# SOIL SURVEY

of the

# KETTLE RIVER VALLEY

in the

## BOUNDARY DISTRICT OF BRITISH COLUMBIA

**P. N. SPROUT and C. C. KELLEY**
**British Columbia Department of Agriculture**
**Kelowna, B.C.**

***Report No. 9***
***of the***
***British Columbia Soil Survey***

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## ACKNOWLEDGMENTS

The British Columbia Department of Agriculture surveyed the soils of the Kettle River valley. The Water Resources Division, Canada Department of Northern Affairs and National Resources, provided financial assistance. The Provincial Department of Lands, Forests and Water Resources supplied base maps and aerial photographs. The Research Branch, Canada Department of Agriculture, Ottawa, prepared the soil maps for printing and published the maps and report.

The writers wish to acknowledge the contributions of the following surveyors, who assisted in classifying the soils: A. L. van Ryswyk, W. D. Holland, A. B. Dawson, C. H. Brownlee, and M. Schaedle. Dr. J. E. Armstrong and the late Dr. W. E. Cockfield, Geological Survey of Canada, Vancouver, and H. Nasmith, Provincial Department of Mines, Victoria, gave advice on the surface geology of the area. A. McLean, Ecologist, Canada Range Experiment Station, Kamloops, prepared the section on native vegetation. Dr. C. A. Rowles, Professor of Soil Science, University of British Columbia, Vancouver, J. F. Carmichael, District Agriculturist, Grand Forks, and other officers of the university, and the British Columbia and Canada departments of agriculture, gave advisory assistance.

Dr. J. Baker, Soil Survey Branch, Department of Agriculture, Kelowna, supervised the analyses of the soils and assisted in preparing the manuscript. Dr. A. Leahey, Associate Director (Soils), Branch Executive, Research Branch, Canada Department of Agriculture, Ottawa, gave advice on the classification of the soils in the field and suggested improvements in the manuscript.

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1964

Cat. No. A57-418

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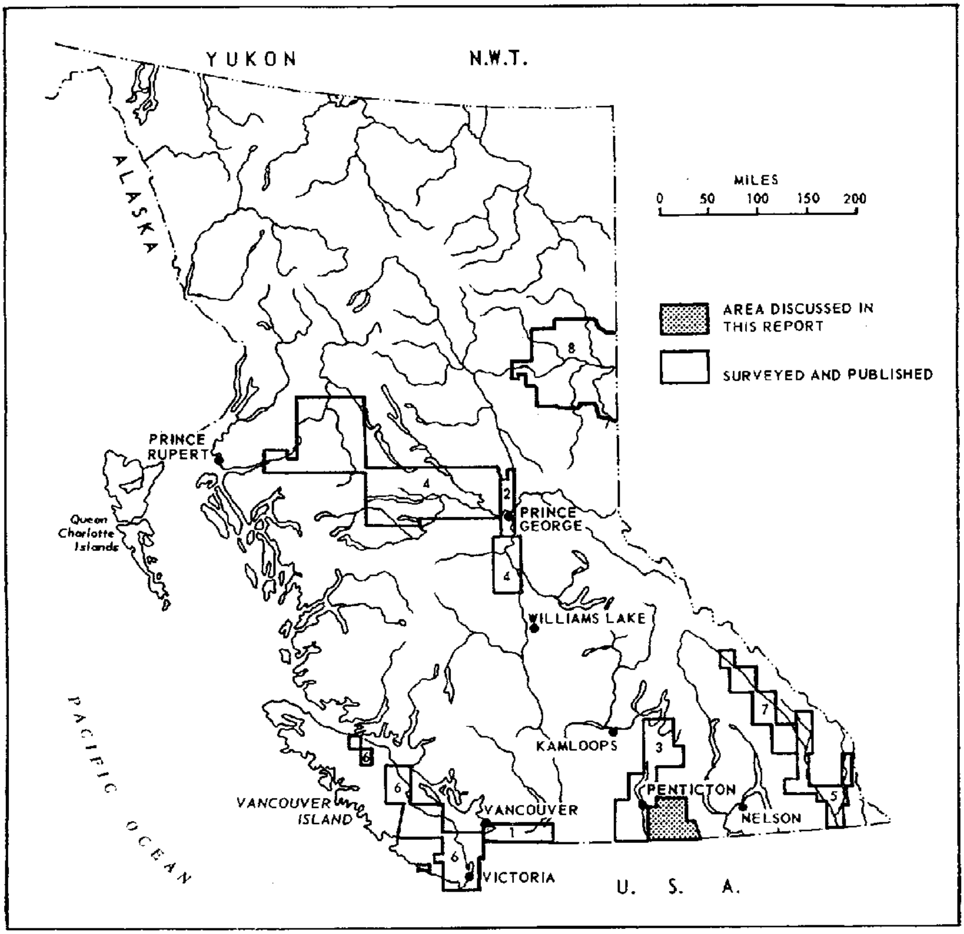


FIGURE 1. Areas of British Columbia in which the soils have been surveyed. 1, Lower Fraser Valley. 2, Prince George area. 3, Okanagan and Similkameen valleys. 4, Quesnel, Nechako, François Lake, and Bulkley-Terrace areas. 5, Upper Kootenay and Elk River valleys. 6, Southeast Vancouver Island and Gulf Islands. 7, Upper Columbia River valley. 8, Peace-River area.

# INTRODUCTION

This report and the accompanying map present information gathered during a reconnaissance soil survey of the Kettle River and tributary valleys. The primary purpose of the survey was to ascertain the irrigation water requirements and the acreage of arable land in the watershed of the Kettle River and its tributaries for the International Columbia River Engineering Board. The area has a low summer rainfall and, except for a small acreage of soils with a high water table, all the arable soils require irrigation for maximum crop yields.

The report begins with a general description of the area, including brief accounts of its history, population, services, agriculture, climate, native vegetation, physiography, drainage, and surface geology. The main part consists of descriptions of the soils. The distribution and area of each soil are given, and its use for agriculture or other purposes is discussed. Special features such as the need for drainage and hazard of erosion are included. The soils are rated on suitability for irrigation on the basis of texture, topography, stoniness, drainage, erosion, alkalinity, and salinity. The natural fertility of the soil is discussed briefly in a section on laboratory studies.

Although compiled mainly for agricultural purposes, the report and map contain information useful to those interested in land use, land assessment, highway construction, forestry, grazing, wildlife conservation, and recreation.

The soil map that accompanies the report consists of three sheets on a scale of one inch to one mile. The various soils are shown by colors and symbols, which are explained in the map legends. The maps also show the locations of lots, towns, highways, railways, and rivers, but do not include farm buildings, cleared land, or irrigation works.

## GENERAL DESCRIPTION OF THE AREA

### Location and Extent

The surveyed area lies in the south-central portion of British Columbia. The international boundary, latitude 49°N., is the southern boundary. From east to west it extends from the base of the Rossland Range of the Monashee Mountains near Cascade to the eastern rim of the Okanagan Valley, a distance of 55 miles. It extends northward in the valleys of the Kettle and Westkettle rivers to latitude 49° 44′ N., and in the Granby Valley to latitude 49° 28′ N. The area surveyed occupies 139,119 acres.

### History and Development

Many of the important early events in the surveyed area are associated with mining. Placer gold was found in Rock Creek near its junction with the Kettle River in 1858. Within a year about 500 miners were at work. In 1860 W. G. Cox was sent to Rock Creek to establish a customs post and to act as gold commissioner, and in the same year J. C. Haynes became his assistant. By 1861 there was a decline in mining operations (1). In 1862, sections of the bed of Boundary Creek were worked for placer gold; however, prospectors were then abandoning the Boundary District for either the Cariboo or the Salmon River in Oregon.

The first claims in bedrock were staked northeast of Camp McKinney in 1884. These were the Victoria and Washington, later renamed the Old England claims. Thereafter the Rocky Bar was staked on Boundary Creek near the falls in 1885, the Bruce on Ingram Mount in 1886, the Big Copper as Bluebird in 1887, and the King Solomon in 1888 (2).

In 1890 the discovery of gold-copper ore at Rossland stimulated prospecting throughout the Boundary District. By 1891 the Mother Lode, Sunset, Crown Silver, and Providence claims were staked near Greenwood. In 1891, in the Phoenix area, the Old Ironsides and Knob Hill claims were staked. Camp McKinney, about six miles north of Bridesville, was the site of a major lode-gold strike. Between 1894 and 1903 over a million dollars in gold was taken from the Cariboo-Amelia mine, and some gold was also obtained from neighboring properties (3).

The important ore bodies near Beaverdell were staked in 1896 and 1897. Although small amounts of silver-lead-zinc ore were shipped out for refining, it was not until the Kettle Valley Railway was built in 1912 that intensive development could be undertaken. Since that time the Beaverdell Camp has produced continuously (4).

### Towns, Population, and Industries

Midway, originally called Eholt's after the preemptor, was so named because it is about midway between the Rocky Mountains and the Pacific Ocean. The townsite was acquired in 1892 by a Montreal group. By 1899 Midway had a court house, a mining recorder, a registrar of vital statistics, a coroner, and a constable, as well as its own newspaper, the *Midway Advance*. In 1899 the town became important as the terminal of the Columbia and Western Railway. In 1905 the Vancouver, Victoria and Eastern Railway, a branch of the Great Northern, was built into Midway from Ferry, Washington (5). By 1914, Midway's population was about 300; however, it decreased on the closing of the mines and smelters. It is now an unincorporated village, consisting of a few homes and stores, a customs station at the border, a primary school, service stations, and an emergency airport.

Greenwood, beginning with a few prospectors' cabins, was established about 1893. Robert Wood obtained the site in 1895, and the town, which included some 640 acres, was incorporated in 1897. The population fluctuated from 1,359 in 1901 to 363 in 1941. In 1942 about 1,200 Japanese were established at Greenwood, and those remaining made up a large portion of the 1961 population of 932. The town has a domestic water supply, an elementary and a high school, a public library, a hotel, and several motels. Lumbering is the chief industry.

Phoenix was called both Phoenix and Greenwood Camp from 1895 to 1898, when a post office was established (6). In 1899 Phoenix became the terminal of the Columbia and Western Railway spur line from Eholt junction. Later it also became the terminal of the Great Northern Railway branch line from Granby. It was incorporated in 1900, with an area of 141 acres. The population was 866 in 1901, 662 in 1911, and 1,750 in 1914. Phoenix became a ghost town after the mines and smelters were abandoned in 1919.

Grand Forks, originally called Grand Prairie, was incorporated in 1897, with an area of 1,726 acres. It obtained a water right for a domestic supply in 1900. The population was 1,012 in 1901, and about 3,000 by 1914. The decline of mining and smelting depleted the population to 1,469 in 1921 and 1,298 in 1931. By 1961 it had grown again to 2,347. The town has a court house to serve the district, elementary and high schools, a hospital, a library, seven hotels, and 11 motels.

Cascade boomed in 1896 in anticipation of its becoming an important center after the Columbia and Western Railway line was built. By 1899 it had a population of about 1,500, but in the same year most of the town was destroyed by fire. Before the fire there were 14 hotels with bars, eight livery stables, a variety of stores, a hospital, and a newspaper. Because of a second fire in 1901 and an unstable economy, the town was abandoned, and today there is little indication that it ever existed.

A two-stamp mill, erected in 1892 at Boundary Falls to reduce quartz ore from the Boundary Falls and American Boy claims, was the first industry established in the surveyed area. In 1899 the Granby Consolidated Mining, Smelting and Power Co., formed by amalgamation of several operating companies at Phoenix, built the Granby Smelter at Grand Forks. The plant had a sampler capacity of 2,000 tons per day, four furnaces with daily capacities of 380 tons, and two converters. The matte from the Greenwood smelters and that from the Hall Mines Smelter at Nelson were converted to blister copper at Grand Forks.

Smelter Lake, which occupied 670 acres, was formed by damming the Granby River in a narrow channel 2½ miles from its junction with the Kettle River. This lake provided the smelter with a water supply, and was used as storage for a small power plant. From the dam, water was conveyed downstream 1½ miles by flume to a plant of four 180-kilowatt generators, designed to develop 1,080 horsepower. However, at minimum river flow the plant developed only about 450 horsepower. One of the generators was owned by the City of Grand Forks, and three served the Granby Smelter. The power plant was dismantled along with the smelter in 1919.

In 1900 a hydroelectric power plant was built at Cascade Falls on the Kettle River by an English syndicate. The plant, known as the Cascade Water, Light and Power Co., Ltd., operated until 1920. Water from a rock-filled crib dam was supplied through a steel pipe seven feet in diameter to three 750-kilowat units. However, at minimum flow the river supplied enough water to operate only one unit. A power line was built westward to supply the Phoenix, Greenwood, and Boundary Falls mining and smelting industry.

About 1900 the British Columbia Copper Co., Ltd., with mines at Deadwood Camp and Phoenix, built the Greenwood Smelter and the Standard Pyritic Smelting Co. plant at Boundary Falls. The Boundary Falls plant was later taken over by the Montreal-Boston Copper Co. The Greenwood Smelter had ore bins, sample mills, and two 2,300-ton furnaces. The pyritic smelter, which never operated as such, had a sampler and one large furnace.

From the start of mining and smelting operations in 1900, the volume of ore increased annually and reached a peak in 1913, when 1,250,000 tons were treated by the Greenwood, Boundary Falls, and Granby smelters. During the First World War the Boundary District was the most important copper-producing area in the British Empire. In the total period of operation the Phoenix and Deadwood camps supplied about 22 million tons of ore, which contained about 1½ percent copper. Gold and silver extracted from the copper had an average value of 75 cents per ton of ore. By 1919 the high-grade ore was nearing exhaustion, and this in conjunction with a labor strike in the Crowsnest coalfield, which cut off the supply of coke, led to the abandonment of the mines and smelters. From 1920 to 1958, mining in the Greenwood-Phoenix area consisted only of desultory development work, which in time may bring renewal of large-scale production.

The West Kootenay Power and Light Co., Ltd., began construction of two hydroelectric units at Bonnington Falls on the Kootenay River in 1897, when the company was incorporated. This company also built a power line to supply Rossland and the smelter at Trail, which had started operations in 1896. In 1901 a new dam and two additional units, each of 8,000 horsepower, were built on the Kootenay River. In 1907 the company took over the Cascade Water, Light and Power Co. At that time a power line was extended from Rossland to Cascade, to connect with the existing line from Cascade to Boundary Falls. Since 1919, when the Granby power plant was closed, the West Kootenay Power and Light Co. has been the only distributor of electricity in the Boundary District.

The population of the Boundary District decreased on the closing of the mines and smelters, but gradually increased again as new activities developed. Today the population is greater than it was during the time of mining activity, the total in 1961 being 8,111. In the same year 1,916 pupils were served by the elementary and high schools.

The British Columbia Telephone Co., Ltd., maintains a line along Highway No. 3, connecting all points east and west. The Canadian Pacific Railway has a telegraph service along the railway line. The Forest Service during the fire season operates a radiotelephone as a means of communication with lookout and ranger personnel. In outlying areas, this radiotelephone is used in emergencies.

## Transportation

Early prospectors and settlers entered the Boundary District by trail from Fort Colville, Washington. There was little east-west traffic north of the border until the Dewdney Trail was completed in 1865. After the Dewdney Trail came into use, horse-drawn stages served the area until the railways were built (7).

Several years before the turn of the century, various companies undertook the construction of railways at about the same time. In 1897 and 1898 the Crowsnest Pass Railway Company laid a line from Fort McLeod, Alberta, to Kootenay Landing, British Columbia, which connected with Nelson by a ferry and car barges on Kootenay Lake. About the same time the Columbia and Kootenay Railway was completed between Nelson and Robson, both lines being under the control of the C.P.R.

In 1894, F. A. Heintz secured part of the Trail townsite and also a site on which he built a smelter (8). In 1895 Heintz obtained a charter for construction of the Columbia and Western Railway from Robson to Trail, which he completed in 1897. In 1897 he sold the smelter, then called Canadian Smelting Works, and the Columbia and Western Railway, to the C.P.R. The transaction included the Trail-Rossland Railway, which Heintz built in 1895, and a charter to build a line from Robson to Midway, with a spur line from Eholt to Phoenix. This line was completed by the C.P.R. in 1899.

To participate in the prosperity of the area, the Great Northern Railway Company built a line in 1905 across the border at Laurier to Grand Forks, and from the Granby smelter there to Phoenix. In the same year this company constructed the Vancouver, Victoria, and Eastern Railway from Ferry, Washington, to Midway. From Midway the rail line was built westward to Molson, where it recrossed the border to Oroville. After the decline in mining and smelting activity, the Great Northern abandoned the tracks between Grand Forks and Phoenix, and between Ferry, Midway, and Oroville.

In 1910 the C.P.R. obtained a charter to build the Kettle Valley Railway from Midway to Hope, and a spur 30 miles up the Granby Valley between Grand Forks and Kennedy Creek. The railway from Midway to Hope was completed in 1915. The spurs in the Granby Valley and from Eholt to Phoenix were later abandoned.

The present name of the line from Hope to McLeod, Alberta, is the Kettle Valley Railway. The increase of air traffic during the past few years caused the C.P.R. to seek abandonment of passenger service in 1963. Freight train facilities are available to the surveyed area, and in addition there is a daily east and west bus and trucking service on Highway No. 3. This highway is paved. There are border crossings and customs offices at Midway, Carson, and Laurier.

In the Granby Valley, a gravelled road extends about 25 miles northward from Highway No. 3 and then it branches into logging roads. The road from Rock Creek to Westbridge is paved, but from Westbridge gravelled roads extend upstream in the Westkettle and Kettle River valleys. In the Westkettle Valley the road serves Beaverdell and Carmi, and ends in the Okanagan Valley at Kelowna. The Kettle Valley road is passable to Damfino Creek and north to Highway No. 6. In addition to public roads, an extensive network of logging roads, old and new, may be safely used during the summer.

## Agriculture

The importance of adequate water supplies was appreciated by the first white settlers of the Boundary District. They obtained property close to rivers and creeks. Authority to have a legal right to water was made possible by the Gold Fields Act of 1859, enacted a year after the Colony of British Columbia was formed. Any person desiring to protect a right to use water was required to register a claim with the nearest gold commissioner. The Water Act of 1909 not only provided for the establishment of a chief water commissioner, later known as the Comptroller of Water Rights, but also a board of investigation to study and decide the priorities of early claims.

On March 7, 1875, James McConnel, who lived near Rock Creek, was the first settler to establish a water right. Later, on August 13, 1883, he registered another claim to use water from Morrisey (McConnel) Creek, for irrigation of Lot 153, near Grand Forks (9).

W. H. Covert entered the Boundary District in 1885 from Fort Colville, Washington. He was the first to plant fruit trees in the Grand Forks area, on Lot 497. On October 18, 1887, Covert obtained a right to use water for irrigation from Fourth of July Creek.

In 1888 three more settlers obtained water rights in various parts of the Kettle River valley. These were Thomas Johnson, on Christina Creek near Cascade; partners Hardy and Casey, on Spring Gulch Creek near Grand Forks; and James Tallyard, on a water source near Rock Creek. On November 9, 1889, the Hardy Brothers established water rights on Hardy Creek for irrigation of Lots 333 and 334. They operated the first nursery in the valley, the Grand Forks Fruit and Nursery Co., Ltd. A number of water rights were recorded each subsequent year.

