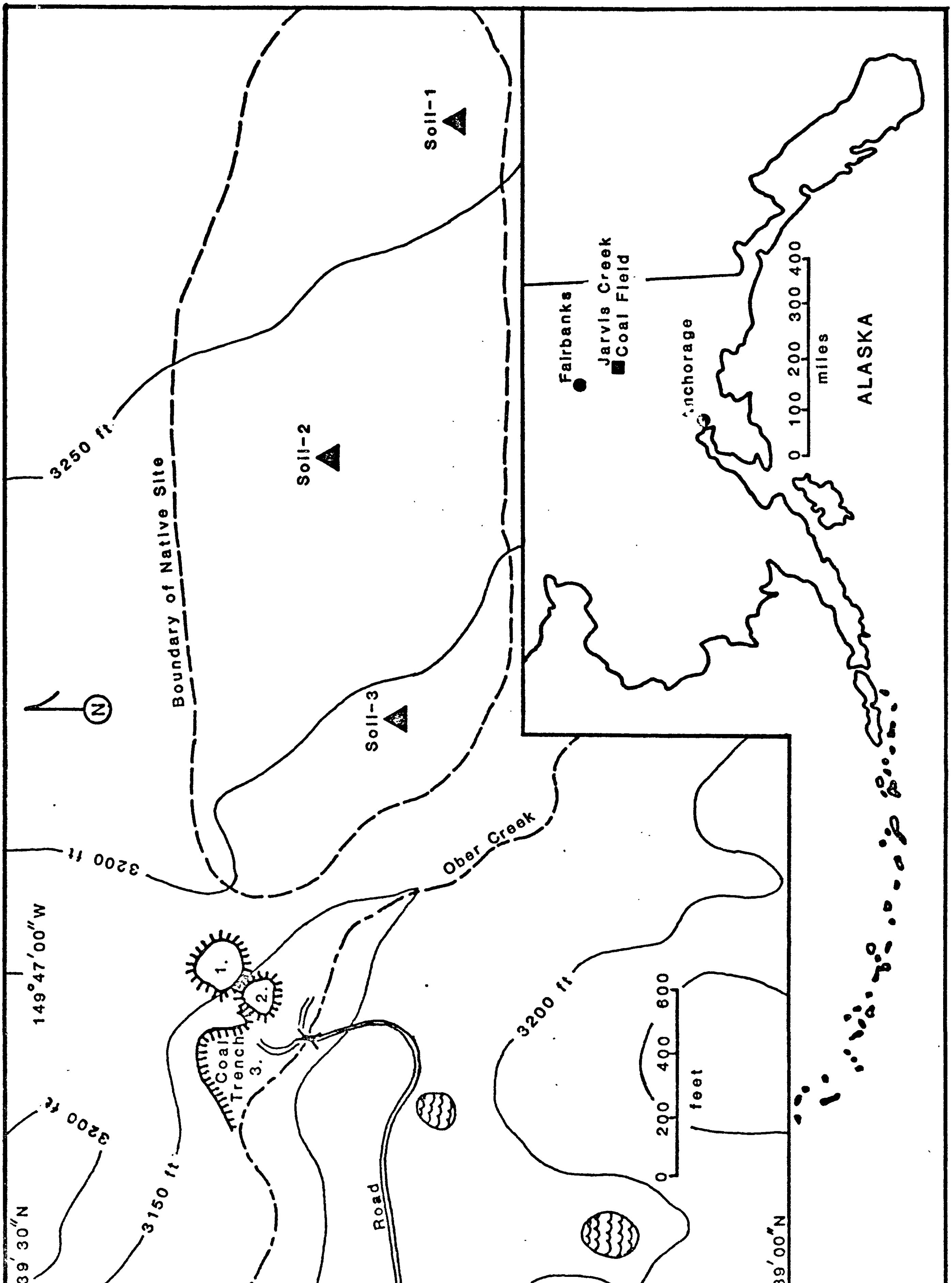
Soil-1
Soil-2
Soil-3
Boundary of Native Site
N
3250 ft
3200 ft
3200 ft
3200 ft
3150 ft
Ober Creek
1.
2.
Coal Trench 3.
Road
149°47'00"W
63°39'30"N
63°39'00"N
0 200 400 600
feet
Fairbanks
Jarvis Creek
Coal Field
Anchorage
0 100 200 300 400
miles
ALASKA

Figure 1.

over the landscape were a few individual erect willow clumps composed of Salix niphoclada and S. pulchra and along the sides of the Ober Creek channel there occurred a very few Picea glauca individuals. Several species of ericaceous shrubs (Arctostaphols and Ledum) as well as Salix arctica complete the list of woody perennials found. Small shallow pools (several meters square) were occasionally found where a deep ground thaw had apparently occurred. These sites had their own characteristic vegetation usually dominated by aquatic mosses.

Based on the compilation of Murray (1980) there were no threatened or endangered plant species noted. A complete list of the species observed during visits at the Jarvis Creek native site on June 16 and August 5-7 follows (the taxonomy--and common names where appropriate--predominantly follows Hultén, 1974, and Thomson, 1979):

Trees, shrubs, and woody perennials

Arctostaphlos alpina	bearberry
A. uva-ursi var. uva-ursi	kinnikinnick
Betula glandulosa	shrub birch
*B. nana	dwarf birch
*Empetrum nigrum	crowberry
Ledum palustre subsp. decumbens	Labrador tea
L. palustre subsp. groenlandica	Labrador tea
Picea glauca	white spruce
Salix arctica	arctic willow
S. niphoclada	
*Vaccinium uligonosum subsp. alpinum	alpine blueberry

*Indicates dominance in terms of area covered.