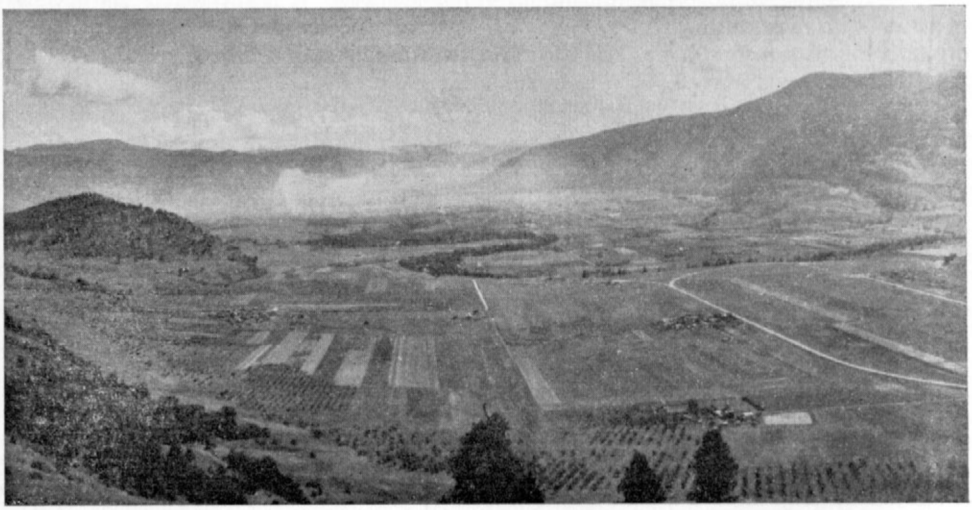

FIGURE 2. The Kettle Valley, looking toward Grand Forks. Groups of buildings originally were Doukhobor communal villages. Abandoned orchards in the foreground. In the center the Kettle River channel, fringed by trees.

Demand for horses, mules, and meat animals by the gold mining camps started a movement of livestock from the United States. The first herd crossed the border at Osoyoos (Sooyoos) in 1858. From the opening of the customs port of Osoyoos in November, 1861, to July, 1864, some 7,720 cattle, 5,378 horses, 1,371 sheep, and 948 mules passed through customs, chiefly for use in the Fraser Valley and Cariboo gold fields. J. C. Haynes, Customs Officer, and W. H. Howe, Chief Constable, undertook cattle ranching in 1866, obtaining cripples and other stock from the drovers. When Haynes died in 1888, Haynes and Howe had acquired some 3,000 head of cattle and 21,000 acres of land in the Osoyoos–Anarchist Mountain area.

Settlement of the Black soils of the Anarchist Mountain area dates from the placer mining boom at Rock Creek. By 1892 there were about 20,000 head of cattle on the ranges of the Similkameen, Osoyoos, and Boundary areas (10).

In 1899 the Christian Community of Universal Brotherhood obtained a water right on Hardy Creek near Grand Forks to irrigate 92 acres. This was the beginning of the Doukhobor influx, which, however, did not attain large proportions until 1908. After this date the greater part of their activities were organized on a communal basis. The unit of settlement became a village composed of two large community houses for each 100 acres. These were surrounded by additional dwellings and farm buildings (Figure 2). Activities in all types of agriculture and construction were undertaken and maintained by the community as a whole. This system flourished during the lifetime of Peter Verigin, but it became disorganized after he died in 1924.

Originally, the Doukhobors separated themselves from their neighbors by distinctions of religion, dress, food, and social life. They sought land and freedom on their own terms. Their agriculture was devised chiefly to provide their basic needs, but also to produce volume sales. The breakdown of the communal organization destroyed their means of producing, processing, and marketing agricultural commodities in large quantities. Off-farm employment took precedence over farming. Today few full-time communal farmers are left, but many still derive benefit from their fields and gardens. The orchards were abandoned and the irrigation systems allowed to deteriorate. Although most of the community houses have survived, living arrangements are on an individual family basis. The present Doukhobor population in the Boundary District is about 3,500 (11).

The first attempt at large-scale irrigation in the area was made by the Kettle Valley Irrigation Fruitlands Co., Ltd., an English organization capitalized at $1,000,000. The company obtained about 2,000 acres between Ingram Bridge and Rock Creek, on the south side of the Kettle River. Water rights on Rock Creek, for 1,000 miner's inches of water for irrigation of Lots 215, 2455, 513, and 514, were obtained on August 1, 1906. Water was diverted by means of a dam about half a mile from the confluence of Rock Creek and the Kettle River. The water was distributed to the land by means of flumes, ditches, and pipes.

The land was subdivided into lots of about nine acres, one to several lots being distributed to a family. The settlers, retired British army personnel, were inexperienced in agriculture. The orchards grew poorly because of the severe climate and an inadequate water supply. The unfavorable conditions for tree fruit production and enlistment to serve in the First World War started a decline that led to abandonment of the project. In 1927 only seven settlers remained, and they had 123 acres under irrigation. Today little evidence remains to indicate that this settlement ever existed.

In 1963 the land under irrigation in the surveyed area was as follows (9):

| *Locality* | *Irrigated Acreage* |
|---|---|
| North of Rock Creek | 560 |
| Rock Creek | 400 |
| Kettle Valley Station | 510 |
| Midway | 370 |
| Greenwood | 620 |
| Granby River | 475 |
| Grand Forks | 1,000 |
| Cascade | 130 |
| Grand Forks Irrigation District | 2,387 |
| Covert Irrigation District | 288 |
| Total | 6,740 |

About 4,065 acres are irrigated (Figure 3) either by small individual systems that divert water from creeks or by small pumping plants along the Kettle River. The two irrigation districts in the surveyed area are corporate bodies under the Water Act.

The Grand Forks Irrigation District, incorporated in 1921, obtains about 10 percent of its water by gravity from Morrisey Creek during the freshet stage and the balance is pumped through a 30-foot lift from the Kettle River. The water for distribution is not supplied under pressure to the individual user, although he may obtain this if desired by pumping from the main system. Delivery to cultivated land for an irrigation season is about 30 acre-inches.

FIGURE 3. Irrigated wheat on McCoy gravelly sandy loam near Midway.

The Covert Irrigation District, incorporated in 1946, was formerly the Covert Estate Irrigation System. The original water right of 1887 on Fourth of July Creek, now July Creek, was confirmed on June 12, 1896. This irrigation district has no storage reservoir. Water is diverted from the creek and distributed in pipes. In 1962 the irrigation works were rebuilt.

The important crops grown under irrigation are potatoes, vegetables, vegetable seeds, tree fruits, small fruits, alfalfa, legume seeds, flower seeds, mixed hay, and pasture. Some 500 to 600 acres per year are used to grow potatoes, the main commercial crop. Certified seed potatoes are grown on about two-thirds of this acreage. At the time of the survey (1957), about 38 acres were used for growing market vegetables such as asparagus, beets, carrots, and onions. Vegetables grown for seed were onions, carrots, parsnips, beets, lettuce, broad beans, bush beans, peas, and tomatoes. Because of reduced competition from abroad during the Second World War, the acreage used for vegetable seed production increased from about 87 in 1940 to 997 in 1945. Competition returned after the war, and the acreage decreased to about 25 in 1962.

Before 1930, tree-fruit plantations were extensive in the Grand Forks area. Thereafter a combination of the breakdown of the Doukhobor communal system, the depression of the 1930s, winterkilling of trees and inadequate irrigation led to the abandonment of many orchards. The neglected orchards remained standing and thus became sources of insect pests to productive orchards. Although a few orchards were still producing apples in 1963, the trend is towards abandonment of commercial tree fruits.

Considerable dry farming (Figure 4) is carried out on the highland areas west of Grand Forks. The present trend of favoring alfalfa and hay production over that of grain helps to control erosion. The 1961 census listed a total of

2,589 acres in grain: 974 of wheat, 649 of barley, 445 of oats, 292 of rye, and 226 of mixed grains. Cultivated hay and other forage crops were grown on 10,466 acres. The total area in grain and hay was 13,055 acres.

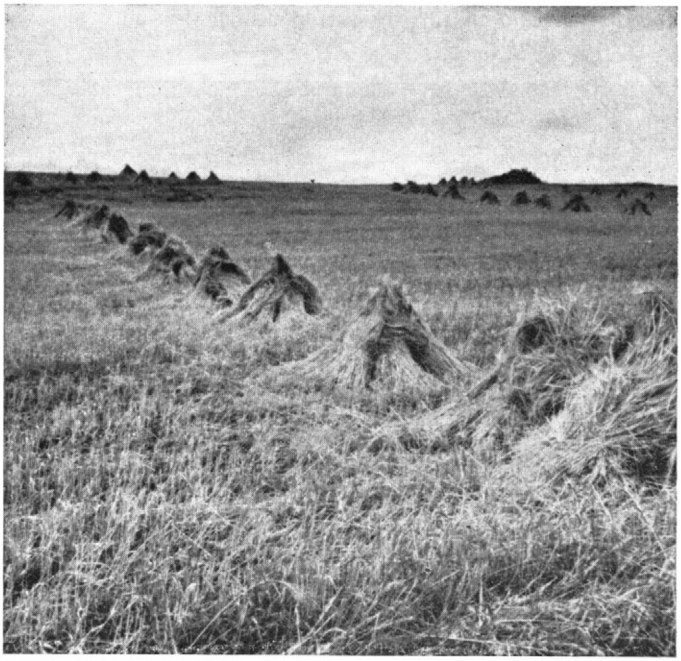

FIGURE 4. Barley on dry-farmed Stevens loam.

Dry farming in this area is undertaken to provide winter feed for livestock. Generally, the numbers of livestock supported between Grand Forks and Bridesville are limited by the amount of winter feed produced. From 1945 to 1957 the annual average of cattle marketed was 2,150 head. Marketing increased thereafter, bringing the 1945 to 1961 average to 2,476 head. The yearly shipments of cattle and hides were as follows (12):

| *Year* | *Cattle shipped* | *Hides* | *Total* |
|---|---|---|---|
| 1945 | 1,969 | 717 | 2,686 |
| 1946 | 1,313 | 1,195 | 2,508 |
| 1947 | 803 | 1,001 | 1,804 |
| 1948 | 1,511 | 1,136 | 2,647 |
| 1949 | 1,569 | 1,008 | 2,577 |
| 1950 | 1,514 | 840 | 2,354 |
| 1951 | 1,104 | 595 | 1,699 |
| 1952 | 763 | 707 | 1,470 |
| 1953 | 972 | 854 | 1,826 |
| 1954 | 932 | 921 | 1,853 |
| 1955 | 1,306 | 833 | 2,139 |
| 1956 | 1,860 | 835 | 2,695 |
| 1957 | 1,180 | 509 | 1,689 |
| 1958 | 2,416 | 590 | 3,006 |
| 1959 | 2,819 | 487 | 3,306 |
| 1960 | 3,715 | 438 | 4,153 |
| 1961 | 3,386 | 297 | 3,683 |

Dairy cattle, which totaled 463 in 1961, are kept mainly on the irrigated land and low river bottoms. During the soil survey of the area (1954 to 1957) the number of sheep notably increased. In addition to cattle and sheep, swine, poultry, and horses were raised in varying numbers.

In 1961, of a total farm population of 1,063, 189 were owners of land and 47 were tenants or part owners. Occupied farm land in the surveyed area totaled 91,994 acres, of which 82,735 were owned by the occupants and 9,259 were rented.

## Climate

Onshore air movement from the Pacific Ocean dominates the weather. The precipitation in any area depends on its elevation in relation to local mountains and on exposure. Rain- and snow-fall is much heavier on the western slopes of the Coast and Selkirk mountains than on the eastern slopes. In the fairly dry interior the lower areas are somewhat drier than the nearby highlands.

In the Kettle River area, the annual precipitation is 21 inches at 3,200 feet and 14 inches at 1,640 feet, in the valley bottom. The lower areas are snow-covered from December to February, and the higher ones longer.

In winter, low-pressure systems cross the country from October to April, and cause cloud-cover and moderate precipitation for most of this period. These systems may come one after another with scarcely a clear day between, and may persist for weeks or even months. However, occasionally the pattern may be interrupted for a few days to a week or more when continental arctic air covers the region. Such interruptions generally begin with strong winds, which soon clear the atmosphere of clouds. When the cold front does not pass beyond the surveyed area, temperatures may approach zero. Occasionally, the cold front moves deep into the United States and the temperature drops considerably below zero. Temperatures rise rapidly in the spring and the weather generally is dry except in June, when rainfall is higher than in any other month. In summer the days are hot and the nights cool; July and August are the warmest and driest months.

### Temperature

In most of the area, temperatures vary inversely with elevations. Table 1 gives the average seasonal temperatures and elevations for five stations in the Kettle River valley, and for four in the Okanagan Valley. For a difference in

**Table 1.—Average Seasonal Temperatures at Stations in the Kettle and Okanagan Valleys**

| Station | Elevation Feet | Winter | Spring | Summer | Fall | Year |
|---|---|---|---|---|---|---|
| | | *Kettle Valley* | | | | |
| Carmi[1] | 4,084 | 20 | 38 | 57 | 40 | 39 |
| Greenwood | 2,490 | 22 | 44 | 61 | 43 | 43 |
| Rock Creek | 2,000 | 21 | 45 | 64 | 45 | 44 |
| Grand Forks | 1,746 | 23 | 47 | 65 | 45 | 45 |
| Laurier | 1,644 | 28 | 45 | 63 | 47 | 46 |
| | | *Okanagan Valley* | | | | |
| Vernon | 1,582 | 25 | 46 | 64 | 46 | 45 |
| Kelowna | 1,160 | 29 | 47 | 65 | 47 | 47 |
| Penticton | 1,121 | 30 | 48 | 65 | 47 | 48 |
| Oliver | 1,008 | 29 | 50 | 68 | 48 | 49 |

[1]*The meteorological station at Carmi is about 1,000 feet above the valley bottom.*

annual mean temperature of 10 degrees Fahrenheit the difference in elevation is 3,076 feet. This supports the finding that for each increase in elevation of 1,000 feet the annual mean temperature is 3.3 degrees lower (13). The monthly mean temperatures at the Kettle Valley stations are given in Appendix Table A.

Table 2 gives the temperature extremes and snowfall for seven widely scattered stations in the surveyed area. The highest temperature, 111° F, was recorded at Rock Creek in 1934 and the lowest —43° F, at the same station in 1924.

**Table 2.—Extreme Temperatures and Average Snowfall at Kettle Valley Stations**

| Station | No. of years | Temperature, °F | | Snowfall Inches |
|---|---|---|---|---|
| | | High | Low | |
| Carmi | 1941–62 | 97 | −31 | 110.8 |
| Beaverdell | 1915–39 | – | – | 67.7 |
| Greenwood | 1914–62 | 110 | −38 | 60.2 |
| Rock Creek | 1913–47 | 111 | −43 | 40.0 |
| Lynch Creek | 1915–48 | – | – | 60.5 |
| Grand Forks | 1912–62 | 109 | −38 | 48.6 |
| Laurier | 1910–54 | 97 | −20 | 38.3 |

Weather records are lacking for the upstream portion of the Kettle River valley from Westbridge to Rendell and Damfino creeks, between which the elevation increases some 513 feet. The estimated annual mean temperatures for these are 44 and 42 degrees respectively.

## The Growing Season

The growing season begins when the mean spring temperature exceeds 42° F, and ends when the mean autumn temperature falls below this value. The growing season for the Rock Creek area lasts 199 days, from about April 6 to about October 27, and for the Grand Forks area 205 days, from about April 1 to about October 23. The growing seasons for several Okanagan Valley points are: Kelowna, 204 days; Penticton, 218 days; Oliver, 225 days.

The dates of the last spring and the first fall frosts have a bearing on the type of agriculture that can be undertaken. The frequency of frosts and the places in which they occur depend mainly on latitude, altitude, air drainage, and cloud conditions. Because of the complexity of these factors, the frost-free period is irregular. In any locality, frost records over a period of years give an estimate of the frost-free season for use as a guide. These dates for stations in the surveyed area are shown in Appendix Table B.

## Precipitation

The precipitation pattern for the area is strongly influenced by the onshore movement of air from the Pacific coast. In winter the incoming low-pressure systems discharge most of their moisture as rain and snow on the western slopes of the Coast and Cascade mountains. East of these mountains they cause considerable cloud cover.

In summer there is less cloud and precipitation, except in June, and some variation occurs in several parts of the surveyed area, due to local influences. In the Carmi, Lynch Creek, Greenwood, and Grand Forks localities, precipitation increases with elevation. The Bridesville–Rock Creek–Midway region forms the northern fringe of a large natural grassland belt, most of which is in Washington. The low precipitation in this belt is due to its lee-side position in relation to local highlands. The Cascade–Laurier area, with elevation only about 1,650 feet, is bounded by the Rossland Range on the east. Storms moving down-valley are trapped in this area, and it receives more precipitation than areas at higher elevations. Figure 5 shows that all the stations have the same precipitation pattern regardless of volume. The average monthly precipitation records are given in Appendix Table C.

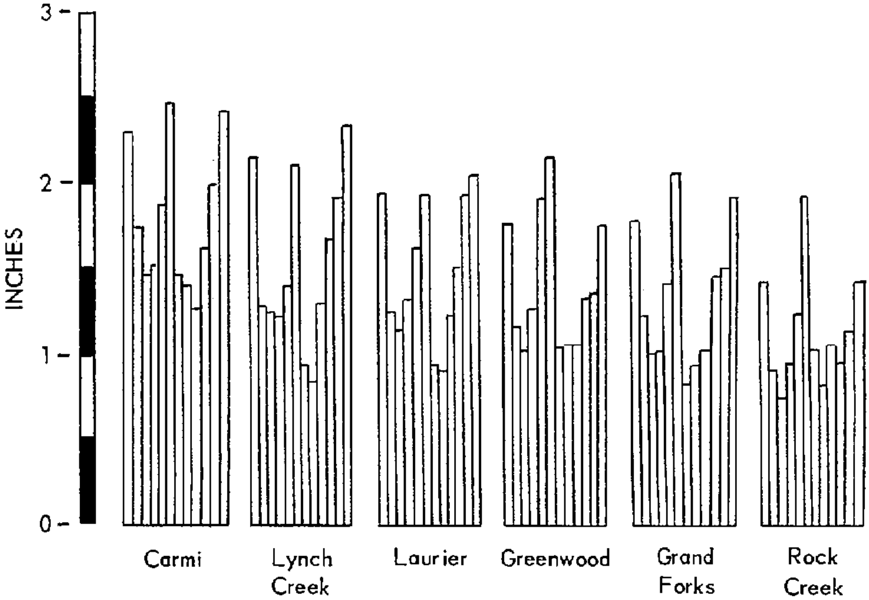


FIGURE 5. Precipitation pattern, January to December, for the Kettle River valley. Snowfall varies from place to place. A dry spring, peak rainfall in June, and a dry summer are common.

In the design of irrigation works, important features are the amount of water that should be stored, and the ability of the system to deliver enough water for the crop in the driest month. The amount to store is evaluated by the acreage to be irrigated and any extreme lack of rainfall in summer. For example, only 0.42 inches fell in June, July, and August in 1945 at Grand Forks. In some years, storage water may be saved when only one or two of the summer months are extremely dry.

The irrigation system must have enough capacity to supply the requirement of each soil type in the driest month, and this is based on the lowest figures on record. The extremes of rainfall and averages for Rock Creek and Grand Forks are shown in Table 3.

**Table 3.—High and Low Summer Rainfall at Rock Creek and Grand Forks in Inches**

| Month | Rock Creek[1] | | | Grand Forks[2] | | |
|---|---|---|---|---|---|---|
| | High | Low | Average | High | Low | Average |
| June | 4.71 | 0.46 | 1.95 | 4.61 | 0.07 | 2.03 |
| July | 4.53 | 0.00 | 1.07 | 2.70 | 0.03 | 0.74 |
| August | 3.58 | 0.00 | 0.83 | 3.37 | 0.00 | 0.94 |

[1]1913–47.
[2]1916–62.

## Cloud and Bright Sunshine

Though hours of sunshine are not recorded in the surveyed area, those for Oliver in the Okanagan Valley are similar to those in the southern part of the Boundary District. In the Okanagan Valley, winter skies are almost as sunless as those at the coast. The average monthly hours of sunshine at Oliver for 38 years are as follows:

| Month | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Jan.* | *Feb.* | *Mar.* | *Apr.* | *May* | *June* | *July* | *Aug.* | *Sept.* | *Oct.* | *Nov.* | *Dec.* | *Year* |
| *Hours* | | | | | | | | | | | | |
| 44 | 78 | 140 | 194 | 237 | 242 | 317 | 277 | 201 | 126 | 61 | 35 | 1,950 |

The total hours of sunshine for the river valleys in the southern part of the surveyed area are very likely within 50 to 100 hours of those in the Oliver area. The plateau, however, enjoys more hours of sunshine per year than the Oliver area. A fog ceiling occurs over the valleys in the early part of the day in spring and fall, and sometimes in winter. The plateau around Bridesville lies above this ceiling and thus has more sunshine.

## Native Vegetation[1]

Plant communities of the yellow pine, and Douglas fir zones are dominant in the surveyed area. The former is an open savannah with a ground cover of grassland species. The Douglas fir zone consists of an open to medium-dense forest with a good ground cover of herbaceous or shrubby species.

Grasslands occur on the southern plateau four or five miles west from Bridesville and extend eastward in the main east-west valley to Boundary Falls. Another section occurs in the valley near Grand Forks.

In the southwestern part of the surveyed area a yellow pine–wheatgrass–fescue community is common on south-facing slopes, on which the soils are mainly Brown Wooded and Black. Open stands of yellow pine (*Pinus ponderosa*) have a ground cover mainly of bluebunch wheatgrass (*Agropyron inerme*) and both rough and Idaho fescue (*Festuca scabrella* and *F. idahoensis*) under climax conditions. A wide variety of forbs such as silvery lupine (*Lupinus sericeus*), balsamroot (*Balsamorhiza sagittata*), sticky geranium (*Geranium viscossissimum*), eriogonum (*Eriogonum heracleoides*) and gromwell (*Lithospermum ruderale*) also characterizes the community. With heavy grazing, Junegrass (*Koeleria cristata*), Sandberg's bluegrass (*Poa secunda*), needle-and-thread grass (*Stipa comata*), pussytoes (*Antennaria umbrinella*), and cheatgrass (*Bromus tectorum*) increase at the expense of the wheatgrass and fescues. Wild rose (*Rosa*) and currant (*Ribes*) are the most important shrubs.

On level topography, Douglas fir (*Pseudotsuga menziesii*) is found in the yellow pine community. With increased moisture effectiveness on north- and east-facing slopes and at slightly higher altitudes, the Douglas fir–pinegrass community usually dominates. The soils here are largely of the Brown Wooded and Gray Forested groups. Douglas fir, yellow pine, larch (*Larix occidentalis*), and aspen (*Populus tremuloides*) all occur. Pinegrass (*Calamagrostis rubescens*) is the dominant ground-cover species, but species such as kinnikinnick (*Arctostaphylos uva-ursi*), heart-leaved arnica (*Arnica cordifolia*), and dwarf blue-

[1] Prepared by A. McLean, Ecologist, Research Station, Kamloops, B.C.

berry (*Vaccinium caespitosum*) are important. In good-sized openings in the forest canopy the cover reverts to grassland species such as silvery lupine, fescues, and sticky geranium. Yellow pine and silvery lupine are seldom found above 4,000 feet elevation, but lodgepole pine (*Pinus contorta* var. *latifolia*) and forest lupine (*Lupinus glacialis*) are found. Uniform, fire-induced stands of lodgepole pine are especially common on soils of coarse texture.

In depressions in the grasslands, clumps of aspen occur on Carbonated Rego Humic Gleysol soils. Associated shrubs are black birch (*Betula fontinalis*), red osier dogwood (*Cornus stolonifera*), and willows (*Salix*). The herbaceous cover consists of a mixture of cultivated and native grasses and forbs.

Near Bridesville the wheatgrass-fescue community grows on Black soils to higher altitudes than elsewhere in the surveyed area, generally without yellow pine, and extends north and east on south-facing slopes. The forest density increases in moist draws and at the higher elevations. Lodgepole pine reproduction dominates on shallow soils and Douglas fir and larch on the better sites after logging or burning. The principal associated species are forest lupine, pinegrass, kinnikinnick, false box (*Pachystima myrsinites*), and twinflower (*Linnaea borealis* var. *americana*). These plant communities are found on Brown Wooded and Gray Forested soils. In the southern plateau section, Gray Forested and Gray Wooded soils appear to support drier plant communities than their equivalents farther north in the north-south valleys.

Eastward to Rock Creek the yellow pine zone containing the wheatgrass–fescue community again becomes dominant on the rolling topography, Douglas fir coming in on the protected slopes and draws. On steep north-facing slopes near Rock Creek, a Douglas fir–yellow pine–ninebark community occurs. The distinguishing feature of this community is the presence of ninebark (*Physocarpus malvaceus*).

South of Westbridge in the Kettle River valley the Douglas fir zone begins at 2,200 feet on Brown Wooded and Gray Wooded soils. The cover is composed of medium-dense Douglas fir, with some yellow pine, lodgepole pine, and larch. The understory is chiefly pinegrass and kinnikinnick, twinflower, and wild rose, with relicts of grasslands such as Junegrass, gromwell, and Richardson's needle-grass (*Stipa richardsonii*) in the open spaces.

North of Westbridge, white spruce (*Picea glauca*) enters the forest, appearing first in wet spots and on heavier-textured terraces having Gray Wooded soils. It forms a Douglas fir–white spruce community at 2,300 feet. On the ground there is a fair moss cover and pinegrass, ricegrass (*Oryzopsis asperifolia*), twinflower, and kinnikinnick on the moist sites. On the drier slopes and coarser soils the Douglas fir-pinegrass community occurs.

On moderately well drained Brunisolic Gray Wooded soils in this vicinity, mature spruce and larch are common, with Douglas fir on the better drained knolls. Other characteristic species are white birch (*Betula papyrifera* var. *subcordata*), black birch, bracken (*Pteridium aquilinum* var. *pubescens*), aralia (*Aralia nudicaulis*), ricegrass, and pinegrass.

North of State Creek (about 30 miles north of Rock Creek) at 2,600 feet, white spruce is abundant on the flats and lower terraces, but considerable Douglas fir may be present. The undercover is characterized by heavy moss cover and the presence of species such as prince's pine (*Chimaphila umbellata*), false box, thimbleberry (*Rubus parviflorus*), fern leaf (*Pedicularis bracteosa*), queen's cup (*Clintonia uniflora*), forest lupine, pinegrass, and kinnikinnick.

Above Christian Valley on the mountainside at 4,200 feet, Engelmann spruce (*Picea engelmannii*), alpine fir (*Abies lasiocarpa*), and cedar (*Thuja plicata*) are commonly found, indicating the lower portion of the cedar zone. The main associated species are twinflower, false box, alpine blueberry (*Vaccinium scoparium*), prince's pine, and queen's cup.

In the southern section of the surveyed area, eastward from Rock Creek, the region dries fairly quickly. East of the Kettle Valley post office the wheatgrass–fescue community with scattered yellow pine becomes important on the lower terraces, which have Dark Brown soils. Most of these terraces have stands of needle-and-thread grass with some Junegrass, Sandberg's bluegrass, and pussytoes; as a result of cultivation or heavy grazing. On recently disturbed areas, sand dropseed (*Sporobolus cryptandrus*) is common. On north slopes and fans having degraded Brown Wooded soils, Douglas fir and larch may be associated with yellow pine. Above 3,000 feet on benches, especially near Midway, there are Black soils that have a cover composed largely of Kentucky bluegrass, Columbia needlegrass (*Stipa columbiana*), Richardson's needlegrass, and miscellaneous broad-leaved species such as wild strawberry (*Fragaria*), purple avens (*Geum triflorum*), kinnikinnick, and snowberry (*Symphoricarpos albus*).

Near Boundary Falls the grassland is confined to Black soils on dry, south-facing slopes. The grassland is replaced in the valley bottom by Brown Wooded and Gray Wooded soils with open forest cover. This area was affected in the past by smelters at Boundary Falls and Greenwood. Though aspen, larch, Douglas fir, lodgepole pine, and yellow pine are invading the area, the present ground cover is dominated by ninebark, snowberry, rose, willow, and saskatoon (*Amelanchier alnifolia*). Around Greenwood the original forest probably was yellow pine and Douglas fir, associated with the wheatgrass–fescue community and ninebark.

In the Boundary Creek valley north of Greenwood the Douglas fir–pinegrass community is soon encountered. Most of the area has been logged and in 1957 was in young lodgepole pine, Douglas fir, and larch. The main associated species are pinegrass, forest lupine, timber milk-vetch (*Astragalus decumbens* var. *serotinus*), kinnikinnick, heart-leaved arnica, and soopolallie (*Shepherdia canadensis*). A number of even-aged stands of lodgepole pine occur on burned-over sites.

White spruce is associated with the Douglas fir community in the Boundary Creek valley about six miles north of Highway No. 3. The ground cover remains similar to that farther south except for an increase of twinflower and soopolallie and the frequent occurrence of false box.

Associated with Acid Brown Wooded soils on north- and east-facing slopes and in seepage spots near the north end of the surveyed area, there is a poorly developed cedar zone. Medium-sized lodgepole pine occurs in dense, uniform stands on burned-over shallow soils. On the deeper soils, larch, Douglas fir, and spruce reproduction dominates, with some alpine fir and cedar. In open areas the Douglas fir–pinegrass community is dominant, but under normal tree cover twinflower, false box, bunchberry (*Cornus canadensis*), aralia, and queen's cup dominate along with black huckleberry (*Vaccinium membranaceum*), red twinberry (*Lonicera utahensis*), and black twinberry (*Lonicera involucrata*). A heavy moss cover usually occurs where the tree canopy is closed in.

On the west slope of Mount Attwood east of Greenwood, the Douglas fir zone is above 3,200 feet. It is occupied by a dense regrowth of Douglas fir, lodgepole pine, larch and aspen. The main shrub is ninebark and the principal herb is pinegrass. Spruce is added to the community at 3,800 feet. Alder (*Alnus sinuata*) and soopolallie become abundant along with pinegrass and forest lupine.

Above 3,000 feet on protected northeast slopes of Mount Attwood, dense stands of spruce and lodgepole pine contain considerable cedar and some alpine fir. In some places the ground cover is dominated by false box, thimbleberry, and bracken; in others, by dense shrub alder and willow. Older trees are mainly Douglas fir and larch, mostly survivors of fires in the mining days. Below 3,200 feet the Douglas fir zone predominates with the addition of spruce and soopolallie. Most of the area is now covered with uniform stands of lodgepole pine.

About ten miles south of Eholt the vegetation is again characterized by drier plant communities. A yellow pine-wheatgrass zone dominates on Dark Brown soils on the lower terraces of the Grand Forks area. Because of disturbance most grassland stands are dominated by needle-and-thread, Sandberg's bluegrass, and Junegrass, with red three-awned grass (*Aristida longesita*) appearing on the lighter-textured soils. Scattered rabbitbush (*Chrysothamnus nauseosus*) also occurs frequently. Dense stands of diffuse knapweed (*Centaurea diffusa*) occur almost everywhere throughout the valley bottom in abandoned fields and waste places.

With slight increases of moisture on protected slopes about four miles north of Grand Forks in the Granby Valley, Douglas fir and larch become associated with yellow pine. In this area the shrub layer, which consists largely of ninebark, saskatoon, and chokecherry (*Prunus demissa*), increases in density on the Brown Wooded soils. About eight miles north of Grand Forks, spruce enters the Douglas fir community on the heavier-textured soils, and cedar and white birch are found in draws. Uniform stands of lodgepole pine, frequently in association with buckbrush (*Ceanothus velutinus*) and willow, are on coarse-textured fans and terraces.

From a point about 16 miles north of Grand Forks, poorly developed cedar communities continue northward. Cedar is not abundant until north of the junction of Burrell Creek and Granby River, at which point there are occasional hemlock (*Tsuga heterophylla*), especially on the east side of the valley. The associated soils are Brown Wooded types. Stands of lodgepole pine with an understory of spruce regrowth and soopolallie cover a number of the coarse-textured terraces. On the better soils there are a few yellow pine, but the regrowth consists mostly of Douglas fir and lodgepole pine, with scattered larch, spruce, white pine, and an occasional alpine fir.

These areas support a dense and variable cover of shrubs, the most important of which are saskatoon, willow, soopolallie, rose, and spirea (*Spiraea lucida*). The ground cover is also shrubby and consists largely of false box, kinnikinnick, black huckleberry, dwarf blueberry, lupine, and pinegrass. A heavy moss cover is generally present.

On burned-over or logged terraces wheatgrass, fescue, Junegrass, Kentucky bluegrass, pussytoes, gromwell, and dwarf goldenrod (*Solidago*) reappear.

## Physiography

The surveyed area comprises parts of three physiographic units: a section of the Fraser Plateau between the Okanagan Valley and the Kettle River valley; two ranges of the Monashee Mountains; and several deeply cut river valleys.

Generally, the Fraser Plateau section is strongly eroded, but some areas in the south have moderate relief. The highest elevations west of the Westkettle River are: Baldy Mountain, 7,558; Little White Mountain, 7,115; and Grayback Mountain, 7,004 feet. Between the Westkettle and Kettle rivers, the plateau is considerably eroded and is called the Beaverdell Range. Though Big White Mountain has an elevation of 7,603, most of the range lies between 2,500 and 5,000 feet. This range represents a transition between the moderate relief to the west and the more mountainous region to the east.

East of the Kettle River there are two north-south trending mountain ranges in the region of the Monashees, and each is separated by a river valley. The westerly one, between the Kettle and Granby rivers, with elevations between 3,000 and 6,000 feet, is the Midway Range. Prominent summits are Almond Mountain, 7,604; Terraced Peak, 7,555; and Mount Arthurs, 7,773 feet (14).

East of the Granby River and bounded by Christina and Lower Arrow lakes is the Christina Range. These mountains rise sharply from the lakes to heights of 5,000 and 6,000 feet. Mount Faith, 7,477, and Bluejoint Mountain, 7,603 feet, are examples of the highest areas. The elevation of Lower Arrow Lake is 1,379, and that of Christina Lake 1,531 feet.

The eastern boundary of the surveyed area is the western foot of the Rossland Range. The Midway (Figure 6), Christina, and Rossland ranges constitute the southern part of the Monashee Mountains. Though much rock is exposed, the greater part of this mountainous region is forested.

In both plateau and mountainous sections, the valleys of the main rivers and streams lie several thousand feet below the general level of the surrounding country. The most important of the valleys drain southward, parallel to the Okanagan Valley, and are occupied by the upper part of the Kettle River, Boundary Creek, Granby River, and Christina Lake.

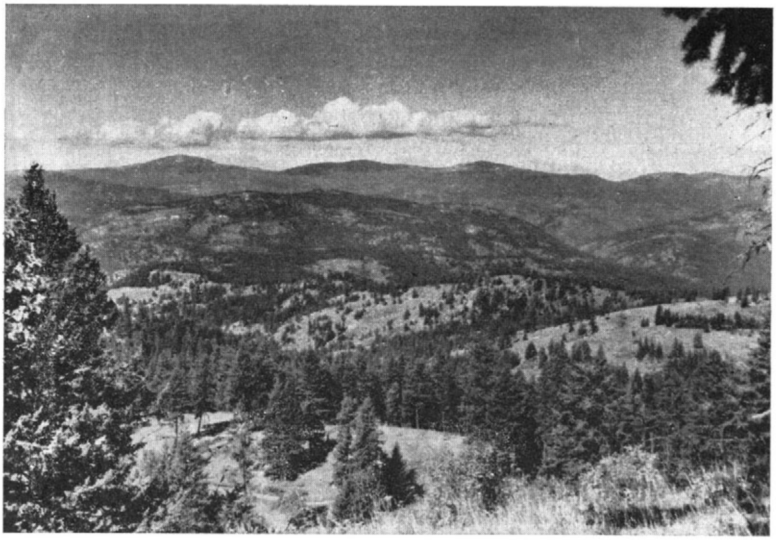

FIGURE 6. The Midway Range northeast of Rock Creek.

These valleys drain into the lower part of the Kettle River, which occupies an east-west trending valley near the 49th parallel from Rock Creek to Midway and from Carson to Cascade. The river loops into the State of Washington between Midway and Carson.

Most of the agricultural land is in the Westkettle, Kettle, and Granby river valleys, and in the Boundary Creek valley. These U-shaped valleys, one to three miles wide, have terraced or flat bottoms and steep walls. Terraces may be as high as 200 feet above the valley bottoms. Alluvial fans commonly occur at the toes of the valley slopes and often spread over the terraces.

## Drainage

All of the surveyed area except a small portion in the western section of the plateau is within the Kettle River watershed, which includes the Westkettle and Granby rivers and some 48 tributary creeks. The western slope of the plateau forms part of the Okanagan valley drainage system.

The Kettle River is about 180 miles long. From its source in the Monashee Mountains between Cherryville and Needles, it flows southward to Rock Creek, then southeastward to Midway and into the United States. It recrosses the 49th parallel at Carson, where it again flows eastward to Cascade. At Cascade it flows south and crosses the border at Laurier and continues into the reservoir of the Grand Coulee Dam. The Westkettle and Granby rivers join the Kettle River near Westbridge and Grand Forks.

The elevation at the Rendell Creek–Kettle River junction is about 2,600 feet. At Rock Creek, about 40 miles downstream, the elevation of the Kettle River is 1,965 feet. This difference of 635 feet gives a gradient of 18.5 feet per mile, about half that for the Westkettle River. Below Rock Creek the stream gradient decreases to about seven feet per mile, which allows the river to meander. From Grand Forks to the gauging station half a mile below the Cascade rapids, the average gradient is 14 feet per mile; but owing to the rapids at Cascade, the gradient along most of this distance is considerably less.

At the Cascade gauge the greatest discharge between 1916 and 1934 was 29,300 cubic feet per second, on June 8, 1921, the lowest was 60 c.f.s., on January 24, 1930. South of Laurier the highest discharge was 35,000 c.f.s., on May 29, 1948. The Kettle River drainage area upstream from Laurier totals about 3,800 square miles, and has an annual runoff between two and three million acre-feet (15).

Only three lakes are worthy of note: Christina, Conkle, and Jewel. Smaller bodies of water are scattered throughout the surveyed area, and swamps and peat bogs are found in small, shallow depressions.

## Geology of Soil Parent Materials

During the last stage of Pleistocene glaciation, the ice sheet advanced 80 to 100 miles south of the 49th parallel. In the surveyed area only the highest summits were free of ice. As the ice receded the plateau area was exposed first. In the valleys, thick tongues of ice were replenished from high mountains to the north. As the valley glaciers moved southward, they excavated unconsolidated materials, abraded valley walls, and converted the main valleys into overdeepened, U-shaped trenches with tributary hanging valleys (Figure 7).

The debris deposited as the ice receded formed the parent materials of most of the soils in the surveyed area. The physiography and associated surface drainage system, as well as the texture and internal drainage of the soils, were strongly influenced by glacier activity. The debris either washed or slid off precipitous slopes, leaving extensive areas of exposed rock in mountainous regions. On more gentle topography the materials accumulated and formed the deposits on which the present soils developed. In areas in which the debris was deposited unsorted, it formed a veneer of till over bedrock. The soils that developed from till are: Stevens loam, Gregoire loam, Sidley silt loam, and Taurus loam. In areas of Stevens loam, slopewash over till partly fills the depressions. The depressions, subject to seepage, accumulated lime in the subsoil, and the soil type derived from this material is Myncaster silt loam. Similarly, slopewash accumulated in other depressions, mostly in areas of till mapped as Gregoire loam. Since these depressions have a fluctuating water table, organic litter to depths up to 16 inches has accumulated over the mineral sediments. The soil type derived from this material is Wilgress muck.