Forbs

Aconitum delphinifolium subsp. delphinifolium	monkshood
Anemone narcissiflora subsp. interior	
Artemisia arctica	
Cornus suecica	bunchberry
Dryas octopetala subsp. octopetala	mountain avens
Epilobium latifolium	fireweed
Equisetum arvense	horsetail
E. pratense	horsetail
Gentiana algida	
G. glauca	
Minuartia rossii	
Oxytropis campestris subsp. gracilis	
Pedicularis capitata	lousewort
Petasites hyperboreus	coltsfoot
Polemonium acutiflorum	Jacob's ladder
Polygonum bistorta	bistort
Rubus chamaemorus	cloudberry
Saxifraga punctata subsp. nelsoniana	cordate-leaved saxifrage
Sedum rosea subsp. integrifolium	kings crown
Stellaria laeta	chickweed
Valeriana capitata	valerian

Grasses and sedges

Calamogrostis canadensis	bluejoint
Carex aquatilis	sedge
C. bigelowii	sedge
C. nardina	sedge
Eriophorum angustifolium subsp. triste	cottongrass
Festuca altiaca	
Phleum commutatum var. americanum	

Lichens (only the most commonly observed macrolichens are reported)

Cetraria cucullata
C. islandica
C. laevigata
C. nivalis
Cladonia arbuscula
C. crispata
C. gracilis
C. pleurota
C. pocillum
C. rangiferina
C. stellaris
C. subfurcata
Cornicularia muricata
Diploschistes scruposus
Leptogium sp.
Lobaria linita
Nephroma arcticum
Ochrolechia upsaliensis

Peltigera aphthosa
P. canina
P. malacea
Sphaerophorus globosus
Stereocaulon sp.

The vegetation and flora of the Mt. Hayes D-4 quad (1:63,360) were very thoroughly investigated by W. S. Benninghoff about 25 years ago (Holmes and Benninghoff, 1957). Those lists may be consulted for an indication of what species are likely to be found in a neighboring geographic area that is much larger than the specific mine site that we studied.

Soils--The three soil profiles examined on the broad plain north of Ober Creek (fig. 1) were uniform in morphology and texture. The only observable differences between profiles were the thickness of the various horizons and the depth to frozen ground. A typical soil profile is shown in Figure 2 and a general soils description of it follows:

O1 horizon, 15-25 cm thick, highly organic silt loam, dark brown moist color (7.5YR 3/2)

O2 horizon, 2 cm thick, root mat with very little inorganic material, dark reddish brown (5YR 3/3)

A1 horizon, 2-5 cm thick, silt loam with low to moderate organic matter content, dark reddish brown (5YR 3/3)

Cg horizon, 35-60 cm before frozen ground was encountered, silt loam, mottled with mainly gray (5Y 5/1) and yellowish red (5YR 4/6) indicating a gleyed horizon.

The O1 and Cg horizons were sampled for chemical analyses. Textural class was estimated by field methods, and colors (determined on moist soil material) follow standard Munsell designations.

Based on the exposure at the coal trench, we presume this soil to be developed in a veneer of loess of unknown depth (probably 2 m or less). Also

Figure 2. Photograph showing a typical soil profile from the broad plain north of Ober Creek. The soil section is approximately 60 cm long. Photographed August 7, 1981.

from observations at the coal-trench exposure, and at small erosional scarps along the slope near Ober Creek, we presume that the surficial deposits within the lease area consist of 1-2 m of loess overlying 1-2 m of glacial till, which in turn overlies 2-4 m of unconsolidated, stream-deposited, sand and gravel. The extent and thickness of these deposits could not be determined because of frozen ground at 1 m or less; however, this information may be obtainable from drill cuttings when the area was evaluated for its coal reserves.

Disturbed or Spoil Sites

Spoil Material--East of, and adjacent to the coal pit were two areas of spoil material (figs. 1 and 3). The upper or northern-most area (referred to as "gravelly spoil") consisted of a silty to sandy loam, yellow brown matrix with pebbles, cobbles, and boulders making up an estimated 50 percent of the spoil volume. This spoil material also contained coal fragments at an estimated volume of five percent or less. This spoil material resembled the glacial till and unconsolidated sand and gravel exposed above the trench.

The lower or southern-most area (referred to as "clayey spoil") consisted of a fine textured dark gray to black matrix with an estimated 10 to 20 percent coarse fragments and an estimated 5 to 10 percent coal fragments. The matrix material resembled the glacial till exposed above the coal. Evidently, this spoil material consisted mainly of overburden of Tertiary age intermixed with a small amount of glacial till. Geologic maps and descriptions of the area (Wahrhaftig and Hickcox, 1955) show the contact of young glacial deposits to follow Ober Creek and state that remnants of older glacial deposits and stream deposited sand and gravel occur on adjacent hill tops and valley sides.

Figure 3. Photograph showing the general appearance of the naturally revegetated gravelly spoil (left-midground in center photo), the largely unvegetated clayey spoil (foreground in center photo), and the undisturbed broad plain where natural soils and native plants were sampled (center-right background in center photo). The top photo shows the general character of the spoil material collected from the gravelly spoil and the bottom photo shows the general character of the spoil material collected from the clayey spoil area. Sample bags are 20 cm by 13 cm. Photographed August 7, 1981.