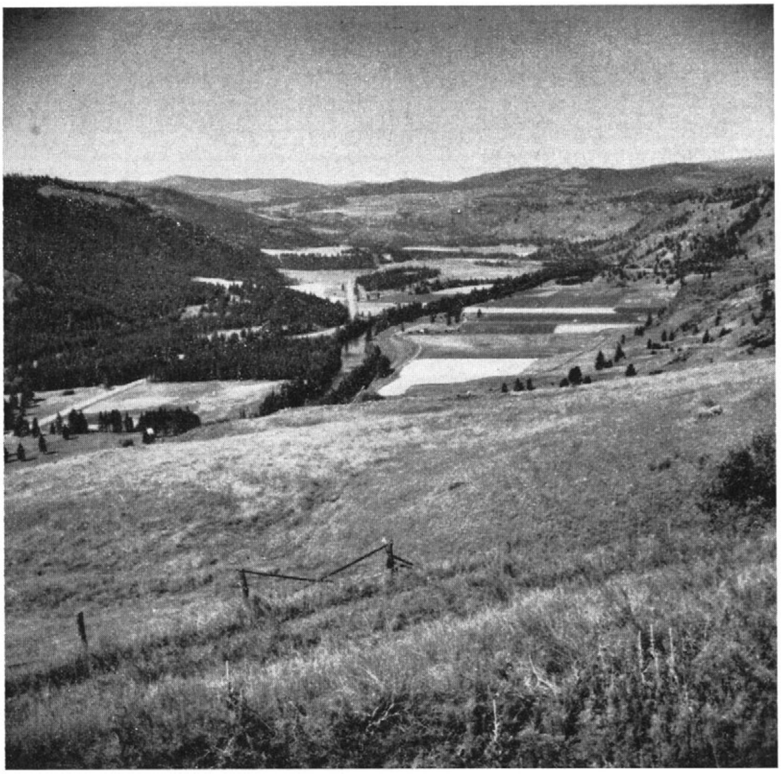

FIGURE 7. Kettle Valley westward from near Ingram bridge.

In the surveyed part of the plateau, meltwater from the ice sheet carried debris that subsequently was sorted and deposited as outwash sands and gravels. Occasionally blocks of ice near the ice front were buried by glacial outwash. As these melted the overburden collapsed and the surface became pitted; such depressions, known as kettles, are common in the McKinney–Jolly Creek area. Another feature of deglaciation, meandering ridges of water-sorted gravels from 15 to 50 feet higher than the adjacent landscape, are common near McKinney Creek. These deposits accumulated in fissures and tunnels in the ice and are known as eskers. The gravelly and sandy outwash material, deposited by the meltwaters from the receding plateau-glacier, was left both as terraces and as fill in meltwater channels. Soils that developed from this outwash are: Mires gravelly sandy loam, Beaverdell gravelly sandy loam, Coteay sandy loam, and Zamora loamy sand.

As the plateau glacier receded, drainage down the tributary valleys was blocked by ice that persisted in the main valleys; temporary lakes were formed behind these ice-dams. The sediments carried into the lakes were deposited as shallow-water deltas of sands and gravels and deep-water beds of finer materials. Removal of the ice-dams by continued lowering of the ice surface caused drainage of the first temporary lakes and the formation of new ones at lower elevations. Glaciolacustrine deposits occur over a wide range of elevations.

The valleys tributary to the Kettle Valley between Bridesville and Cascade, and the Okanagan Valley west of Bridesville, contain lacustrine sediments. These sediments are often situated well above the present level of drainage. In places, subsequent erosion dissected many of the deposits; in others they were left in the form of terraces, often with a surface capping of gravels. The lacustrine sediments seldom exceed 50 feet in thickness and overlie till or bedrock. A few ice-rafted cobbles and boulders are present. The soils derived from the lacustrine deposits are: Kermel silt loam, Conkle silt loam, and Mogul very fine sandy loam.

As the valley glaciers retreated, sorted debris carried by the overloaded meltwater streams partly filled the U-shaped trenches. In most valleys the streams subsequently carved channels in the relatively flat valley floors; the depth of downcutting is marked by the elevation of the highest terrace. Before many of the gravelly terraces were abandoned by the streams they received a veneer of finer texture during the freshets. Not all coarse-textured terraces received this veneer; some in the upper parts of the valleys are stony and bouldery to the surface. Soil types derived from gravelly terraces are: McCoy gravelly sandy loam, Mires gravelly sandy loam, Beaverdell gravelly sandy loam, Hulme gravelly sandy loam, and Burrell sandy loam.

Terraces composed of medium to coarse sands mixed with small gravels are less numerous than the coarser-textured ones. The sands and small gravels accumulated in areas where stream velocity was reduced. Soils derived from such deposits are: Marble sand, Bubar sandy loam, loamy fine sand and sand, Spion loamy sand, Zamora loamy sand, and Hoolan sandy loam.

In addition to those described above, terraces composed of finer materials, mainly silts, are found in most of the surveyed area, but they occupy only a small acreage. Occasionally the silty terraces may be found up to 100 feet above present river level, but most of them are less than 20 feet higher. Those occurring between 10 and 20 feet above river level have restricted drainage in their lower parts during the freshet season. The soil types that developed on these terraces are Wilkinson, Ingram, and Thone silt loam.

The lowest alluvial terraces still receive material during freshets. The texture of the deposit varies from sand to silt, depending on the velocity of the flood waters. The finer-textured materials being laid over gravels are thin on most of the first and second bottoms, and thus gravel bars often protrude to the surface. The soils derived from these low-lying terraces of variable texture are grouped as the Saunier soil complex.

After the ice receded and before vegetation was established, extensive erosion produced numerous fans at the base of the valley sides at entry points of tributaries. The fans, composed chiefly of coarse materials, spread over terraces or areas of valley fill that became terraced. The coarser detritus is concentrated near the fan apex; the finer sediments are near the margins. Where downcutting of valley fill was progressive, some of the fans formed on the highest terrace, then on each successive terrace. These terraced or compound fans may be observed near Midway. Though most fans are stable, some still receive periodic additions of material. Soil types that developed on sandy loam to loamy sand fan deposits containing variable quantities of gravels and stones are: Fiva, Carmi, Ferroux, and Phoenix sandy loam, and Tuzo and Republic gravelly sandy loam.

An additional soil type on fans, Boldue gravelly sandy loam, was separated on the basis of high lime content. The lime is derived partly from inclusions of limestone fragments, and in part lime deposition from calcareous seepage water.

In the surveyed area a noteworthy feature is the prevalence of white volcanic dust near the surface. A continuous layer, one-half to two inches thick, lies just beneath the organic litter where forest soils are undisturbed. Where trees were uprooted, this dust is in pockets up to a foot deep. In the grassland soils the volcanic dust layer is buried several inches deep, due to activity of burrowing animals. The volcanic dust also occurs at variable depths in stream and fan deposits and in peat bogs. The volcanic dust is most easily seen between Myncaster and Grand Forks.

# SOIL MAPPING AND CLASSIFICATION

The soils were examined in test pits, road and railway cuts, and other exposures. Their boundaries were determined with the aid of photographs on a scale of two inches to a mile. Bulk and core samples were taken from the various horizons of representative soils for laboratory studies. Random surface and subsoil samples were used to find the variation in texture and soil alkalinity or acidity within each soil series.

In the survey, related information such as the ecology, geology of soil-forming materials, and the agricultural use of the area was collected, and these data are given in various sections of the report. Field trips with pedologists of the Canada and United States departments of agriculture were made to ensure conformity with survey practices elsewhere in Canada, and agreement in the classification and naming of soils adjoining the international boundary.

The mapping units used in the survey were soil series, types, phases, and complexes. A *soil series* is a group of soils similar in parent materials, drainage, and profile characteristics except for the texture of the surface layer. If possible, soil series are given geographic or place names from the localities in which they are first identified.

Soil series are divided into *soil types* according to the texture of the surface soil, or plow layer. Textural names, such as sandy loam, loam, and silt loam, are added to the series name to name the soil type, for example, Conkle silt loam. Since soil types are subdivisions of soil series, distinguishing them often requires detailed field work.

In turn, soil types can be subdivided into phases on the basis of external features that have significance in agriculture. Variations in these, such as topography, gravel, and stoniness, are indicated on the map by appropriate symbols.

In this report the term *complex* is used for recent alluvial soils along the river courses. These soils, named the Saunier complex, have not developed distinct horizons. The relationship of the soil-forming deposits to the soil subgroups and series is shown in Table 4.

## Soil Development

Soils develop as the result of climatic and biotic conditions acting on various parent materials. In the early stages of development the soil characteristics are closely related to those of the parent materials. In time this relationship becomes less emphatic and is gradually modified by soil-forming factors. Since there is a great variety of formative influences, many different kinds of soils develop.

The stage of development a soil has attained is ascertained by identifying and measuring the succession of layers, or horizons, of which the solum is composed. These horizons differ in one or more features such as texture, color, structure, consistence, thickness, and chemical characteristics. A vertical section through the solum and the upper part of the parent material constitutes the *soil profile*.

Beginning at the surface, the main or master *horizons* are designated A, B, and C. The A and B horizons make up the solum, or altered portion of the soil profile; the C horizon is mainly unaltered parent material. If the upper and lower parts of a soil have different parent materials, the lower part or parts are denoted by Roman numerals as prefixes. Variations in the A, B, and C horizons are identified by the use of lower-case letters and Arabic numeral suffixes such as Ah1, Ah2, Ae1, and Ae2.[2]

[2] See the glossary.

## Table 4.—Soils and Parent Materials in the Kettle River Valley

| Subgroup | Parent Materials | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Shallow loess and colluvium over glacial till | Glacio-lacustrine deposits | Gravelly outwash and river deposits | Sandy outwash and river deposits | Silty river terraces | Gravelly river terraces | Alluvial-colluvial fans | Recent alluvial deposits | Slopewash deposits | Organic deposits |
| Orthic Regosol | – | – | – | – | – | – | – | Saunier | – | – |
| Orthic Dark Brown | – | Kermel | McCoy | Bubar | Ingram | – | – | – | – | – |
| Rego Dark Brown | – | – | – | – | – | – | Tuzo | – | – | – |
| Carbonated Rego Dark Brown | – | – | – | – | – | – | Boldue | – | – | – |
| Orthic Black | Stevens | – | Mires | – | – | – | Republic | – | – | – |
| Rego Dark Gray | – | – | – | Marble | – | – | – | – | – | – |
| Orthic Brown Wooded | – | Mogul | Beaverdell<br>Burrell | Zamora | – | – | Ferroux<br>Phoenix | – | – | – |
| Degraded Brown Wooded | – | – | – | – | – | – | Fiva | – | – | – |
| Gleyed Brown Wooded | – | – | Coteay | – | – | – | – | – | – | – |
| Orthic Gray Wooded | – | Conkle | – | Spion | Wilkinson | – | Carmi | – | – | – |
| Brunisolic Gray Wooded | – | – | – | Hoolan | Thone | – | – | – | – | – |
| Brown Wooded–Gray Wooded | Sidley | – | – | – | – | – | – | – | – | – |
| Orthic Gray Forested | Taurus | – | – | – | – | – | – | – | – | – |
| Brown Wooded–Gray Forested | Gregoire | – | – | – | – | – | – | – | – | – |
| Orthic Acid Brown Wooded | – | – | – | – | – | Hulme | – | – | – | – |
| Carbonated Rego Humic Gleysol | – | – | – | – | – | – | – | – | Myncaster | – |
| Peaty Rego Gleysol | – | – | – | – | – | – | – | – | Wilgress | – |
| Fibrous Peat | – | – | – | – | – | – | – | – | – | Peat |

In addition to the mineral horizons mentioned, organic matter accumulates on the surface of soils under forest or with impeded drainage. This organic mat may be subdivided into L, F, and H horizons, depending on the degree of decomposition. The kind and sequence of horizons in a soil profile place it in one of a number of great soil groups.

In the surveyed area, the great soil groups can be broadly divided into two categories: those developed under forest and those under grass. The grassland soils have accumulations of organic matter in the surface mineral soil horizons. According to the color imparted by organic matter, these soils are Dark Brown or Black, each being divided into subgroups.

Between the forested and grassland soils a transitional Dark Gray soil group may occur, because of invasion of grassland by forest. The horizon sequence is similar to that of the grassland soils, degradation of organic matter in the surface mineral horizons being the distinguishing feature.

The forested soils were separated into several groups and subgroups, depending on the degree of weathering and movement of soil constituents. The groups are: Brown Wooded, Gray Wooded, Gray Forested, and Acid Brown Wooded. Generally, the Brown Wooded soils have the most lime and other plant nutrients. These are gradually depleted under intensive weathering, the Acid Brown Wooded soils being the most impoverished and consequently the least fertile.

In all the great soil groups described, poorly drained depressions often occur. Under the influence of a high water table, aeration is limited and reduction processes, known as gleying, are important. The soil becomes grayish and often streaked with bright-colored mottles. The poor aeration may also retard the decomposition of organic matter, which accumulates to a thickness of many feet under favourable conditions. Poorly drained soils that are gleyed and contain accumulations of organic matter in the surface mineral horizons are classed as Humic Gleysols. Poorly drained soils lacking this accumulation are classed as Gleysols. These Gleysol soils may have 12 inches or less of accumulated organic matter on the surface; those with more than 12 inches of organic matter were classed as Organic soils.

## DESCRIPTIONS OF SOILS[3]

This section gives information on the classification, locations, surface features, profiles, and agricultural uses of the soils. Table 5 gives the arable and nonarable acreages for each soil. Most of the arable soils require irrigation for crop production (Tables 6, 7).

### Regosol Soils

Regosols are mineral soils that lack discernible horizons or have only a very weakly developed A horizon; an L-H horizon less than 12 inches thick may be present. Though Regosols are most often found on recently deposited materials, they may be found also on older deposits in which profile development was arrested either by the composition of the soil-forming material or by the environment. On Regosols, in which the drainage may range from rapid to imperfect, the cover is either forest or natural grass. Only the Orthic subgroup was found.

The Saunier complex comprises the only Regosols in the surveyed area and occur on recently deposited river alluvium. One or two inches of forest litter has accumulated on the surface and only the top two or three inches of mineral soil may differ from the parent material.

[3] In the descriptions, the soil colors are as in the Munsell soil color charts (Munsell Color Company Inc., Baltimore 2, Maryland, U.S.A. 1954).

## Orthic Regosols

### *Saunier Soil Complex*

This complex is a group of soils that have developed on recent alluvial deposits of variable texture. The soils are found along the Kettle, Westkettle, and Granby rivers and their chief tributaries.

The topography is mainly level except for a slight downstream slope. Slopes away from the river are also found; these mark the sites of old flood-plains. There are hummocks and undulations resulting from protruding sand or gravel bars and the uprooting of trees.

Many of the first and second bottoms are scarred by abandoned stream channels. The frequency and depths of these channels vary greatly, so that in some places they hinder cultivation not at all but in others render the area nonarable. Many of the channels carry water in the freshet season and are dry thereafter, but the deeper ones have water in them the entire year.

The elevations of these soils range from a low of 1,640 feet at Cascade to 3,200 in the upper reaches of the Westkettle River. A total of 18,026 acres were mapped, of which 17,620 are arable, 238 are excessively stony, and 168 are rough-broken.

The Saunier soils vary from three to 10 feet above average river level, some areas being flooded annually and higher portions inundated only in years of exceptionally high water. The areas that are flooded annually have one or more buried leaf mats, and those flooded only by exceptional freshets may have slight horizon development. The alluvium varies in thickness from a few inches to several feet, and overlies coarse sands and gravels. It contains pockets and lenses of volcanic dust in the upper 10 inches and generally has a neutral reaction.

The surface layer is usually sandy loam or loam, with frequent inclusions of fine sandy loam and silt loam. With depth the soils become coarser, grading into sands and gravels. Layers of variable texture may be found anywhere in the profile. Bars of sand and gravel, thinly covered by alluvium, are common; however, stones are found only near gravel bars.

The drainage is good to imperfect for most of the year. During the spring freshet, flooding and poor drainage may occur for a short time. Although a groundwater table keeps the lowest areas moist all summer, it has little effect on the surface soil of areas only two feet higher. Mottling is generally confined to the lower parts of the profile.

These soils are classed as Orthic Regosols. A few on scattered, better-drained positions have slight Brown Wooded and Gray Wooded characteristics. Most of the soils have a heavy forest cover. The abundance of the various tree species depends on drainage. Cottonwood and aspen are dominant on areas having imperfect drainage; cedar, spruce, larch, and Douglas fir are most numerous in the better-drained positions. The undercover is composed mainly of thimbleberry, red-osier dogwood, queen's cup, and prince's pine. The following profile description is typical of the deeper phase of the Saunier complex:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–F | $1\frac{1}{2}$ – 0 | Forest litter, chiefly needles, leaves, and wood. The top raw; the lower part partly decomposed and containing white mycelia. pH 6.5. |
| C1 | 0 – 5 | Pale-brown (10YR 6/3, dry) or dark yellowish brown (10YR 4/4, moist) silt loam or loam. The first inch platy and the remaining four fine blocky in structure. Slightly hard when dry, friable when moist. Many fine roots and some bits of charcoal. pH 6.4. |

| | | |
|---|---|---|
| C2 | 5 – 14 | Pale-brown (10YR 6/3, dry) or brown (10YR 5/3, moist) sandy loam. Massive. Soft when dry, very friable when moist. Lenses, pockets, and flecks of volcanic dust. Numerous roots. pH 6.6. |
| IIC | 14 – 19 | Pale-brown (10YR 6/3, dry) or light olive brown (2.5Y 5/6, moist) loamy sand. Massive. Soft when dry, very friable when moist. Occasional roots. pH 6.4. |
| C3 | 19 – 28 | Pale-brown (10YR 6/3, dry) or yellowish-brown (10YR 5/4, moist) sandy loam. Massive. Micaceous. Soft when dry, very friable when moist. A few roots. pH 6.5. |
| IIC–C | 28 – 39 | Alternating layers of loose fine to medium sand and sandy loam. A few faint mottles in the sandy loam. Roots concentrated in the sandy loam layers. pH 6.7. |
| IICgj | 39 – 60 | Coarse sand, with sandy loam at 46-51 inches; loose. Faint mottles in the sand and prominent ones in the sandy loam. pH 6.8. |
| IIIC | 60+ | Roughly stratified gravels. |

*Agriculture*

In the surveyed area, most of the forested soils that have been cultivated belong to the Saunier complex (Figure 8). The high water table supplies sufficient moisture for crop growth until midsummer. Thereafter, irrigation is

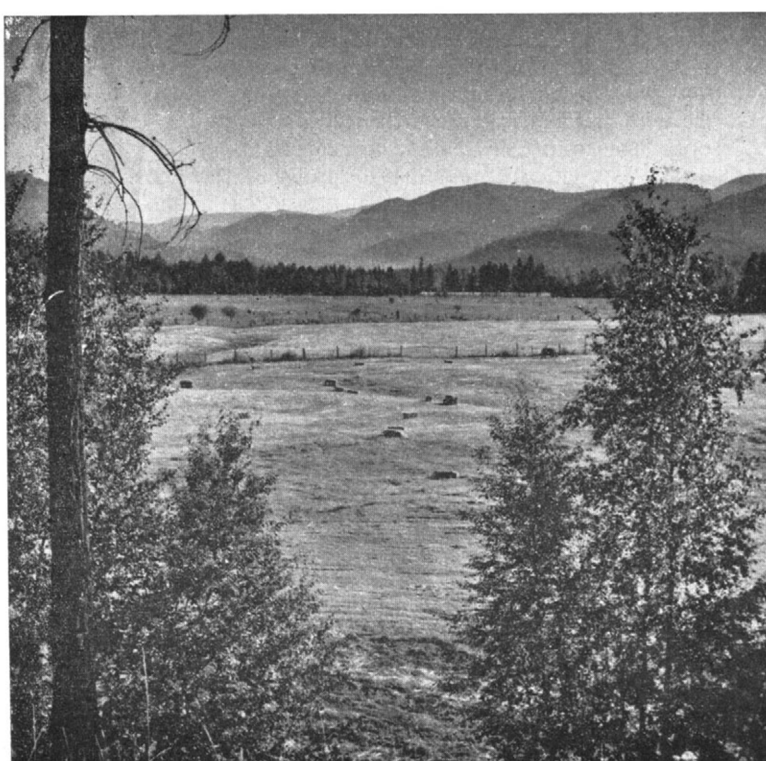

**FIGURE 8. Cultivated Saunier soil complex in the Kettle Valley north of Westbridge.**

necessary, particularly on the lighter-textured soils and the higher areas. For sprinkler irrigation the farm delivery requirement is about 20 acre-inches. Water for irrigation and domestic use is available from rivers and shallow wells. In the native state these soils have value as a source of timber and forested grazing.