At three locations on the gravelly spoil and on the clayey spoil, a 40-cm-deep trench was dug. Composite samples of the 40 cm section were collected at each of the six locations for chemical analyses.

Coal Trench Exposure Material--Single composite samples of each different material exposed in the coal trench were collected for chemical analyses. The general orientation of the different materials is shown in figure 4 and photographs of the sections sampled are given in figure 5. The glacial till sample (fig. 5, section A) consisted of a composite of material exposed throughout the 2 m section. According to the discussion given in Wahrhaftig and Hickcox (1955), this material represents an "older" rather than the most recent glaciation. Below the glacial till, a composite sample of the 4 m of exposed unconsolidated sand and gravel (fig. 5, section B) was collected. Because of presumed scalping of surficial deposits (depth and extent unknown) to expose coal, glacial till and sand and gravel were not exposed above the area where overburden and interburden were collected. The composite sample of Tertiary overburden, therefore, consisted of the remaining exposed section as shown to the right of the section-C marker in figure 5. The interburden-1 sample was composited from the area to the right of the section-D marker in figure 5, and the interburden-2 sample was composited from the area to the left of the section-E marker.

Vegetation--There appears to have been no attempt in the past (by those who have made coal excavations) to purposely revegetate the two spoil piles mentioned above. Natural revegetation has occurred, however, and a reconnaissance of the flora of these sites was made. Several generalizations concerning the rehabilitation potential of the Jarvis Creek site are based on these field observations and follow:

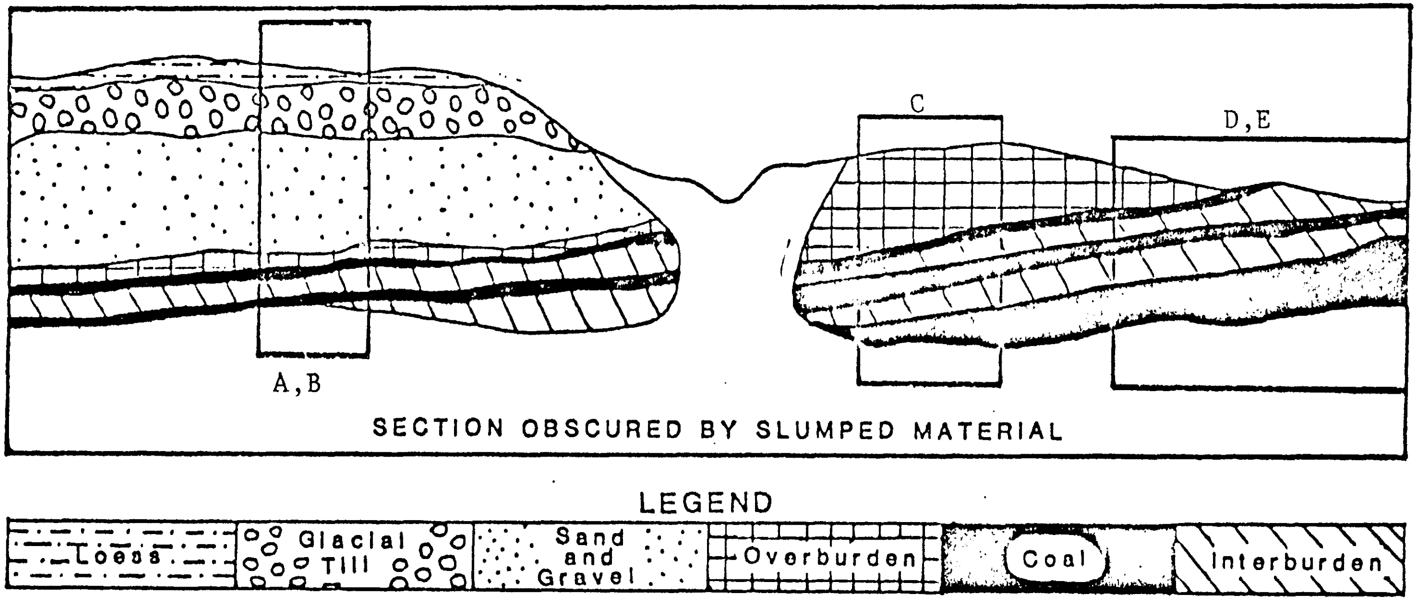

Figure 4. Diagrammatic cross section(not to scale) of coal trench exposure (coal pit location is shown in fig. 1). Sections outlined by rectangles in the illustration represent the locations and orientation of photographs in fig. 5.

Figure 5. Photographs showing the various materials sampled in the coal trench exposure. Locations of photographs are shown in Figure 4. Section A, composite sample of glacial till. Section B, composite sample of unconsolidated sand and gravel. Section C, composite sample of Tertiary overburden. Section D, composite sample of interburden-1. Section E, composite sample of interburden-2. Photographed August 7, 1981.

1. With only a few exceptions, the vegetation of the gravelly and clayey spoil areas contained species not commonly found in the undisturbed areas (fig. 3). The spoil-area species are typical of those expected to colonize disturbed ground in this part of Alaska. There was no difference between the species lists from the two spoil areas.
2. Greater vegetative cover occurred on the gravelly spoil pile than on the clayey spoil pile. Further the gravelly spoil pile possessed a greater proportion of its total vegetation as shrubs.
3. Based on field observations, it is not possible to state whether the better vegetative recovery of the gravelly spoil pile (as opposed to the clayey spoil pile) is due to more favorable physical properties, chemical properties, or a combination of both.
4. Small organic mats of varying thickness and of undetermined origin were found scattered over the spoil surfaces. These served as loci for the establishment of Polytricaceous mosses (which were observed to spread outward from the mats) and for the germination of wind-deposited seeds. These observations indicate that the incorporation of the native shallow organic mat into the spoil (fig. 2), and perhaps also the till where present, would probably promote revegetation.

A list of the spoil-site species and their common names (where appropriate) follows (taxonomy after Hultén, 1974):

Shrubs

Alnus crispa	American green alder
Betula nana	dwarf birch
*Salix alaxensis	Alaska willow
S. arctica	arctic willow
S. phylicifolia	

Forbs

Arabis divaricarpa	
**Artemisia tilesii*	
Epilobium angustifolium subsp. *angustifolium*	fireweed
E. latifolium	river beauty
Equisetum arvense	horsetail
Rumex fenestratus	dock

Grasses and sedges

Agrostis scabra	
**A. stolonifera*	
Carex bigelowii	sedge
Phleum commutatum var. *americanum*	

*Inidcates dominance in terms of area covered.

CHEMICAL ANALYSES

Methods

Plant Material--There is a large difference in the species composition of the vegetation of the native (or undisturbed) site when compared to that of the upper gravelly spoil or the lower clayey spoil pile. Very few species, therefore, were common to both the undisturbed and disturbed areas. (There was essentially no difference, however, between the composition of the vegetation of the two spoil sites.) Comparisons of the chemistry of *like* plant species between the disturbed and undisturbed areas was not possible; however, comparisons of *similar* material was possible.

Willow (*Salix niphoclada* and *S. alaxensis*) stems were collected at the native site and at the upper gravelly spoil pile, respectively. The stems, leaves, and seed-heads of *Agrostis stolonifera* (a grass) were collected at both the upper gravelly spoil site and the lower clayey spoil site. The willow stem material consisted of the terminal 10- to 30-cm of branches (without leaves) and the grass material consisted of clippings of grass clumps at about 10 cm above the ground. This material was sampled at three separate locations within each site, placed in canvas bags (which allowed for some drying), and mailed to the Denver Laboratories of the U.S. Geological Survey.

In the laboratory the samples were dried at between 35° and 40°C in a convection oven with circulating air, ground in a Wiley mill (to pass a 1.3 mm screen), and ashed in a muffle furnace at 500°C. A measured (0.1 g) amount of plant ash was then fused (at 400°C for 10 minutes) with 1 g of potassium hydroxide in a vitreous-carbon crucible. The fusion cake was then dissolved in 25 ml of 30% nitric acid to affect a solution-to-sample dilution of 250:1. This solution was then aspirated directly into a 63 channel direct-reading induction-coupled plasma optical emission spectrometer (ICP-OES). By using internal standards, both precision and accuracy were considered acceptable by the analyst.

Soil and Spoil Material--Samples of natural soils were collected for chemical analyses from three profiles (fig. 1) on the broad plain north of Ober Creek. Three samples of spoil material were collected from each of the two spoil areas (area 1 and area 2, fig. 1). In addition, the coal-trench exposure was examined and a single composite sample of each of the various materials exposed was collected. From the top of the exposure down to the lower-most and thickest coal seam, samples of glacial till, stream-deposited sand and gravel, Teritary overburden, interburden between two thin coal seams, and interburden between the lower thin coal seam and the thickest coal seam were collected.

Samples of each material (2- to 3-kilograms) were placed into paper bags and mailed to the Denver Laboratories of the U.S. Geological Survey. The samples were dried under forced air at ambient temperature. The dried samples were disaggregated in a motor-driven ceramic mortar and pestle, and the portion passing a 2-mm stainless-steel sieve was saved. The less-than-2-mm material was used for all chemical determinations. Water-soluble constituents, pH, and hot-water-soluble B were determined by standard methods with slight modifications as detailed in Crock and Severson (1980).

"Available" trace metals were determined by extracting the samples with ammonium bicarbonate-DTPA (diethylene-triamine-pentaacetic-acid) following the method of Soltanpour and Schwab (1977). The solution extracts were then aspirated directly into the ICP-OES.

RESULTS AND DISCUSSION

The following information is provided so that meaningful management practices can be formulated based on a knowledge of soil, spoil, overburden, and plant chemical characteristics.

Soil Materials--Results of chemical analyses are given in Table 1 ("available" trace metals), Table 2 (exchangeable cations), and Table 3 (water soluble constituents). Table 4 provides data on available trace metals and pH of spoil and natural soil from the Usibelli coal mine (see Severson and Gough, 1981, for study details).

The following generalizations were made from the ICP-OES analytical data in Tables 1 and 4.

(1) Glacial till and outwash sand generally possess smaller extractable trace element levels than overburden, interburden, or natural soils. We do not, however, have sufficient data to assess whether the smaller amounts in the till and sand represent a potential deficiency condition for plants growing on them or that the larger amounts in overburden, interburden, and natural soils represent a potential toxicity condition.

(2) The relatively high levels of Fe and Mn measured in natural soil means that these soils are water saturated and represent a reduced rather than an oxidized condition. Generally, if these soils are disturbed by mining so that the frozen ground condition is eliminated and soil drainage is improved, much of the Fe and Mn, and probably other trace metals, will become less

Table 1. DTPA-extractable metals in samples of soil, spoil, and overburden collected from the Jarvis Creek preference lease area in mid-August, 1981. Data are in parts per million in sample. Sample descriptions are included in the text and figures.