Since most of the Saunier soils are inundated during the annual freshet, they cannot be worked until late June. Most of the cultivation is therefore done in the fall. On the cultivated areas, mainly forage crops are grown. The native fertility of these soils is fair to moderate, though nitrogen and organic matter are deficient in some.

The high cost of clearing the heavy forest cover and undergrowth is the main obstacle to the use of these soils for agriculture. The cost of leveling hummocks and installing drainage systems in the imperfectly drained areas is also considerable. River erosion is a hazard, expensive river-bank protection sometimes being required. Dyking is necessary to prevent annual inundation. Stones are restricted to localized bars, and generally do not hinder cultivation.

Of the soils suitable for irrigation, there are 119 acres of second-, 8,316 of third-, 5,964 of fourth-, and 3,221 of fifth-class land.

## Dark Brown Soils

Soils of this group developed under natural grass on south-facing slopes in the southern portion of the surveyed area, and on adjoining level areas. Grass dominates as a result of the drier than average conditions of the exposures. Dark Brown soils are found in the Kettle River valley bottom and adjoining south-facing slopes between Rock Creek and Gilpin, on glaciolacustrine deposits between Bridesville and Myncaster, and around Grand Forks.

The Dark Brown soils have an accumulation of organic matter that imparts a dark-brown color to the surface horizons. Since leaching is not pronounced, soil reactions at the surface are generally neutral and lime accumulations may occur at shallow depths. Three subgroups are found in the surveyed area: Orthic Dark Brown, Rego Dark Brown, and Carbonated Rego Dark Brown.

*Orthic Dark Brown* soils have a dark grayish brown Ah horizon underlain by a pale-brown to yellowish-brown Bm horizon. The Bm horizon has subangular blocky or blocky structure without free lime. A horizon of calcium carbonate accumulation beneath the B horizon is present in fine-textured profiles, but not in coarser ones. The soil types in this subgroup are: Kermel silt loam, McCoy gravelly sandy loam, Bubar sandy loam, loamy fine sand and sand, and Ingram silt loam.

*Rego Dark Brown* soils differ from the Orthic subgroup in not having a B horizon. Horizon Ah rests directly on the C horizon, or on a transitional horizon, AC, if this is present. The only Rego Dark Brown soil type in the surveyed area is Tuzo gravelly sandy loam.

*Carbonated Rego Dark Brown* soils are similar to the Rego Dark Brown soils except for an accumulation of secondary carbonates in the Ah horizon. In the surveyed area, Boldue gravelly sandy loam is the only representative. This soil type is well drained except for a short period in the spring, when it is saturated by calcareous seepage water.

### ORTHIC DARK BROWN SOILS

#### *Kermel Silt Loam*

The glaciolacustrine deposits from which the Kermel soils are derived are found chiefly on the plateau near Bridesville. Small areas also occur where the Boundary Creek and Granby valleys join the Kettle River valley.

The lacustrine deposits originally had level surfaces, some of which still exist. Over most of the area the topography is irregular, with moderate to steep slopes. The elevations range from 1,800 feet near Grand Forks to 3,700 southeast of Bridesville. In a total of 1,009 acres, 700 are topographically suitable for cultivation and 309 are a rough-broken phase.

The parent material was deposited in small, temporary ice-margin lakes. The deposits are stratified, with little evidence of varving. Ice-rafted stones are scattered in the deposits, which overlie till or bedrock at depths from eight to 50 feet. In places erosion has exposed underlying till, which appears as small patches of stony land in areas of the Kermel series. The dominant surface layer is mainly silt loam, with minor areas of fine sandy loam and silty clay loam. The texture of the deposit coarsens with depth, generally to fine sand.

The solum is well drained and the parent material is rather strongly alkaline in the upper part. Virgin areas support bunchgrass and annual weeds. In some areas there are patches having solonetzic development. Eroded knolls with lime a few inches from the surface, and surface colors that vary from light brownish gray to dark grayish brown, occur in areas of rough topography. An undisturbed soil profile (Figure 9) was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| Ah1 | 0 – 11 | Dark grayish brown (10YR 4/2, dry) or very dark grayish brown (10YR 3/2, moist) silt loam. Weak, medium, subangular blocky structure. Soft when dry, very friable when moist. White flecks of volcanic dust and small white bits of unweathered parent material. Numerous fine roots. pH 6.8. |
| Ah2 | 11 – 17 | Pale-brown (10YR 6/3, dry) or dark grayish brown to dark-brown (10YR 4/2.5, moist) silt loam. Weak, coarse blocky structure. Slightly hard when dry, friable when moist. Minute white particles of parent material. Scattered roots. pH 6.8. |
| Bm | 17 – 23 | Very pale brown (10YR 7/3, dry) or brown (10YR 5/3, moist) silt. Very weak blocky structure. Hard when dry. Pieces and nodular forms of parent material. Occasional roots. pH 6.9. |
| BC | 23 – 35 | Light-gray (10YR 7/2, dry) or light brownish gray (10YR 6/2, moist) silt or silt loam. Massive; hard with soft spots. Numerous bits of parent material of various sizes, the largest showing stratification. Occasional roots. pH 6.9. |
| Cca | 35 – 39 | Light-gray (10YR 7/2, dry) or light brownish gray (10YR 6/2, moist) silt. Massive. Soft when dry. Visible carbonates. Occasional roots. pH 8.0. |
| C1 | 39 – 46 | White (10YR 8/2, dry) or light brownish gray (10YR 6/2, moist) silt. Massive. Hard when dry. Roots in vertical cracks, terminating in thin mats. pH 8.9. |
| C2 | 46+ | White (10YR 8/1, dry) or light brownish gray (10YR 6/2, moist) stratified silt loam. Gradually becoming coarser in texture with depth. pH 9.1. |

*Agriculture*

In their native state the Kermel soils have value as rangeland. Topographically suitable areas on the plateau are dry-farmed, and at these higher elevations the soils give moderate yields of wheat, barley, rye, oats, and alfalfa. With moisture the limiting factor, the best yields are obtained in depressions, where crops are aided by slight seepage.

FIGURE 9. Profile of Kermel silt loam, an Orthic Dark Brown soil, near Grand Forks.

On the plateau, greater crop yields could be obtained with irrigation, but during the soil survey (1957) no information was available as to sources of water. Aside from a few seepage areas in the plateau section, from which hard water is available, domestic water cannot be obtained from the substrata. Areas of Kermel silt loam near Grand Forks are at lower elevations than those on the plateau, and cannot be farmed without irrigation. Under irrigation the farm delivery requirement for sprinklers is 20 acre-inches.

The Kermel silt loam requires careful management to prevent erosion. Summerfallowing should be done on the contour, and organic matter must be maintained. Of the soils suitable for irrigation, there are 63 acres of second-, 173 of third-, 287 of fourth-, and 177 of fifth-class land.

### *McCoy Gravelly Sandy Loam*

This soil type is derived from gravelly river terraces in the southern part of the surveyed area. Most of the acreage is in the Kettle River valley between Rock Creek and Midway, and from Carson to Cascade. Two ice-margin terraces on the east rim of the Okanagan Valley near Highway No. 3 were included.

The topography is smooth with a gentle down-stream slope (Figure 10). There are occasional undulations marking the locations of former stream channels. Some of the terraces have kettles, and a few have been so narrowed and cut by stream erosion as to be unsuitable for cultivation. In the Kettle River valley the elevations vary from 1,650 feet near Cascade to 2,200 near Rock Creek. The ice-margin terraces at the east rim of the Okanagan Valley are at about 3,500 feet. Of 4,773 acres mapped, 3,813 are arable, 869 have rough-broken topography, and 91 are excessively stony.

The substrata are composed of calcareous sands, gravels, and cobbles deposited as valley fill. The streams have cut into the fill, leaving terraces at several elevations above present runoff levels. Before these terraces were abandoned, they were flooded during freshets and the gravelly deposits received a capping of fine-textured sediments from six to 24 inches thick, the average being about 16 inches. In addition to the fine sediments, sufficient gravels were incorporated so that the surface layer is usually gravelly sandy loam. Surface stoniness is confined chiefly to areas of thin overlay. The combination of a sandy loam surface and gravelly substrata is responsible for rapid soil drainage.

The McCoy gravelly sandy loam, an Orthic Dark Brown soil, developed under bunchgrass. In most areas the bunchgrass has been destroyed by overgrazing and replaced by needle-and-thread grass, downy bromegrass, downy plantain, yarrow, and others. Ponderosa pine is scattered on the inner terrace margins. Stands of pine have invaded overgrazed grassland near Christina Lake. A soil profile about four miles east of Rock Creek was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| Ah | 0 – 8 | Grayish-brown to dark grayish brown (10YR 4.5/2, dry) or very dark grayish brown (10YR 3/2, moist) gravelly sandy loam. Fine granular structure. Soft when dry, friable when moist. Thin lenses and flecks of volcanic dust. Numerous fine roots. pH 6.5. |
| AB | 8 – 12 | Brown (10YR 5/3, dry; or 10YR 4/3, moist) gravelly sandy loam. Weak, fine granular and some weak, subangular blocky structure. Soft when dry. Increasing gravel content. Numerous fine roots. pH 6.7. |
| Bm1 | 12 – 16 | Light yellowish brown (10YR 6/4, dry) or yellowish-brown (10YR 5/4, moist) gravelly sandy loam. Weak, fine, subangular blocky structure. Slightly hard when dry. Scattered fine roots. pH 7.1. |
| Bm2 | 16 – 24 | Yellowish-brown (10YR 5/4, dry) or dark yellowish brown (10YR 4/4, moist) gritty sandy loam or loamy sand in a matrix of gravel and cobbles. Weak, fine granular or single-grained structure between gravel and stones; loose. Roots ending in this horizon. pH 7.4. |
| IIC | 24+ | Roughly stratified gravels and small cobbles interspaced with coarse sand. Lime plating on stones. pH 8.3. |

*Agriculture*

In the natural state this soil type is suitable for limited grazing, but with irrigation good yields of alfalfa or hay are obtained. Where the solum is deeper than average, as in the Midway locality, potato yields are from 10 to 12 tons per acre. Tree fruits were planted in the past near Grand Forks, but these are being eliminated because of the unfavorable winter climate.

Water for irrigation and domestic use is available from the Kettle River, or from wells drilled below river level. The farm delivery requirement for sprinkler irrigation is 40 acre-inches. To avoid loss, irrigation water should be piped or flumed to points of distribution.

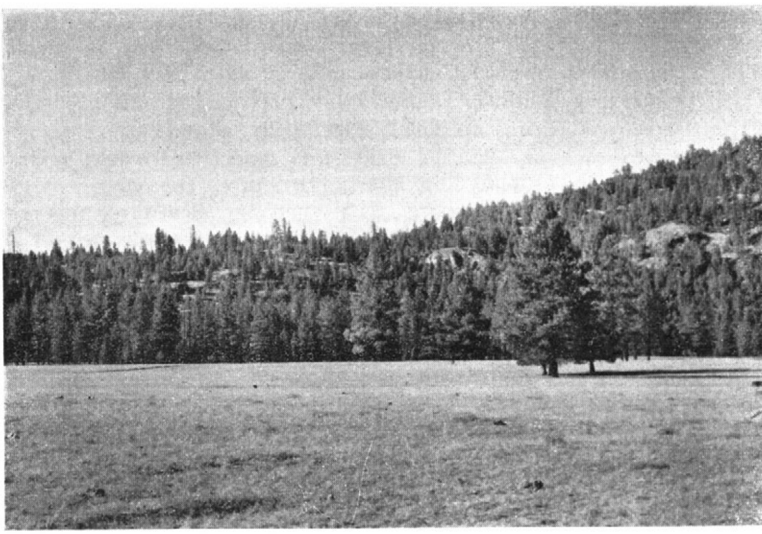

FIGURE 10. Level surface and grass vegetation of McCoy gravelly sandy loam.

At the time of the soil survey (1957) only a small part of the total acreage was irrigated. The soils suitable for irrigation are 646 acres of third-, 2,174 of fourth-, and 993 acres of fifth-class land.

### *Bubar Series*

The Bubar series is derived from sandy river terraces in the southern section of the surveyed area. Most of the acreage is in the Kettle River valley from Rock Creek to Midway, and between Carson and Gilpin.

The surface varies from level to irregular, moderate slopes, and a few rough-broken areas. On some terraces there is a gentle slope away from the river, suggesting remnants of old floodplains. The small acreage having irregular slopes is duned, and erosion produced the rough-broken areas. The eletions vary from 1,680 feet near Gilpin to 2,000 near Rock Creek. The total area is 4,488 acres, of which 72 are nonarable.

The parent material consists of calcareous and mildly alkaline fine to coarse sands. The sandy deposits are underlain at variable depths by outwash gravels. Here and there gravels are scattered in the solum; but cobbles are found only near the contact with the underlying gravelly strata.

The Bubar series was differentiated into three soil types. Bubar sandy loam, 1,577 acres, includes small areas of fine sandy loam. Bubar loamy fine sand, 2,034 acres, varies in places to loamy sand. Bubar sand, 877 acres, contains some loamy sand and more gravel in the solum than other members of the series.

These are rapidly drained Orthic Dark Brown soils that developed under bunchgrasses. The original vegetation was largely destroyed by overgrazing, and replaced by secondary grasses and weeds. There are a few scattered pondersosa pine. A profile representative of the loamy fine sand (Figure 11) was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| Ah | 0 – 8 | Dark grayish brown (10YR 4/2, dry) or very dark grayish brown to very dark brown (10YR 2.5/2, moist) loamy fine sand. Very weak, medium granular structure. Soft when dry. A moderate number of fine roots. pH 7.0. |
| AB | 8 – 15 | Brown (10YR 5/3, dry) or dark-brown (10YR 3/3, moist) loamy fine sand. Very weak, medium, subangular blocky structure, breaking easily to single grains. Soft when dry. Scattered fine roots. pH 7.5. |
| Bm | 15 – 26 | Light yellowish brown (10YR 6/4, dry) or dark-brown (10YR 4/3, moist) loamy fine sand. Very weak, medium, subangular blocky structure, breaking easily to single grains. Soft when dry. Scattered fine roots. pH 7.6. |
| BC | 26 – 33 | Pale-brown (10YR 6/3, dry) or brown (10YR 5/3, moist) loamy sand. Single-grained. Loose. Scattered fine roots. pH 7.9. |
| C | 33+ | Light-gray (10YR 7/2, dry) or pale-brown (10YR 6/3, moist) fine sand. Single-grained. Loose. Occasional fine roots in the upper part. pH 8.1. |

*Agriculture*

The Bubar series is nearly all cultivated and irrigated. Grain, hay, alfalfa, potatoes, and other crops are produced. Limited acreages were planted to tree fruits in the pioneer period, but owing to unfavorable climatic conditions most orchards have ceased production.

The high percentage of the acreage farmed is due to the ease of cultivation. Few forest trees have to be removed and there are few or no stones. In the native state the soil is moderately fertile, and it becomes productive when irrigation and fertilizers are used.

The terraces from which the Bubar soils are derived are near the Kettle River, where domestic and irrigation water is obtained. Well water is found in the lower terraces near the river.

Sprinkler or furrow irrigation may be used on the Bubar sandy loam. To avoid excessive percolation loss, sprinklers only are recommended for the Bubar loamy fine sand and sand. The farm delivery requirement for sprinkler irrigation should be about 38 acre-inches for the sandy loam, 44 for the loamy fine sand, and 60 for Bubar sand. The water should be piped or flumed to the farm headgate, to prevent excessive transmission loss.

Of the soils suitable for irrigation, there are 84 acres of first-class Bubar sandy loam, 1,037 of second-, 418 of third, and 10 of fourth-class land. Nonarable land occupies 28 acres. There are 1,991 acres of third- and 24 of fourth-class Bubar loamy fine sand. Nineteen acres are nonarable. Bubar sand occupies 781 acres of fourth- and 71 of fifth-class land. The nonarable portion amounts to 25 acres.

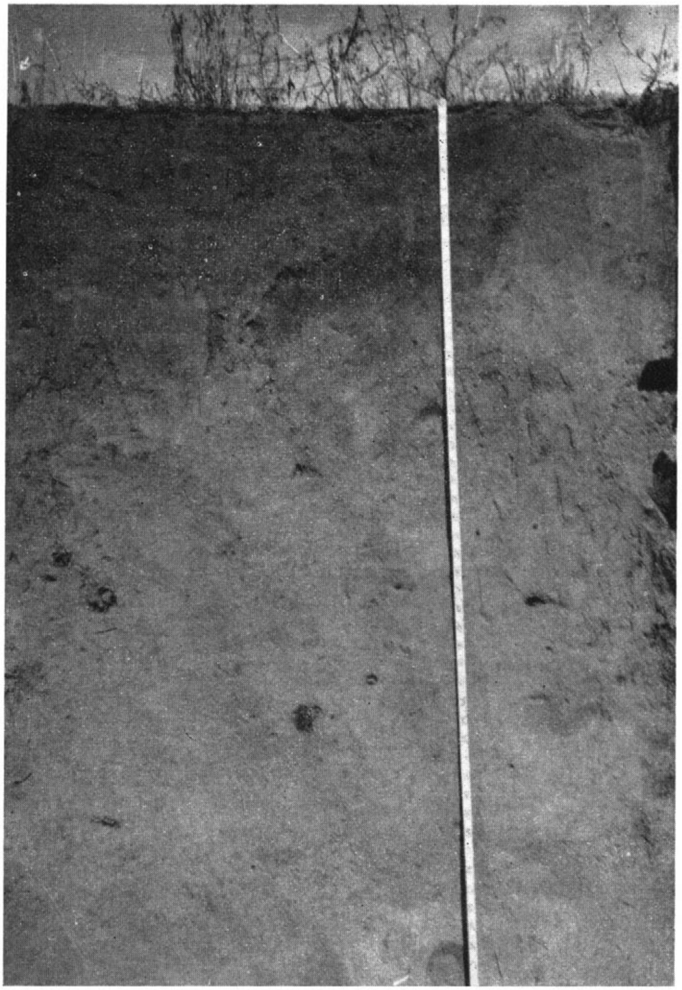

FIGURE 11. Profile of Bubar sandy loam, an Orthic Dark Brown soil, near Grand Forks.

### *Ingram Silt Loam*

Ingram silt loam is derived from silty terraces in the Kettle River valley between Rock Creek and Midway, and near Grand Forks. The surface varies from smooth to irregular very gentle slopes. There is a downstream slope and one away from the river. The range in altitude is from 1,750 feet near Grand Forks to 1,960 in the Rock Creek locality. A total of 500 acres were mapped, all of which are arable and suitable for irrigation.

The parent material is composed of fine-textured sediments originally deposited in quiet waters of floodplain ponds and lakes. The sediments are three feet or more thick and overlie sands and gravels. The fine-textured material is calcareous, the lower part of the profile ranging from moderately to strongly alkaline.

Silt loam is the main texture of the surface soil, minor areas being loam. The heavier subsoils are clay loam or silty clay loam. There is good drainage and no coarse material above the substrata.

The Ingram silt loam is an Orthic Dark Brown soil that developed under bunchgrasses. Uncultivated areas support scattered ponderosa pine and a cover of wheatgrass, fescues, Junegrass, and other grasses and weeds. A profile (Figure 12) in an area cultivated and abandoned was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| Ap | 0 – 6 | Dark grayish brown (10YR 4/2, dry) or very dark grayish brown (10YR 3/2, moist) silt loam. Medium platy, breaking to granular structure. Slightly hard when dry. Many fine roots. pH 7.4. |
| Ah | 6 – 15 | Grayish-brown (10YR 5/2, dry) or dark grayish brown (10YR 4/2, moist) silt loam. Strong, medium prismatic structure. Hard when dry. Many worm casts; scattered roots. pH 6.8. |
| Bm | 15 – 22 | Light brownish gray (10YR 6/2, dry) or olive-brown (2.5Y 4/4, moist) silty clay loam. Strong, fine blocky structure. Very hard when dry, sticky when wet. An occasional root. pH 7.4. |
| Cca | 22 – 38 | White (10YR 8/2, dry) or light olive brown (2.5Y 5/4, moist) silty clay loam. Strong, medium blocky structure. Very hard when dry, sticky when wet. Highly vesicular. pH 8.1. |
| C | 38+ | White (10YR 8/2, dry) or light olive brown (2.5Y 5/4, moist) silty clay loam. Finely stratified and very vesicular. A layer of micaceous loamy fine sand at 59 to 67 inches depth. pH 8.0 to 8.5. |

*Agriculture*

In 1957 about 75 percent of the acreage produced grain, alfalfa, and potatoes under irrigation. Water for irrigation and domestic use is obtained from the Kettle River and wells near the river. The level topography permits furrow or sprinkler irrigation. The farm delivery requirement for sprinklers is about 30 acre-inches.

The Ingram silt loam is one of the best soils for irrigation in the surveyed area. The solum is deep, the drainage is good, and the soil has excellent moisture-holding and cation-exchange capacities. Of the soils suitable for irrigation, there are 307 acres of first- and 193 of second-class land.

## Rego Dark Brown Soils

### *Tuzo Gravelly Sandy Loam*

This soil type, which developed on alluvial-colluvial fans, is confined chiefly to scattered south-facing fans on the north side of the Kettle River between Rock Creek and Midway, and near Gilpin.

The topography is not too steep for agriculture on any fan. The slopes, steepest at the apex, run downward toward the valley center, becoming more gentle at the fan margins. The elevations range from 1,660 feet near Gilpin to 2,180 near Rock Creek. In a total of 809 acres, 24 are excessively stony.

The parent material consists of erosion products from gravelly outwash terraces and glacial till. The fan deposits are roughly stratified and of variable texture. The coarser aggregates concentrate near the apexes of the fans, from which there is downslope grading to finer-textured, almost stone-free areas. The surface layer is usually gravelly sandy loam. Minor areas of gravelly loamy sand occur near the apexes of some of the fans. Profile textures become coarser and more gravelly with depth. At about four feet the undersides of stones are lime-plated.

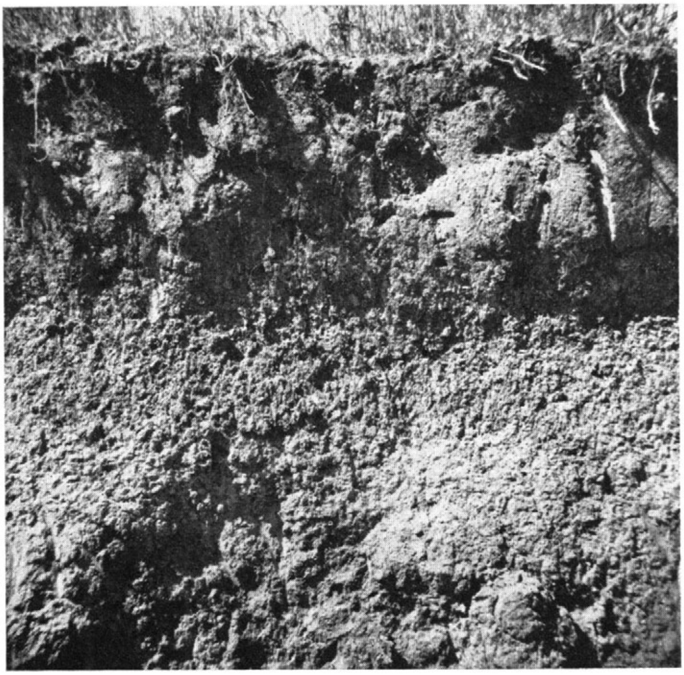

FIGURE 12. Profile of Ingram silt loam, an Orthic Dark Brown soil near Grand Forks.

This is a rapidly drained Rego Dark Brown soil that developed under bunchgrasses. In areas of restricted grazing, wheatgrass and fescues survive, but most of the acreage has converted to annual grasses and weeds. A representative soil profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| Ah1 | 0 – 5 | Gray to dark-gray (10YR 4.5/1, dry) or very dark grayish brown (10YR 3/2, moist) gravelly sandy loam. Weak granular and some weak, subangular blocky structure. Soft when dry. Occasional angular cobbles. Scattered lenses and pockets of white volcanic dust. Numerous fine roots. pH 6.4. |
| Ah2 | 5 – 10 | Grayish-brown (10YR 5/2, dry) or very dark grayish brown (10YR 3/2, moist) gravelly sandy loam. Weak, medium granular structure. Soft when dry. Occasional angular cobbles. Many fine roots. pH 7.0. |
| AC | 10 – 29 | Brown (10YR 5/3, dry) or dark-brown (10YR 3/3, moist) gravelly sandy loam. Weak, fine granular structure. Soft when dry. Increasing amount of angular gravels and cobbles. Numerous fine roots. pH 7.2. |
| C1 | 29 – 40 | Grayish-brown (10YR 5/2, dry) or dark grayish brown (10YR 4/2, moist) gravelly sandy loam or loamy sand. Single-grained. Loose. Many angular gravels and cobbles. Occasional fine roots. pH 7.8. |
| C2 | 40+ | Light brownish gray (10YR 6/2, dry) or grayish-brown (10YR 5/2, moist) gravelly sand. Single-grained. Loose, stony; lime plating on undersides of cobbles. pH 8.0. |

*Agriculture*

The Tuzo gravelly sandy loam is suitable for range but submarginal for dry farming. The limited acreage cultivated is irrigated. The irrigated areas are between Rock Creek and Midway, and they produce good crops of grain, alfalfa, and hay. For sprinkler irrigation the farm delivery requirement is about 30 acre-inches. The water supply for irrigation and domestic use could be pumped from the Kettle River.

The irrigated areas are confined to the lower and least stony parts of the fans. With southern exposure and light texture, the soil warms early for spring planting. Of the soils suitable for irrigation, 328 acres are third-, 375 fourth-, and 82 fifth-class land.

## Carbonated Rego Dark Brown Soils

### *Boldue Gravelly Sandy Loam*

The Boldue gravelly sandy loam is derived from calcareous sandy and gravelly alluvial-colluvial fans. Small areas are scattered in the Kettle River valley from Rock Creek to Grand Forks, and in the Boundary Creek valley south of Greenwood.

The topography, typical of fans, has smooth five to 10 percent slopes that extend outward from the mouths of the coulees that supplied the deposited material. Of 362 acres classified between elevations of 1,800 and 2,900 feet, 287 are arable, 35 are rough-broken, and 40 are excessively stony.

The parent material is distinguished from that of other fan deposits by secondary lime enrichment. Lime accumulated as a result of freshet water dissolving calcareous material at higher elevations and depositing it throughout the fans. This feature makes the fans mildly to moderately alkaline and restricts solum development. The fans are moderately well drained.

The soil is light textured, with varying amounts of angular gravels and stones in the profile. The surface layer is mainly gravelly sandy loam, with inclusions of loamy sand near the apexes of the fan deposits. With depth the textures become coarser and the gravels and cobbles increase. Near the tops of some fans, stones render the land unsuitable for cultivation.

The Boldue gravelly sandy loam developed under bunchgrasses, and an Ah horizon containing carbonates is the only layer that has developed from the parent material. Included are a few areas too small for separate classification, in which tree cover is dominant. In these the Ah horizon is lacking and horizon C extends to the surface. A profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| Ah | 0 – 11 | Dark-gray (10YR 4/1, dry) or very dark gray to very dark grayish brown (10YR 3/1.5, moist) gravelly sandy loam. Weak, subangular blocky to weak, medium granular structure. Slightly hard when dry. Scattered cobbles. Many fine roots. pH 7.5. |
| Ahk | 11 – 18 | Dark grayish brown (10YR 4/2, dry) or very dark grayish brown to very dark brown (10YR 2.5/2, moist) gravelly sandy loam. Weak, medium granular structure. Soft when dry. Scattered cobbles. Many fine roots. pH 7.9. |
| Cca | 18+ | Grayish-brown to light-gray (10YR 5/2–7/2, dry) or very dark grayish brown to grayish-brown (10YR 3/2–5/2, moist) gravelly sandy loam. Becoming coarser with depth. Massive. Hard when dry. Roots to depth of 45 inches. Scattered cobbles; lime coating on gravels below 45 inches. pH 8.0. |

*Agriculture*

The Boldue gravelly sandy loam is suitable for range under the natural conditions. Since moisture is limited, except in spring during the period of seepage, irrigation is necessary for farming. Lime-induced chlorosis (yellowing of leaves) may appear in lime-sensitive plants. Sodium and magnesium salts are not present in harmful quantities.

One or two fans have streams for part of the year, but the main source of irrigation water is the Kettle River. For sprinkler irrigation the farm delivery requirement is about 35 acre-inches. Excessive irrigation would increase seepage and bring drainage problems. Hard water for domestic use may be obtained from wells that intercept seepage.

Preparation of the land for cultivation involves the removal of stones, concentrations of which vary from place to place, and a few trees. Suitability for agriculture is fair to poor, due to low moisture-holding capacity and high lime concentrations, but southern exposures warm quickly in the spring. A limited acreage was cultivated and irrigated at the time of the survey (1957), and fairly good yields of alfalfa, hay, and pasture were obtained. Of the soils suitable for irrigation, 42 acres are third-, 52 fourth-, and 193 fifth-class land.

## Black Soils

This group of soils developed in the most humid parts of the natural grassland region. In a few grassland–forest fringe areas, Black soils extend for a short distance into the forest, showing recent encroachment by the latter. The Black soils occur mainly on the plateau, but there are small areas at lower elevations between Midway and Greenwood and near Grand Forks.

These soils are characterized by an accumulation of organic matter that imparts very dark gray to very dark brown colors to the surface horizons. The surface layer may be slightly acid to neutral. All the Black soils found belong to the Orthic subgroup. These have very dark gray to very dark brown Ah horizons, underlain by pale-brown to yellowish-brown Bm horizons. The Bm horizons have subangular blocky to blocky structure.

AB and BC transitional horizons may or may not be present. The calcareous parent materials may have lime accumulations above an impervious substratum. The Orthic Black soils are: Stevens loam and Mires and Republic gravelly sandy loam.

### Orthic Black Soils

#### *Stevens Loam*

The Stevens loam is derived from a mixture of glacial till, loess, and slopewash. In the surveyed area it is confined to a strip along the 49th parallel between Anarchist Mountain and Grand Forks. The largest acreage is on the plateau west of Rock Creek, where the maximum width is four to five miles.

The topography varies from undulating to rolling (Figure 13), with some steep, hilly land. Elevations are from 2,000 feet near Grand Forks to 2,600 near Rock Creek and up to 4,200 on the south slope of Anarchist Mountain. The total area is 11,653 acres, of which 8,329 are suitable for farming and 3,324 are not.

The parent material is moderately gravelly and stony loam-textured till with a shallow overlay of loess, volcanic dust, and slopewash mixed by burrowing rodents. The thickness of the modified layer averages about 24 inches, and ranges from 12 on knolls to 48 on some slopes. A stone-line often occurs between the till and the comparatively stone-free overlay. The till is weathered to about five feet from the surface, beneath which it is compact and more alkaline than the solum above. The till, from six to 20 feet thick, overlies bedrock or, more rarely, unconsolidated deposits.

FIGURE 13. The landscape of Stevens loam near Bridesville.

The surface layer is loam, with variations to sandy loam and clay loam. Similar variations occur in the till itself. Stones occur on the surface on knolls where erosion has exposed the underlying till, and around bedrock outcroppings where angular fragments have been cracked off by frost and mixed with the surrounding soil. Though most of the soil is well to moderately well drained, some minor depressions are poorly drained.

The Stevens loam, originally named in the State of Washington, developed under bunchgrasses. In the surveyed area it is found along the fringe of a more extensive area in Washington. The main species of groundcover are wheatgrass, fescues, Junegrass, lupine, annual grasses, and weeds. In places at the highest elevations the forest invasion extends to half a mile, the main trees being Douglas fir and larch. A profile (Figure 14) was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| Ah1 | 0 – 15 | Very dark grayish brown (10YR 3/2, dry) or black to very dark brown (10YR 2/1.5, moist) loam. Fine granular structure. Soft when dry. Scattered gravels. Many fine roots. pH 6.7. |
| Ah2 | 15 – 21 | Dark grayish brown (10YR 4/2, dry) or very dark grayish brown (10YR 3/2, moist) sandy loam. Medium, weak, subangular blocky breaking to granular structure. Slightly hard to soft when dry. Scattered gravel. Many fine roots. pH 6.6. |
| AB | 21 – 24 | Brown (10YR 5/3, dry) or dark-brown (10YR 4/3, moist) sandy loam. Medium blocky structure. Hard when dry. Scattered gravels and occasional cobbles. A few roots. pH 6.4. |
| IIBm1 | 24 – 42 | Pale-brown (10YR 6/3, dry) or light olive brown (2.5Y 5/4, moist) sandy loam or loam. Strong blocky structure. Very hard when dry. Scattered gravels, cobbles, and roots. pH 6.6. |

| | | |
|---|---|---|
| IIBm2 | 42–50 | Light yellowish brown (2.5Y 6/4, dry) or light olive brown (2.5Y 5/4, moist) loam. Strong blocky structure. Hard when dry. Scattered gravels, stones, and roots. pH 6.9. |
| IIC | 50+ | Pale-yellow (2.5Y 7/4, dry) or light olive brown (2.5Y 5/4, moist) loam-textured till. Very hard when dry. Accumulated lime in the top 12 inches. pH 7.6. |

Lenses and pockets of white volcanic dust occur at three to six inches from the surface where the land is undisturbed. This is most commonly seen around Myncaster. When mixed in the cultivated layer the volcanic dust may give lighter color values (10YR 4/2–4/1) than is normal in Black soils.

FIGURE 14. Profile of Stevens loam, an Orthic Black soil, west of Bridesville.

*Agriculture*

The Stevens loam is the most extensively dry-farmed soil in the Bridesville area. Very little of the arable acreage is not under cultivation. The main crops are wheat, barley, rye, oats, alfalfa, and some red clover. Lack of moisture is the chief factor limiting growth; depressions outyield knolls. The yields vary with rainfall.

This soil would benefit from irrigation, and in time this may be accomplished. With irrigation, the farm delivery requirement for sprinklers is about 18 acre-inches. Domestic water is obtained from springs and wells located in seepages. Unlined dugouts for storage of stock water are feasible, as the underlying till is impervious.

Gully and sheet erosion occurs on fallow land during violent summer rainstorms and rapid snowmelt in the spring. Such erosion could be reduced by contour cropping with grass and legume mixtures. Ranching and farming of the Stevens loam began in the 1860's. Tree removal was unnecessary and stone picking minor. Crops could be grown without irrigation. Natural fertility is high and some fields are still cropped without the use of fertilizers, although this is not recommended. Of the soils suitable for irrigation, there are 307 acres of third-, 4,094 of fourth-, and 3,928 of fifth-class land.

*Mires Gravelly Sandy Loam*

The Mires series, derived from gravelly outwash terraces, was named in the State of Washington. It is found near the 49th parallel in scattered areas between North Ninemile Creek and Grand Forks. The main acreage borders Baker and Rock creeks on the plateau, and Boundary Creek between Greenwood and Midway.

The average topography is level to gently sloping. A few terraces are kettled and dissected so that they are unfit for cultivation. The kettled and eroded areas were classed as rough-broken topography. The altitude ranges from 1,850 feet near Carson to 3,950 north of Bridesville. The total area is 2,550 acres.

The parent materials are a light-textured layer six inches to four feet deep and a lower, roughly stratified, coarse-textured layer. The lower layer, composed of coarse sands, gravels and cobbles, was transported, sorted, and deposited by meltwater during the retreat of glacier ice. Near Bridesville and Boundary Creek the lower layer, which overlies fine sand, till and bedrock, is less than 50 feet thick. Near Carson it exceeds 50 feet, the depth being unknown. The terraces are above the flood levels of present streams.

The surface layer is usually gravelly sandy loam; there are minor inclusions of gravelly loam. The texture becomes coarser and more gravelly with depth. Areas in which the overlay exceeds 18 inches total 439 acres and are suitable for cultivation. Terraces having an overlay less than 18 inches thick were classed as a shallow phase, and occupy 1,286 acres of arable land. Parts of the Mires series classed as non-arable consist of 798 acres having rough-broken topography, and 27 are excessively stony. Stoniness ranges from none to heavy; eroded knolls and the outer margins of terraces are stoniest. The coarse-textured lower layer causes rapid drainage.

The Mires series is composed of Orthic Black soils that developed under bunchgrass. Most areas are or have been cultivated. Uncultivated terraces support a fairly dense cover of wheatgrass, fescues, Junegrass, needle-and-thread grass, and others. Scattered ponderosa pine grow in kettles and along the inner margins of terraces. A representative profile (Figure 15) was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| Ap | 0 – 12 | Dark-gray to very dark gray (10YR 3.5/1, dry) or very dark brown (10YR 2/2, moist), gravelly sandy loam. Medium granular structure. Friable when moist, slightly hard when dry. Numerous roots. pH 5.9. |
| Ah | 12 – 17 | Dark grayish brown (10YR 4/2, dry) or very dark grayish brown (10YR 3/2, moist) gravelly sandy loam. Fine to medium granular structure. Soft when dry, very friable when moist. Occasional cobbles. Numerous roots. pH 6.7. |

| | | |
|---|---|---|
| Bm1 | 17 – 26 | Dark yellowish brown (10YR 4/4, dry) or very dark yellowish brown (10YR 3/4, moist) gravelly sandy loam. Weak, fine, subangular blocky breaking to granular structure. Friable when moist. Many cobbles and roots. pH 6.8. |
| Bm2 | 26 – 31 | Yellowish-brown (10YR 5/4, dry) or dark yellowish brown (10YR 4/4, moist) gravelly loamy sand. Weak, fine, subangular blocky structure. Friable when moist. Numerous cobbles, a few being lime-plated in the lower part. A few roots. pH 6.9. |
| IIBC | 31 – 40 | Light yellowish brown to yellowish-brown (10YR 5.5/4, dry) or dark yellowish brown (10YR 4/4, moist) gravelly sand. Single-grained, loose. Numerous lime-plated gravels and cobbles. A few roots. pH 7.2. |
| IIC2 | 40+ | Stratified fine gravel, lime-plated in the upper few inches. pH 7.5. |

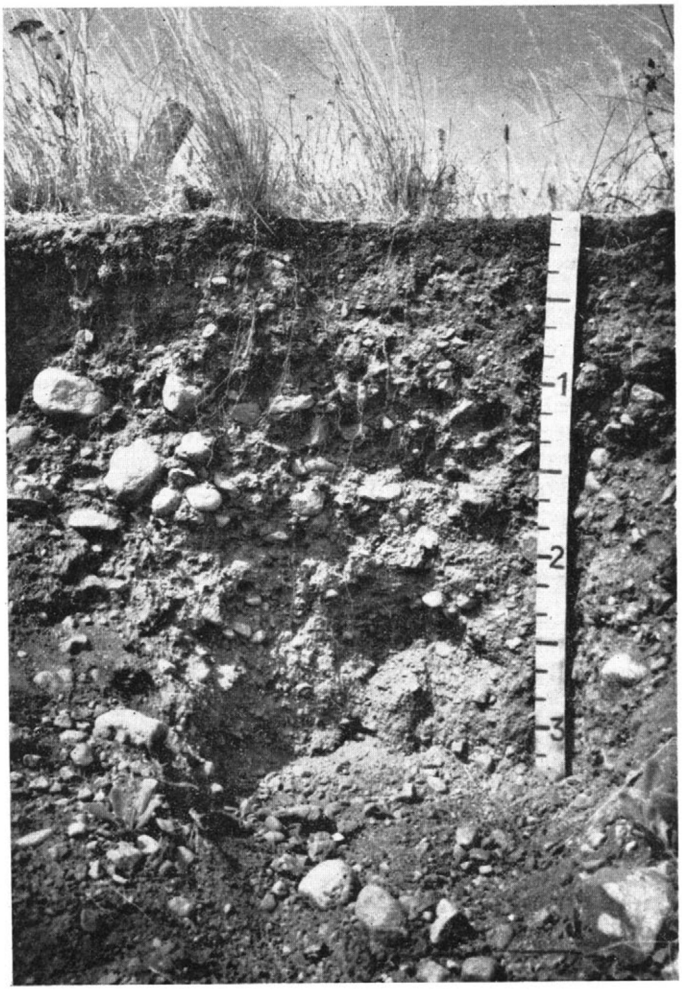

FIGURE 15. Profile of Mires gravelly sandy loam, an Orthic Black soil, near Bridesville.