Sample	Cd	Co	Cu	Fe	Mn	Ni	Pb	Zn
Natural Soil								
Soil-1, O1 horizon	0.3	2.5	6	1000	33	5	2	7
Soil-1, Cg horizon	.2	1.6	14	1200	12	6	4	5
Soil-2, O1 horizon	<.2	5.7	3	860	170	4	1	5
Soil-2, Cg horizon	.4	1.9	14	730	28	5	3	7
Soil-3, O1 horizon	.4	.6	5	330	150	4	2	9
Soil-3, Cg horizon	.3	.7	15	510	19	5	3	4
Spoil Material								
Gravelly spoil-1	.4	<.5	13	380	8	5	2	5
Gravelly spoil-2	.3	<.5	13	600	10	4	2	5
Gravelly spoil-3	.4	.5	15	550	16	5	2	6
Clayey spoil-1	.3	<.5	15	430	10	6	3	13
Clayey spoil-2	.4	<.5	21	380	9	6	4	17
Clayey spoil-3	.3	<.5	13	320	42	5	3	13
Coal Trench Exposure								
Glacial till	<.2	<.5	6	67	4	1	4	1
Outwash sand	<.2	<.5	2	37	1	<1	<1	1
Overburden	.8	.6	27	68	6	7	6	24
Interburden-1	1.0	1.0	38	130	7	15	8	37
Interburden-2	.2	.9	15	300	7	3	5	19

Table 2. Cation exchange capacity (C.E.C.) and exchangeable cations measured on samples of soil, spoil, and overburden collected from the Jarvis Creek preference lease area in mid-August, 1981. Data are in milliequivalents per 100 grams of sample (me/100 g). Sample descriptions are included in the text and figures.

Sample	C.E.C.	Ca	Mg	K	Na
Natural Soil					
Soil-1, 01 horizon	34	2.7	1.3	0.3	<0.1
Soil-2, Cg horizon	20	1.4	.9	<.1	<.1
Soil-2, 01 horizon	29	2.1	.9	.2	<.1
Soil-2, Cg horizon	14	1.0	1.0	<.1	<.1
Soil-3, 01 horizon	14	2.3	1.4	.4	<.1
Soil-3, Cg horizon	10	1.3	.8	<.1	<.1
Spoil Material					
Gravelly spoil-1	16	7.0	2.4	.1	<.1
Gravelly spoil-2	14	4.0	1.4	<.1	<.1
Gravelly spoil-3	13	3.3	1.4	.1	<.1
Clayey spoil-1	28	17	4.0	.2	<.1
Clayey spoil-2	23	12	3.4	.2	<.1
Clayey spoil-3	30	18	4.5	.2	<.1
Coal Trench Exposure					
Glacial till	10	3.3	.6	.1	<.1
Outwash sand	2.5	2.5	.8	<.1	<.1
Overburden	20	14	4.6	.3	.3
Interburden-1	22	11	2.8	.2	<.1
Interburden-2	20	17	4.0	.2	<.1

Table 3. Cations in, and specific conductance (S.C.) of water saturation extracts of samples of soil, spoil, and overburden collected from the Jarvis Creek preference lease area in mid-August, 1981. Data for cations are in millequivalents per liter (me/L), S.C. is in reciprocal milliohms per centimeter (mmhos/cm), and the saturation index (S.I.) is the amount of water necessary to bring the soil to saturation. S.I. is expressed as a percentage. pH was determined by selective-ion electrode on a 1:1 soil:water paste. Sample descriptions are included in the text and figures.

Sample	S.C.	S.I.	Ca	Mg	K	Na	pH
Natural Soil							
Soil-1, O1 horizon	<.2	173	<.1	.2	.2	<.1	4.8
Soil-1, Cg horizon	<.2	47.9	.7	.4	.2	<.1	5.0
Soil-2, O1 horizon	<.2	85.3	<.1	.1	.2	<.1	5.3
Soil-2, Cg horizon	.2	43.9	.3	.2	.2	<.1	5.4
Soil-3, O1 horizon	.2	64.6	.4	.4	.2	.2	5.0
Soil-3, Cg horizon	.1	37.9	.2	.2	.3	<.1	5.6
Spoil Material							
Gravelly spoil-1	.7	22.1	1.1	3.6	.8	<.1	5.8
Gravelly spoil-2	.2	25.0	.5	.4	.5	<.1	5.6
Gravelly spoil-3	.2	27.8	.5	.4	.6	<.1	5.7
Clayey spoil-1	1.5	43.5	11	4.6	.4	<.1	5.1
Clayey spoil-2	.9	44.0	5.7	2.6	.4	<.1	5.3
Clayey spoil-3	1.1	44.3	7.2	3.2	.5	.1	5.5
Coal Trench Exposure							
Glacial till	.2	26.6	.7	.2	.2	<.1	6.1
Outwash sand	1.3	21.1	9.3	4.1	.8	.1	6.3
Overburden	.8	59.8	3.4	1.7	1.9	.2	6.5
Interburden-1	.4	55.9	2.7	.9	.2	<.1	5.5
Interburden-2	3.0	41.3	26	10	.5	.1	4.4

Table 4. DTPA-extractable metals in, and pH of, C horizon samples of natural soil and rehabilitated mine-spoil soil collected from the Usibelli coal mine near Healy, Alaska, in June 1979. Data for DTPA-extractable metals are in parts per million (ppm), and for pH are in standard units.