*Agriculture*

Most of the Mires gravelly sandy loam is on the plateau. It is dry-farmed, regardless of the droughty soil profile. Wheat, barley, rye, and oats are grown, the land being summerfallowed in alternate years. Crop yields are fair to poor, depending on the season and the depth of solum.

A limited acreage of the deep phase, irrigated in the Boundary Creek valley and in the Covert Irrigation District near Carson, yields excellent crops of forage and vegetables. The shallow phase produces well under irrigation, but is not suitable for root crops because of the thin solum. Under sprinkler irrigation the farm delivery requirements are 25 acre-inches for the deep and 30 for the shallow phases. In a few places, water is obtainable from springs on the inner margins of terraces adjacent to higher ground. Well water is also found near streams.

This land can be readily brought under cultivation, and crop returns are sufficient to warrant dry farming. Stone removal is necessary in the shallow phase, but no other reclamation is required unless the land is to be irrigated. Of the soils suitable for irrigation, the deep phase occupies 48 acres of second-, 313 of third-, and 78 of fourth-class land. The shallow phase has 379 acres of third-, 537 of fourth-, and 370 of fifth-class land.

### *Republic Gravelly Sandy Loam*

The Republic series was named in the State of Washington. It is derived from alluvial-colluvial fans scattered on the plateau, in the Kettle River valley from Rock Creek to Gilpin, and in the valley of Boundary Creek.

From the mouths of coulees from which the materials were derived, the fans slope downward toward the margins with gradually decreasing gradients. Slopes may be up to 15 percent in the upper part of a fan, but most vary between two and five percent. The elevation ranges from 1,700 feet near Gilpin to 3,780 on Anarchist Mountain. In a total of 1,344 acres mapped, 977 are arable, 53 have rough-broken topography, and 314 are excessively stony.

The parent materials were eroded from glacial till and gravelly outwash originally deposited at higher elevations. The fan deposits vary in thickness over gravelly terraces. The fan materials are graded; the coarser textures are near the apex and the finer ones near the lower margin. The soils are light textured, and have a fairly high content of angular gravels. The surface layer is usually gravelly sandy loam, with variations to gravelly loamy sand near the apex and gravelly loam around the fan apron. With depth the texture coarsens and the quantities of angular and rounded gravels and stones increase. Runoff channels on the fan surface are gravelly and stony. Lime plating on the undersides of cobbles is found about four feet deep. The fans are rapidly to moderately well drained.

The Republic gravelly sandy loam is an Orthic Black soil that developed under natural grass. Included is a minor acreage of fan soils that grade to Rego Black. In most areas the bunchgrasses have been destroyed and replaced by annual grasses and weeds, including downy bromegrass, downy plantain, mullein, lupine, and yarrow. In the well-drained areas scattered ponderosa pine are found, and in seepages aspen and willow. A profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| Ap | 0– 7 | Dark-gray to very dark gray (10YR 3.5/1, dry) or very dark brown (10YR 2/2, moist) gravelly sandy loam. Weak, fine granular structure. Soft when dry. A few angular gravels and fine roots. pH 6.3. |

| | | |
|---|---|---|
| Ah | 7 – 12 | Grayish-brown (10YR 5/2, dry) or very dark grayish brown (10YR 3/2, moist) gravelly sandy loam. Weak, medium blocky with indication of weak, fine prismatic structure. Slightly hard when dry. Some fine roots. pH 6.3. |
| AB | 12 – 18 | Brown (10YR 5/3, dry) or dark yellowish brown (10YR 4/4, moist) gravelly sandy loam. Weak, medium blocky structure. Slightly hard when dry. A few fine roots. pH 6.6. |
| Bm1 | 18 – 26 | Pale-brown (10YR 6/3, dry) or dark brown (10YR 4/3, moist) gravelly sandy loam. Weak, medium blocky structure. Slightly hard when dry. Scattered cobbles. An occasional fine root. pH 6.7. |
| Bm2 | 26 – 35 | Pale-brown (10YR 6/3, dry) or yellowish-brown (10YR 5/4, moist) gravelly sandy loam. Subangular blocky to weak, fine granular structure. Soft to loose when dry. Many cobbles and fine roots. pH 7.0. |
| C | 35 – 50 | Very pale brown (10YR 7/3, dry) or brown (10YR 5/3, moist) gravelly sandy loam. Massive. Hard when dry. Scattered cobbles and roots. Lime plating on undersides of some gravels. pH 7.2. |
| Ck | 50+ | Light-gray (10YR 7/2, dry) or light brownish gray (10YR 6/2, moist) gravelly sandy loam. Cobbly, calcareous; much lime plating on stones. pH 7.9. |

*Agriculture*

Dry-farming yields are fair to poor, depending on the amount of rainfall. Wheat, barley, rye, and oats are grown, with summerfallow every other year. This soil would produce a wide range of crops under irrigation and give good yields. Excellent forage crops are grown in the irrigated areas. For sprinkler irrigation the farm delivery requirement is 25 acre-inches. Domestic water is obtainable from wells that intercept seepage, or from irrigation systems.

In 1957 nearly all arable acreages of this soil were under cultivation. Aside from irrigation works, reclamation costs are low and soil fertility high. Areas too stony for cultivation are good grazing land if controlled to maintain the native bunchgrasses. Of the soils suitable for irrigation, 112 acres are second-, 270 third-, 337 fourth-, and 218 fifth-class land.

## Dark Gray Soils

The Dark Gray soils occur in the valley of the Kettle River downstream from Westbridge. They developed under native grasses or mixed trees and grass. A change of conditions favored trees and the areas are now dominated by forest.

Though the soils retain most of the characteristics of grassland, there is some degradation of the Ah horizon. It is more brown or gray than normal for the grassland soils of the surveyed area. The Ah horizon may have a speckled appearance, due to sand grains that have lost their organic coating.

The Rego Dark Gray subgroup was the only one found. These soils are characterized by a thin L–H layer of forest litter and a grayish-brown Ah horizon overlying horizon C. The only soil type in this subgroup is Marble sand.

## Rego Dark Gray Soils

### *Marble Sand*

Marble sand is derived from sandy terraces of the Kettle River between Westbridge and Cascade. The main areas are between Rock Creek and Midway, and near Grand Forks.

The topography varies from smooth, very gently sloping to irregular with moderate slopes. Low dunes, some of recent origin, are responsible for the irregular slopes. The elevation ranges from 2,100 feet near Westbridge to 1,640 near Cascade. A total of 1,400 acres were mapped, all of which could be cultivated.

The parent material, similar to that from which the Bubar series is derived, consists of medium to fine sandy outwash deposits that may contain occasional gravels. The Marble sand differs mainly from the Bubar soils by more limited solum development. The surface layer varies from fine to medium sand, the sand becoming coarser with depth. The soil is rapidly drained.

The Marble sand, a Rego Dark Gray soil, occurs in the dry, southern section of the surveyed area. The native vegetation is a light to medium stand of ponderosa pine, with a few Douglas fir in areas north of Rock Creek. The sparse ground cover is largely downy bromegrass, diffuse knapweed and pussytoes, with patches of bunchgrass in open areas. A profile near Grand Forks (Figure 16) was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L | Trace | Thin litter of undecomposed ponderosa pine needles, cones, and wood. Absent away from trees. |
| Ah | 0 – 5 | Grayish-brown (2.5Y 5/2, dry) or very dark grayish brown (10YR 3/2, moist) fine sand. Very weak, subangular blocky and single-grained structure. Soft to loose when dry. Fine roots in upper part. In places this horizon is covered by a few inches of drifted sand. pH 6.5. |
| C1 | 5 – 21 | Pale-brown (10YR 6/3, dry) or grayish-brown to dark grayish brown (2.5Y 4.5/2, moist) fine sand. Breaking to fragments and then to single grains. Soft when dry. Scattered tree roots. pH 6.9. |
| C2 | 21+ | Pale-brown (10YR 6/3, dry) or grayish-brown to dark grayish brown (2.5Y 4.5/2, moist) fine sand. Single-grained, loose. Scattered tree roots. pH 7.0. |

*Agriculture*

In the virgin state the Marble sand can support light grazing. With irrigation it could be used for producing crops suitable to the areas in which it occurs. Irrigation water must be flumed or piped to delivery points, owing to the high porosity of the parent material.

For effective irrigation, light sprinkler applications should be applied frequently. In dry years and for some crops a May irrigation is necessary. The farm delivery requirement for irrigation is about 60 acre-inches. Domestic water is obtainable from the Kettle River, or from wells drilled below river level.

When reclaimed, the Marble sand has only fair suitability for farming, due to low organic matter and available plant nutrients, and a high water requirement. Advantages are that it is stone-free and warms early in the spring. Of the soils suitable for irrigation, 1,132 acres are fourth- and 268 are fifth-class land.

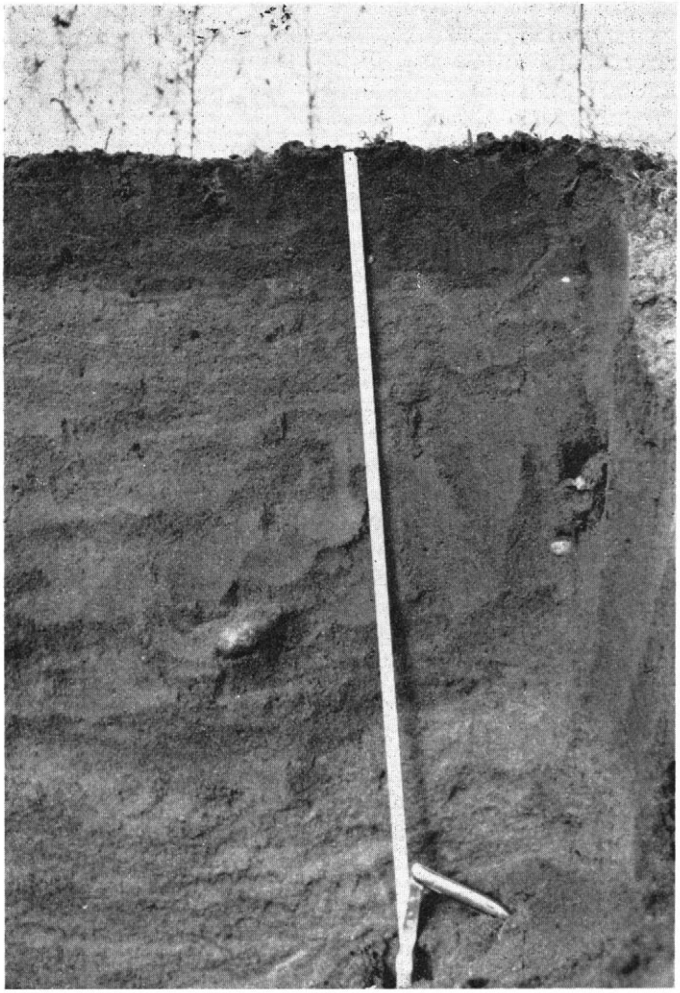

FIGURE 16. Profile of Marble sand, a Rego Dark Gray soil, near Grand Forks.

## Brown Wooded Soils

The Brown Wooded soils have brownish sola that are slightly acid or neutral, and lack distinct Ah, eluvial, and illuvial horizons. The parent material may or may not be calcareous. The climate is semiarid to subhumid, and the vegetation is open to heavy coniferous forest. These soils occupy most of the forested land in the surveyed area. Three subgroups were found:

*Orthic Brown Wooded* soils are well-drained soils characterized by pale-brown to yellowish-brown Bm or Bf horizons that show no translocation of clay or sesquioxides. There is a thin L–H horizon of forest litter at the surface.

Where the soils are deeply weathered, the Bf horizon is underlain by a Bm horizon. In other places a transitional BC horizon is usually present. The soils in this subgroup are: Mogul very fine sandy loam, Beaverdell gravelly sandy loam, Burrell sandy loam, Zamora loamy sand, Ferroux sandy loam, and Phoenix sandy loam.

*Degraded Brown Wooded* soils have slight movement of clay and sesquioxides. This is shown by a weakly developed pale-brown to light brownish gray Aej horizon, underlain by a yellowish-brown Btj horizon that shows slight clay accumulation. Transitional AB and BC horizons may be present. The only soil in this subgroup is Fiva sandy loam.

*Gleyed Brown Wooded* soils are similar to Orthic Brown Wooded soils, except for gleying and mottling in the lower part of the solum, due to a fluctuating water table. The only representative is Coteay sandy loam.

## Orthic Brown Wooded Soils

### *Mogul Very Fine Sandy Loam*

This soil type is derived from stratified glaciolacustrine deposits in the Boundary Creek valley near its junction with the Kettle River valley. A small area in the Granby Valley having the same profile development, but derived from a floodplain, was included.

The topography is smooth to gently sloping, with eroded areas having an irregular, steeply sloping surface. The elevation ranges from 2,400 to 2,650 feet. Of a total of 161 acres, 150 are arable and 11 are rough and broken.

The parent materials are light-colored loamy sediments that are mildly to moderately alkaline. They were deposited in small ice-margin lakes during decay of the last glacier. The deposits, 30 feet thick or more, overlie stratified gravels and bedrock. The surface layer is usually very fine sandy loam. There are minor inclusions of loam and silt loam. At depths there are loam and fine sandy loam strata. Scattered gravels and cobbles occur; there generally is a thin stone-line in the solum.

The Mogul very fine sandy loam is a well-drained Orthic Brown Wooded soil that developed in a fairly dry climate under open forest. The most common tree is ponderosa pine; minor numbers of Douglas fir and larch occur. There is a sparse groundcover of bunchgrass, kinnikinnick, and lupine. The profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–F | 1½ – 0 | Forest litter of needles, twigs, cones, and grass. Partly decomposed in the lower part. |
| Bm1 | 0 – 3 | Light brownish gray to grayish-brown (10YR 5.5/2, dry) or very dark grayish brown (10YR 3/2, moist) very fine sandy loam. Weak, fine, platy to weak, subangular blocky structure. Soft when dry. Numerous roots. pH 6.6. |
| Bm2 | 3 – 15 | Pale-brown (10YR 6/3, dry) or dark grayish brown (10YR 4/2, moist) very fine sandy loam to loam. Very weak, medium subangular blocky structure. Softer than horizon above. Scattered gravels; a cobble layer at contact with underlying horizon. pH 6.8. |
| BC | 15 – 23 | Light-gray to light brownish gray (10YR 6.5/2, dry) or grayish-brown to light olive brown (2.5Y 5/3, moist) loam. Medium, subangular blocky structure. Slightly hard when dry. Occasional gravels and cobbles. A few roots. pH 7.0. |
| CB | 23 – 43 | Light-gray (10YR 7/2, dry) or dark grayish brown (2.5Y 4/2, moist) loam. Massive, slightly hard with soft spots. Scattered, flat-angular pieces of parent material. Occasional cobbles lime-plated on undersides. A few roots. pH 7.3. |

| | | |
|---|---|---|
| C | 43 – 52 | White (10YR 8/1, dry) or grayish-brown (2.5Y 5/2, moist) very fine sandy loam. Massive, breaking into flat-angular fragments. Hard when dry. A few roots terminating in root mats. pH 7.6. |
| Cca | 52+ | White (10YR 8/1, dry) or light brownish gray to grayish-brown (2.5Y 5.5/2, moist) stratified loam. Hard when dry. Visible carbonates. pH 8.3. |

*Agriculture*

Only one small area in the Granby Valley is cultivated. Though marginal for dry farming, the soil is productive when irrigated. The farm delivery requirement for sprinkler irrigation is about 25 acre-inches. Domestic water, unavailable from wells, would have to be stored in lined cisterns.

This moderately fertile soil is susceptible to erosion. When irrigated it requires the protection afforded by sod crops. Legume–grass mixtures are recommended, with grain growing restricted to companion crops. To improve the soil structure, the organic matter content of the soil should be increased.

Reclamation of the land involves the removal of a light forest cover, cultivation, and irrigation works. Of the acreage suitable for irrigation, 16 acres are second-, 11 third-, and 123 fourth-class land.

### *Beaverdell Gravelly Sandy Loam*

The Beaverdell gravelly sandy loam is derived from gravelly outwash, including gravelly river terraces. Though it occurs throughout the surveyed area, the acreage is most extensive on the plateau and in the Kettle and West-kettle river valleys north of Rock Creek.

The topography varies from level and gentle irregular slopes to very steep slopes in eroded areas. Terrace areas are often composed of several small step-like terraces differing in elevation by from two to 25 feet. Areas severely eroded or kettled were mapped as a rough-broken phase, unsuitable for cultivation. The altitude ranges from 1,720 feet near Cascade to 4,400 near Camp McKinney. Of a total of 25,439 acres, 11,362 are topographically suitable for farming, 5,234 are rough-broken, and 8,843 are excessively stony (Figure 17).

The coarse substrata were deposited by overloaded, melt water streams. The deposits occur as abandoned stream channels and terraces. At the time of deposition the streams eroded glacial drift, carried away the finer sediments, and concentrated the coarser and heavier sands, gravels, cobbles, and boulders. The proportions of the different components in any deposit depended on the stream velocity from place to place and from time to time. The deposits are roughly stratified and the gravels and stones have different degrees of rounding. They vary in thickness from a few feet to 150 feet or more, and overlie stratified sands, till, and bedrock. The substrata are neutral to slightly acid.

During the last stages of stream abandonment, as the valley fill was down-cut, a finer-textured surface coating up to 20 inches thick, and containing some gravel, was deposited on the coarser strata. Additional gravel was later mixed into the overlay by frost and by upheaval of tree roots. The finer-textured surface layer averages about 16 inches thick, and its average texture is gravelly sandy loam. There are minor areas of loamy sand that were not mapped. The texture coarsens with depth. Surface stoniness varies from none at all to excessive where the overlay is thin or lacking.

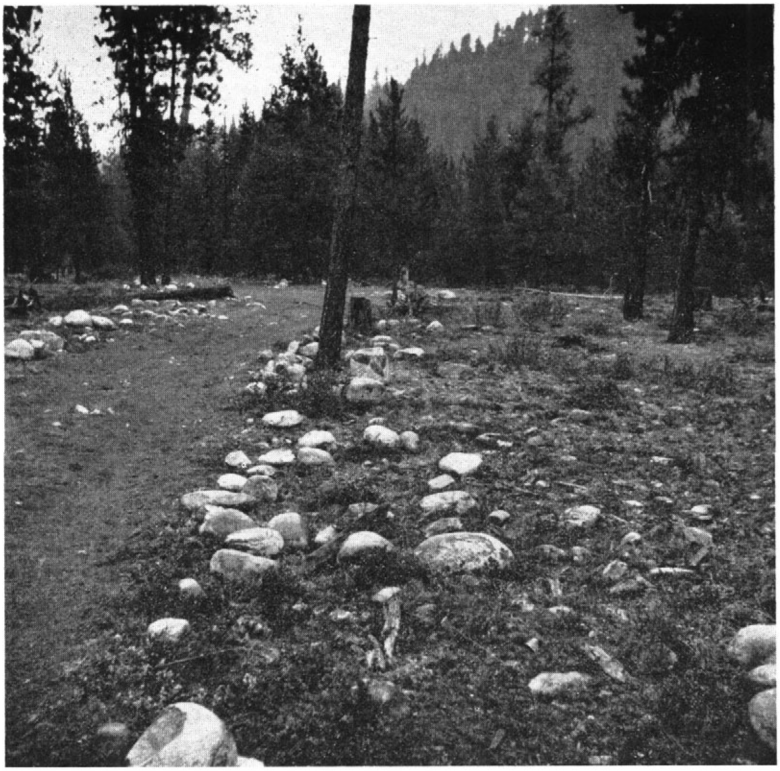

FIGURE 17. Landscape of Beaverdell gravelly sandy loam, excessively stony phase, near Carmi in the Westkettle Valley.