Sample	Cd	Co	Cu	Fe	Mn	Ni	Pb	Zn	pH
Soil C horizon-1	.2	<0.5	4	580	6	2	3	2	5.1
Soil C horizon-2	<.2	<.5	1	270	2	<1	<1	2	5.0
Soil C horizon-3	<.2	<.5	1	410	3	<1	2	2	4.7
Spoil-1	.2	<.5	14	210	43	4	5	3	7.1
Spoil-2	<.2	<.5	12	210	25	2	3	2	6.9
Spoil-3	<.2	<.5	11	190	24	2	3	3	6.8

available due to changes in oxidation state. While trace metal levels in natural soils and gravelly spoil are not directly comparable, the lower trace metal content of the gravelly spoil may indicate a condition expected for well-drained and oxidizing soil conditions.

(3) The mixing of coal fragments and interburden with soil material exposed at the surface as plant growth media will probably result in higher available trace metal levels than if these materials were buried or isolated. Whether or not the high extractable Cd, Ni, and Pb levels in overburden and interburden are detrimental to plant growth is uncertain (a further discussion based on the plant element levels, is provided in the next section).

(4) Comparisons of trace metal levels in C horizons of natural soils with spoil from the Jarvis Creek area and the Usibelli mine are difficult to justify because the natural soils differ between the two areas (loess at Jarvis Creek and sandy materials at Usibelli). The spoil materials also differ between the areas as clay and gravel were sampled at Jarvis Creek and a silty material derived from mica schist was sampled at Usibelli). The data for the Usibelli soil and spoil are provided mainly as additional data for trace metals at natural and rehabilitated areas in Alaska.

Generalizations concerning exchangeable cations (Table 2) follow.

(1) Natural soils are moderate to high in cation exchange capacity but low in the plant nutrients Ca, Mg, and K.

(2) Spoil material, overburden, and interburden contain the highest exchangeable plant nutrient levels, while glacial till and outwash sand contain the lowest levels. Additions of lime and fertilizers to glacial till and outwash sand would be more practical than attempting to lower the high trace metal levels in overburden and interburden. The low cation exchange capacity of outwash sands can be modified by mixing it with glacial till and, perhaps, natural soils.

(3) Exchangeable sodium, commonly a problem in mined land rehabilitation in the conterminous western United States, is very low in all samples and is, therefore, of little or no concern.

Water soluble constituents (Table 4) are determined generally to evaluate potential problems of alkalinity or salinity. No such problem is evident from the data for any of the samples collected. Low pH values (less than 6.5) are commonly corrected by liming. Increasing soil pH to the 6.5 to 7.0 range usually results in increased availability of plant nutrients and decreased availability of trace metals. Hot-water-soluble B was determined on all samples but was consistently 0.3 parts per million or less. Plants with moderate to high B requirements may show deficiency symptoms at this B level in soils.

No laboratory determinations of soil physical properties were made. However, the more rapid natural revegetation of the gravelly spoil, as opposed to the clayey spoil, may be influenced more by soil physical properties than by soil chemical properties. We conclude this because: (1) except for Zn, similar levels of trace metals were measured for both types of spoil and, therefore, should not be a contributing factor; (2) clayey spoil contained more exchangeable and water soluble plant nutrients and, therefore, should be the better media for plant growth, and; (3) the pH of the clayey spoil was slightly more acid than the gravelly spoil; however, the slight difference apparently does not greatly affect metal or nutrient availability and plant uptake.

Plant material--The ICP-OES analytical results for the concentration of 22 elements (and ash yield) in the plant materials sampled are listed in Table 5. The concentrations were originally reported on an ash-weight basis; however, because most individuals interested in these data are more comfortable with concentrations based instead on dry-weight equivalents, the values we report were converted to a dry-weight base. This conversion explains the variable lower limits of analytical determination (LLD) that are reported in Table 5. The true LLD (determined on an ash-weight basis) can be calculated using the formula:

$$\underline{LLD}_{aw} = \frac{\underline{LLD}_{dw}}{(\underline{A} / 100)},$$

where $\underline{LLD}_{aw}$ is the LLD on an ash-weight basis, $\underline{LLD}_{dw}$ is the LLD on a dry-weight basis (Table 5), and $\underline{A}$ is the percent ash yield for the sample in question (column one, Table 5).

Several generalizations can be made from the data presented in Table 5:

(1) Because the pH of the native soils and spoils was generally below 6.0 (Table 3) trace metals such as Al, Cd, Cu, Fe, Mn, Ni, and Zn should be available for plant uptake. Compared to concentrations of these elements in similar native plants growing in near-neutral soils and spoils (Gough and Severson, 1981), the concentrations of Al, Cd, Mn, Ni, and Zn are greater in the Jarvis Creek samples whereas concentrations of Cu and Fe do not appear elevated.

(2) The concentrations of Cd in willow stems are unusually high and it appears that the samples collected on the spoil pile are slightly higher in Cd than the samples from the native site. Gough and others (1979) report that Cd concentrations in plant material of 3-5 ppm (dry weight) are indicative of potential phytotoxic conditions for some row crops. Certainly the Cd levels in willow at Jarvis Creek are high, but this may simply be a characteristic of willow and not of other plants. For example, the Cd levels in grass material growing on spoil were an order of magnitude less (<.27-.34 ppm). Further, samples of alder collected at the Usibelli mine on spoil had Cd levels that were even lower (.01-.05 ppm); whereas the willow at the Usibilli coal mine had levels similar to the willow at Jarvis Creek (Table 6).

Table 5. Concentrations of elements (dry-weight basis) in plant samples, Jarvis Creek preference lease area, Alaska

Sample	Ash %	Al ppm	B ppm	Ba ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe ppm	La ppm	Mg %
Willow stems from the native or undisturbed site												
AS1	1.5	38	9.6	109	.240	1.65	.32	.13	3.2	44	.105	.078
AS2	1.7	44	13.4	90	.323	3.23	.51	.14	2.2	58	.102	.102
AS3	2.2	66	15.8	218	.440	3.74	.99	.31	4.2	57	.176	.103
Willow stems from the upper gravelly spoil pile												
TS1	2.0	36	13.6	76	.420	4.20	.54	.12	2.4	28	<.100	.082
TS2	2.6	57	23.4	120	.520	6.24	.73	.16	5.5	62	.130	.127
TS3	2.2	37	19.6	119	.418	3.52	.62	<.11	3.5	55	<.110	.101
Grass from the upper gravelly spoil pile												
TC1	4.2	38	12.6	20	.126	.34	<.21	<.21	2.0	84	<.210	.035
TC2	5.2	47	16.1	52	.229	<.26	<.26	<.26	3.8	47	<.260	.104
TC3	5.9	89	14.2	36	.177	<.29	<.29	.35	2.8	65	<.295	.071
Grass from the lower clayey spoil pile												
SC1	5.3	1,060	22.3	30	.233	<.27	.32	1.91	6.4	392	.371	.138
SC2	11.8	1,652	22.4	63	.496	<.59	<.59	2.48	10.1	684	<.590	.224
SC3	10.7	1,712	30.0	51	.589	<.54	<.54	2.78	5.0	770	.535	.161

Sample	Mn ppm	Mo ppm	Na ppm	Ni ppm	P %	Pb ppm	Sr ppm	Ti ppm	V ppm	Zn ppm	Zr ppm
Willow stems from the native or undisturbed site											
AS1	210	<.075	105	1.95	.048	.30	18.0	<7.5	<.08	180	.30
AS2	170	<.085	34	3.40	.056	.51	23.8	<8.5	<.08	238	.34
AS3	130	<.110	176	3.52	.077	<.44	28.6	<11.0	<.11	220	.22
Willow stems from the upper gr.velly spoil pile											
TS1	148	<.100	<20	1.38	.084	<.40	22.0	<10.0	<.10	240	<.20
TS2	148	<.130	156	1.92	.109	.52	31.2	<13.0	<.13	312	.26
TS3	165	<.110	44	1.74	.103	<.44	28.6	<11.0	<.11	330	<.22
Grass from the upper gravelly spoil pile											
TC1	630	<.210	<42	.50	.084	<.84	3.7	<21.0	<.21	20	<.42
TC2	624	.468	104	1.66	.125	<1.04	9.4	<26.0	<.26	35	<.52
TC3	525	.649	<59	1.30	.124	<1.18	9.4	<29.5	<.29	35	<.59
Grass from the lower clayey spoil pile											
SC1	270	.795	<53	5.83	.170	2.12	12.2	53.0	2.49	41	1.06
SC2	496	.944	<118	2.83	.153	2.36	24.8	82.6	4.37	142	2.36
SC3	578	.856	<107	4.92	.150	<2.14	22.5	96.3	4.49	88	2.14

Table 6. Concentrations of elements (dry-weight basis) in plant samples, Usibelli coal mine, Alaska

Sample	Ash %	Al ppm	B ppm	Ba ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe ppm	La ppm	Mg %
Alder stems from the regraded spoil site												
S1AS	3.6	115	11.9	8.3	.65	.02	.11	.17	9.3	83	1.15	.18
S2AS	3.6	194	11.9	23.8	.58	.05	.07	.25	9.4	130	1.26	.17
S3AS	3.4	85	10.9	8.2	.54	.03	.07	.14	8.8	92	1.16	.16
Alder stems from the native or undisturbed site												
S1AN	3.3	241	13.9	16.8	.53	.03	.10	.19	7.3	115	1.12	.21
S2AN	3.0	129	9.6	20.7	.48	.03	.12	.13	5.7	81	.81	.16
S3AN	2.7	116	8.6	12.7	.43	.01	.05	.13	7.6	89	.73	.15
Willow stems from the regraded spoil site												
S1WS	4.5	198	10.8	6.8	.77	3.74	.18	.50	6.8	95	1.22	.18
S2WS	3.7	115	13.3	4.8	.55	2.59	.15	.15	6.7	74	1.33	.19
S3WS	3.5	95	11.1	8.8	.60	2.00	.24	.22	7.4	74	1.12	.14
Willow stems from the native or undisturbed site												
S1WN	3.1	121	13.3	7.8	.46	.12	.15	.19	3.7	84	.87	.22
S2WN	4.1	209	7.0	10.7	.57	3.94	.28	.24	6.2	115	<.82	.22
S3WN	3.4	323	10.5	7.8	.54	2.38	.27	.34	5.1	126	.34	.16

Sample	Mn ppm	Mo ppm	Na ppm	Ni ppm	P %	Pb ppm	Sr ppm	Ti ppm	V ppm	Zn ppm	Zr ppm
Alder stems from the regraded spoil site											
S1AS	137	.11	14	4.0	.21	.43	12.6	<3.3	<.07	67	.79
S2AS	576	.11	5	2.9	.22	.36	18.0	<3.3	.09	61	2.23
S3AS	218	.08	10	4.1	.22	.37	9.9	<3.2	<.07	63	.95
Alder stems from the native or undisturbed site											
S1AN	>660	.16	25	2.5	.17	.40	16.8	4.0	.10	54	2.90
S2AN	420	.07	14	2.2	.15	.21	12.9	<2.8	.10	46	1.44
S3AN	540	.16	19	2.2	.17	.30	8.9	<2.5	.08	38	2.00
Willow stems from the regraded spoil site											
S1WS	284	.09	18	3.9	.20	.41	18.0	<4.2	.09	173	1.26
S2WS	333	.11	15	4.4	.19	.29	13.7	<3.4	<.07	144	1.48
S3WS	315	.15	21	3.8	.17	.33	13.0	<3.3	.11	200	1.47
Willow stems from the native or undisturbed site											
S1WN	192	.15	14	3.4	.15	.34	10.9	<2.9	<.06	133	.90
S2WN	192	.15	14	3.4	.15	.34	18.9	3.9	.16	164	1.68
S3WN	303	.07	31	1.1	.15	.41	13.6	6.5	.22	180	1.46

(3) Because of similar valences, reactivities, and ionic radii, Zn and Cd commonly move together in lithologic, edaphic, and biologic systems. It is not unusual, therefore, to see that the high Cd levels in willow samples from both the Usibelli mine and the Jarvis Creek sites are paralleled by high levels of Zn. These high Zn levels are truely unusual for plant material. They are not, however, so high as to suspect phytotoxic soil conditions.

(4) The concentration of Al in the grass collected on the clayey spoil is high. Unlike Cd in willow, the high Al in the grass may be directly related to substrate differences and not to the element uptake characteristics of the plant. Table 5 shows that samples of grass from the clayey spoil contain 20-35 times more Al than similar samples from the gravelly spoil. A certain undefined proportion of this difference may be due to surface contamination which would effectively increase the concentration in the plant ash of Sr, Ti, V, and Zr as well as Al. These elements are indeed higher in the grass from the clayey spoil site than in the grass from the gravelly spoil site. High levels of plant Al can be indicative of potential Al-toxicity conditions and further work is needed to ascertain the degree to which the high Al levels are due to plant uptake or surface contamination.

(5) Table 6 lists concentrations of the same 22 elements found in Table 5 for samples of willow and alder stems collected at the Usibelli coal mine. This table is provided so that comparisons of the relative amounts of these elements in similar materials can be made. Geologically, the Usibelli and Jarvis Creek study sites are similar (Wahrhaftig and Hickcox, 1955); however, vegetationally, edaphically, and probably climatically they are different. The following list compares, in general, the concentration of these elements in willow stems between the Usibelli and Jarvis Creek sites: concentrations of elements that are similar between sites--B, Ca, Cd, Fe, Mn, Ni, Pb, Sr, Ti,

V, and Zn; concentrations of elements that are greater at Jarvis Creek--Ba, Co, and Na; concentrations of elements that are greater at the Usibelli mine--Al, Cu, La, Mg, Mo, P, and Zr.

References Cited

Crock, J. G., and Severson, R. C., 1980, Four reference soil and rock samples for measuring element availability in the western energy regions: U.S. Geological Survey Circular 841, 16 p.

Gough, L. P., and Severson, R. C., 1981, Element concentrations in rehabilitation species from thirteen coal-stripmines in five western states and Alaska: U.S. Geological Survey Open-File Rept. 81-182, 110 p.

Gough, L. P., Shacklette, H. T., and Case, A. A., 1979, Element concentrations toxic to plants, animals, and man: U.S. Geological Survey Bulletin 1466, 80 p.

Holmes, G. W., and Benninghoff W. S., 1957, Terrain study of the Army test area, Fort Greely, Alaska: U.S. Army Corps of Engineers Waterways Exp. Sta., Vicksburg, Miss., Vol. 1 (text), Contribution to Proj. 8-97-10-004, 287 p.

Hultén, E., 1974, Flora of Alaska and neighboring territories: Stanford, Stanford Univ. Press, 1008 p.

Murray, D. F., 1980, Threatened and endangered plants of Alaska: Forest Service and Bureau of Land Management joint publication (no number), 59 p.

Severson, R. C., and Gough, L. P., 1981, Chemical character of minesoils at one Alaskan and twelve western conterminous United States coal-stripmines: U.S. Geological Survey Open-File Report 81-243, 80 p.

Soltanpour, P. N., and Schwab, A. P., 1977, A new soil test for simultaneous extraction of macro- and micro-nutrients in alkaline soils: Communications in Soil Science and Plant Analysis, v. 8, no. 3, p. 195-207.

Thomson, J. W., 1979, Lichens of the Alaskan Arctic Slope: Toronto, Univ. of Toronto Press, 314 p.

Viereck, L. A., and Dyrness C. T., 1980, A preliminary classification system for vegetation of Alaska: Pacific Northwest Forest and Range Exp. Sta. Gen. Tech. Rept. PNW-106, 38 p.

Wahrhaftig, C. A., and Hickcox C. A., 1955, Geology and coal deposits, Jarvis Creek Coal Field, Alaska: U.S. Geological Survey Bulletin 989-G, p. 353-367.