This rapidly drained Orthic Brown Wooded soil developed under coniferous forest. The tree cover consists of open to medium heavy stands of Douglas fir and larch, with ponderosa pine in the most arid and spruce in the most humid sections. A sparse and variable ground cover includes pinegrass, shepherdia, kinnikinnick, twinflower, lupine, saskatoon, and others. A representative profile (Figure 18) was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–F | 1 – 0 | Forest litter of grass, needles, twigs, etc. Somewhat decomposed in the lower part. |
| | 0 – 2 | Light-gray (10YR 7/1-7/2, dry) or grayish-brown (10YR 5/2, moist) volcanic dust of fine sandy loam texture. Weak platy, breaking to fine granular structure. Scattered gravel and fine roots. pH 6.1. |
| Bf1 | 2 – 7 | Pale-brown (10YR 6/3, dry) or yellowish-brown (10YR 5/4, moist) gravelly sandy loam. Weak granular and some very weak, subangular blocky structure. Soft when dry. Occasional cobbles. Many fine roots. pH 6.5. |
| Bf2 | 7 – 13 | Very pale brown (10YR 7/4, dry) or dark yellowish brown (10YR 4/4, moist) gravelly sandy loam. Weak granular structure. Soft when dry. Occasional cobbles. Many fine roots. pH 6.5. |

| | | |
|---|---|---|
| IIBC | 13 – 17 | Pale-brown (10YR 6/3, dry) or brown (10YR 4/3, moist) sand in matrix of gravels and cobbles. Single-grained, loose. Concentration of large cobbles. Numerous roots. pH 6.4. |
| IIC | 17+ | Clean coarse sands in a matrix of roughly stratified gravels and cobbles. Variegated colors. A few roots to 36 inches deep. pH 6.6. |

FIGURE 18. Profile of Beaverdell gravelly sandy loam, an Orthic Brown Wooded soil, near Waddell Creek in the Kettle Valley. White horizon of volcanic dust near the surface.

*Agriculture*

Under natural cover the Beaverdell gravelly sandy loam is used for forestry and limited grazing. It is submarginal for dry farming, and with irrigation the rating is fair to poor. Cultivation should be kept to a minimum, owing to the thin solum. The farm delivery requirement is about 35 acre-inches for sprinkler irrigation. The water should be flumed or piped to points of distribution.

Irrigation water is available from the rivers in the Kettle and Westkettle valleys. In selected areas on the plateau, creeks and depressions could be dammed and water stored to irrigate adjacent areas. Irrigation systems, cisterns, and seepages on adjoining soils are sources of domestic water.

The shallow solum and cool climate limit the range of crops to legume-grass mixtures, hay, and grain on most areas. Row crops, such as potatoes, are confined to areas having a deeper than average solum. Natural fertility is low and only a few small clearings were farmed at the time of the survey (1957).

Preparation of the land for cultivation involves the clearing of light to moderate forest and removal of stones; all degrees of stoniness occur. Areas of moderate stoniness are best used for pasture. Excessively stony areas should be used for range and forestry. In the establishment of a farm, part of the acreage should include another soil type. Of the soils suitable for irrigation, 947 acres are third-, 6,334 are fourth-, and 4,081 are fifth-class land.

### *Burrell Sandy Loam*

Soils of this type occur on scattered gravelly terraces in the Granby River valley north of Lynch Creek. The topography is smooth to irregular, gently to very gently sloping. The terraces generally have a slight slope away from the river, the inner edge having the thickest overlay. The elevation ranges from 1,900 to 2,300 feet. All of a total of 1,069 acres mapped are arable.

The parent material is a moderately coarse sandy deposit from 20 to 60 inches thick and overlying gravelly substrata. After the gravels were laid down in the stream bed, the sandy overlay was deposited during the final stages of flooding. The Burrell sandy loam is closely associated with the Beaverdell soil, which occupies terrace areas where the gravels are 20 inches or less from the surface. Small areas of Beaverdell gravelly sandy loam are included with the Burrell sandy loam. These areas consist of former gravel bars that protrude above the general level of the gravelly substrata.

The surface layer is usually sandy loam with scattered gravels. The texture grades to loamy sand and sand with depth, with an increase in gravel content. Cobbles are absent from the solum except where the gravelly substrata are close to the surface. In such places the texture may vary to loamy sand.

The Burrell sandy loam is a well-drained, slightly acid Brown Wooded soil that developed under a fairly humid climate. Severe burns have destroyed most of the climax cover. In the drier areas this was spruce and alpine fir, with some white pine. In the humid ones it was cedar and hemlock. Lodgepole pine, Douglas fir, and larch are now the main species of trees, and the shrub and ground cover is saskatoon, dwarf blueberry, kinnikinnick, pinegrass, and others. A profile on a terrace near the junction of Burrell Creek and Granby River is described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 1 – 0 | Coniferous forest litter. Charcoal at contact with the mineral soil. |
| | 0 – 3 | Pale-brown (10YR 6/3, dry) or yellowish-brown (10YR 5/4, moist) loam-textured volcanic dust slightly mixed with mineral soil. Weak, medium granular structure. Soft when dry, friable when moist. Scattered fine roots. pH 6.6. |

| | | |
|---|---|---|
| Bf1 | 3 – 8 | Yellowish-brown (10YR 5/4, dry) or strong-brown (7.5YR 5/8, moist) sandy loam. Weak, medium, subangular blocky structure. Soft when dry, friable when moist. Occasional gravels. Many fine roots. pH 6.6. |
| Bf2 | 8 – 12 | Light yellowish brown (10YR 6/4, dry) or yellowish-brown (10YR 5/8, moist) sandy loam. Weak, medium, subangular blocky structure. Soft when dry, friable when moist. Irregular lower boundary. Occasional gravels. Many fine roots. pH 6.6. |
| Bm | 12 – 26 | Light yellowish brown (10YR 6/4, dry) or yellowish-brown (10YR 5/4, moist) sandy loam. Coarse blocky structure. Slightly hard when dry, friable to firm when moist. Vesicular in upper part. Variegated color due to clay remnants. Occasional gravel; a few cobbles in lower part. pH 6.5. |
| IIC | 26+ | Very pale brown (10YR 7/4, dry) or light yellowish brown (10YR 6/4, moist) sand in matrix of gravels and cobbles. Single-grained, loose. Occasional roots. pH 6.4. |

Thin layers of illuvial clay occur in the lower part of solums having overlays exceeding 36 inches. Numerous iron-stained bands are found in the gravelly substrata to depths of 15 feet.

*Agriculture*

There is fair summer range where tree cover is light. Limited yields of hay are obtained by dry farming. One small area was irrigated at the time of the survey (1957), and gave a moderate hay crop. The sources of irrigation and domestic water are the Granby River and its tributaries. The farm delivery requirement for sprinkler irrigation is 30 acre-inches.

Land clearing is light because the mature forest was destroyed by logging and fire. Stone removal is necessary where gravel bars approach the surface. When first cultivated the land should be seeded to legume-grass mixtures. The Bm horizon becomes hard when dry, restricting the rooting zone. This can be overcome with irrigation by keeping the subsoil moist. The soils suitable for irrigation are 944 acres of third-, 60 of fourth-, and 65 of fifth-class land.

### *Zamora Loamy Sand*

The Zamora loamy sand is derived from sandy outwash deposits, including sandy river terraces. The largest areas are along North Ninemile and McKinney creeks on the plateau, and in the Kettle River valley north of Westbridge. Small areas occur throughout the surveyed area.

The topography varies from level to gently sloping and undulating. A small acreage is severely eroded and steeply sloping. The elevations are from 1,670 feet near Cascade to 4,400 east of Camp McKinney. The total of 2,718 acres consists of 2,480 topographically suitable for agriculture and 238 of rough-broken land.

The parent material, associated with gravelly deposits of similar origin, was laid down by meltwater streams as glacier ice decayed. The sandy deposits vary from a few to 50 feet or more thick, and overlie glaciolacustrine silts, till, or bedrock. Included with the Zamora loamy sand is a small acreage of sandy fans.

The surface layer is usually loamy sand, with small areas of sand and sandy loam. The texture coarsens with depth, grading to medium and coarse sands within 12 to 18 inches. Scattered gravels occur throughout the solum. Layers of gravels and cobbles are common in the substrata.

The Zamora loamy sand is a rapidly drained, slightly acid to neutral Orthic Brown Wooded soil that developed under a forest of Douglas fir and larch. Ponderosa pine appears in the arid sections and spruce in the most humid. Lodgepole pine occupies recent burns along with scattered groves of aspen and willow. The ground cover consists mostly of pinegrass, kinnikinnick, sheperdia, lupine, twin-flower, dwarf blueberry, and dogbane. A representative profile is described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 1 – 0 | Forest litter of needles, cones, twigs, and grass, decomposed in the lower part. Charcoal at contact with the mineral soil. |
| | 0 – 1 | White (10YR 8/2, dry) or light brownish gray (10YR 6/2, moist) volcanic dust of fine sandy loam texture mixed with a little mineral soil. Usually continuous but not always present as a layer. Very weak, fine platy structure. |
| Bf1 | 1 – 9 | Pale-brown (10YR 6/3, dry) or yellowish-brown (10YR 5/4, moist) loamy sand. Weak granular structure. Soft to loose when dry. Occasional fine gravel; pockets and flecks of volcanic dust to a depth of five inches. Many fine roots. pH 6.4. |
| Bf2 | 9 – 20 | Very pale brown (10YR 7/3.5, dry) or yellowish-brown (10YR 5/6, moist) loamy sand. Very weak, subangular blocky to weak granular structure. Soft to loose when dry. Occasional gravel. Numerous fine roots. pH 6.6. |
| BC | 20 – 28 | Light-gray (2.5Y 7/2, dry) or grayish-brown to light olive brown (2.5Y 5/3, moist) sand. Weak, subangular blocky structure. Soft with slightly hard spots when dry. Scattered gravel and roots. pH 6.7. |
| C1 | 28 – 48 | White to light-gray (10YR 7.5/2, dry) or grayish-brown (2.5Y 5/2, moist) medium sand. Single-grained, loose, micaceous. A layer of gravels and cobbles at 40 to 48 inches. A few roots. pH 6.5. |
| C2 | 48+ | Clean coarse sand and fine gravel. Single-grained, loose, micaceous. pH 6.5. |

In dry sites thin clay layers may occur in the BC horizon.

*Agriculture*

The open substrata and the summer-dry climate make Zamora loamy sand submarginal for dry farming. In the native state it has value for timber, Christmas trees, and range. With irrigation hardy crops could be grown. The farm delivery requirement for sprinkler irrigation is about 30 acre-inches. The water should be piped or flumed to farm headgates. Areas in the river valleys could be irrigated from the rivers or wells near the rivers. The domestic water supply would come from the same sources. On the plateau the water supply could be stored snowmelt.

Legume–grass mixtures are the most suitable crops, with grain as a companion crop. Cool-season vegetables could be produced. Preparation of the land for farming requires removal of a light to medium forest, mostly second-growth, and old logs and stumps. The soil dries and warms rapidly in the spring. This soil should be combined with another soil type in the farm unit. The soils suitable for irrigation are 43 acres of third-, 1,927 of fourth-, and 510 of fifth-class land.

### *Ferroux Sandy Loam*

The Ferroux sandy loam is derived from alluvial-colluvial fans which are widely scattered in the Kettle, Westkettle, and Granby river valleys and in the larger tributary creek valleys.

Smooth, steep to gentle slopes prevail. The upper parts of eroded compound fans are rough-broken land with slopes up to 50 percent. The slopes are greatest near the apex, and become gentle toward the fan apron. Some of the fans that overlie terraces have truncated lower margins. The elevations range from 1,600 feet near Christina Lake to 3,950 on the plateau. Of 8,778 acres mapped, 3,942 are arable, 1,054 are rough-broken, and 3,782 are excessively stony (Figure 19).

FIGURE 19. Landscape of Ferroux sandy loam, excessively stony phase, near Lynch Creek in the Granby Valley.

The fan deposits vary in texture because of differences in the volume and velocity of the streams that contributed material. Temporary and permanent streams transported debris from higher elevations and dropped their loads at the toes of the valley slopes. The coarser materials dropped first, so that stones are concentrated near the fan apex. Progressively finer materials were deposited downslope. Most of the fans were stage-built by a succession of cloudbursts or outwashes. At each deposition the previous runoff channel was filled and a new one excavated, which left lenses of gravels buried at various depths in different parts of the fan. When the fan is irrigated the gravel lenses convey excess water and often create drainage problems.

The deposits consist of roughly stratified coarse sands, angular and rounded gravels, cobbles, and larger stones, mixed with variable amounts of finer materials. The proportion of fines increases toward the surface; the surface layer may be largely free of gravel and cobbles to a depth of 48 inches. The finer-textured top layer indicates that the velocity and volume of the more recent outwashes inundating the fans were lower than the older ones and did not move the heavier detritus.

The surface layer is usually sandy loam, but may vary to loamy sand near the fan apex and to loam near the margins. In places the soil is gravelly. Surface stoniness varies with concentrations in places of thin or no overlay. Most fans lie well above drainage levels, and both surface and internal drainage are rapid. Drainage is imperfect in places along the outer margins of a few fans that overlie impervious substrata.

The slightly acid to mildly alkaline Ferroux sandy loam is an Orthic Brown Wooded soil. Included in the mapping unit are minor, excessively stony areas that lack solum development. The forest cover is composed of medium heavy stands of Douglas fir and larch, with ponderosa pine in the dry and spruce in the humid sections. Spruce, cedar, cottonwood, willow, and red-osier dogwood grow in seepage areas. Lodgepole pine, aspen, and willow occupy recent burns. The light to medium undercover includes pinegrass, fireweed, twinflower, kinnikinnick, soopolallie, and Oregon grape. A profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 1 – 0 | Thin forest litter of needles, leaves, twigs, and moss. pH 5.6. |
| | | White volcanic dust from $\frac{1}{8}$ to $\frac{1}{4}$ inch thick. |
| Bf1 | 0 – 8 | Pale-brown (10YR 6/3, dry) or dark yellowish brown (10YR 4/4, moist) sandy loam. Weak granular structure. Soft when dry. Some angular gravels and fine roots. pH 7.1. |
| Bf2 | 8 – 17 | Pale-brown (10YR 6/3, dry) or light olive brown (2.5Y 5/6, moist) sandy loam. Weak granular structure. Soft when dry. Occasional gravels and some fine roots. pH 7.3. |
| C | 17 – 32 | Pale-brown (10YR 6/3, dry) or dark grayish brown to olive-brown (2.5Y 4/3, moist) gravelly sandy loam. Single-grained, loose. Sandy and gravelly layers. Some roots. pH 7.4. |
| C–IIC | 32+ | Light brownish gray to grayish-brown (2.5Y 5.5/2, dry) or dark grayish brown to olive-brown (2.5Y 4/3, moist) gravelly loamy sand with lenses of clean coarse sand and gravels. Single-grained, loose, porous, micaceous. Occasional small cobbles and roots. pH 7.4. |

*Agriculture*

In the native state the Ferroux sandy loam supports grazing and forest for timber and Christmas trees. The open substrata render the soil marginal to submarginal for dry farming. Sprinkler irrigation is recommended to limit erosion and water losses. The farm delivery requirement for sprinkler irrigation is about 25 acre-inches.

Most of the arable acreage is in the river valleys, where irrigation and domestic water is obtainable from nearby rivers or tributary streams. On the plateau, areas near creeks could be irrigated.

Preparation of the land for farming consists of removing the forest, stone picking, and irrigation works. Areas of light to moderate stoniness are suitable for all climatically suitable crops; those with greater stone concentrations are best used for pasture. Excessively stony land is limited to range and woodlots.

Legumes and legume–grass mixtures are adapted to the prevailing climate, and grain could be grown in a rotation. Specialized crops, such as potatoes and cool-season vegetables, can be produced where the solum has adequate depth. A few small areas that include other soil types are irrigated.

The suitability of different areas for agriculture depends on the depth of the sandy loam overlay and the degree of slope. Areas averaging 24 inches of sandy loam have adequate moisture-storage capacity and rooting zones. Of the soils suitable for irrigation, 84 acres are second-, 330 third-, 1,927 fourth-, and 1,601 fifth-class land.

### *Phoenix Sandy Loam*

The Phoenix sandy loam, which is derived from light-textured alluvial-colluvial fans, is confined to the more humid sections of the surveyed area. These fans are in the northern part of the Granby River valley, near Eholt, in the upper Boundary Creek valley, and in the Rendell Creek valley.

The steeper slopes are near the fan apex, and become more gentle toward the outer margins. Some fans were dissected by streams, and the topography is rough-broken. Elevations are from 1,850 feet south of Lynch Creek in the Granby Valley to 3,300 in the upper part of the Boundary Creek valley. A total of 834 acres were mapped, of which 715 are arable, 103 rough-broken, and 16 excessively stony.

The parent materials are roughly stratified sands, gravels, and cobbles and variable amounts of finer materials. The coarser materials are most common near the apex and the proportion of finer textures increases downslope. The average texture of the surface layer is sandy loam; minor areas of loamy sand near fan apexes are included. Textures become coarser with depth, grading to sand containing gravels and cobbles. Surface stoniness is generally light except where the sandy overlay is thin or absent.

The well-drained, slightly acid Phoenix sandy loam is an Orthic Brown Wooded soil. It developed under fairly moist forest conditions that support spruce, alpine fir, and white pine as the climax growth. Younger forest is composed of Douglas fir, larch, and lodgepole pine, with an understory of spruce and alpine fir. Saskatoon, spirea and sheperdia are the main shrubs, and pachystima, prince's pine, kinnikinnick, ground dogwood, and others make up a dense ground cover. A typical profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 1 – 0 | Coniferous forest litter, partly decomposed in the lower part. |
| | 0 – 2 | Light-gray to light brownish gray (10YR 6.5/2, dry) or grayish-brown to brown (10YR 5/2.5, moist) volcanic dust of fine sandy loam texture, mixed with some mineral soil. Weak, medium granular structure. Soft when dry, friable when moist. pH 6.3. |
| Bf | 2 – 10 | Light yellowish brown (10YR 6/4, dry) or dark yellowish brown (10YR 4/4, moist) sandy loam. Weak, medium granular structure. Soft when dry, friable when moist. Occasional specks of volcanic dust. Scattered gravels. Irregular lower boundary with tongues down to 18 inches. Many fine roots. pH 6.4. |

| | | |
|---|---|---|
| Bm | 10–40 | Pale-brown (10YR 6/3, dry) or yellowish-brown (10YR 5/4, moist) loamy sand. Weak, medium, subangular blocky structure. Slightly hard to hard when dry, friable when moist. Scattered gravels and cobbles. Clay remnants in the form of nodules and thin layers giving horizon a variegated color pattern. pH 6.1 to 5.9. |
| C–IIC | 40+ | Very pale brown (10YR 7/3, dry) or light olive brown (2.5Y 5/4, moist) gravelly sand. Single-grained, loose. Scattered cobbles. pH 6.0. |

*Agriculture*

In the native state the Phoenix sandy loam is suitable for limited forest range and the production of timber. A small acreage on lower parts of fans near Eholt is dry-farmed, and crop yields are only fair. The full potential yield is attained with irrigation. The farm delivery requirement for sprinklers is about 25 acre-inches. Since most of the acreage is in river and creek valleys, an irrigation and domestic water supply is nearby.

The clearing of heavy forest cover is the greatest reclamation expense, and some stones must be picked. The rating of the land is fair to poor, depending on slope and depth of solum. Under dry farming the rooting zone is restricted by the compact Bm horizon, but this would soften under irrigation. The cool climate and short frost-free period limit crops mainly to legumes and legume-grass mixtures. Of the soils suitable for irrigation, 11 acres are second-, 149 third-, 279 fourth-, and 276 fifth-class land.

## Degraded Brown Wooded Soils

### *Fiva Sandy Loam*

This soil type occurs on alluvial-colluvial fans. Small areas are scattered between Westbridge and Midway in the Kettle River valley, near Kerr Creek in the Boundary Creek valley, and in the southern part of the Granby Valley.

The topography, characteristic of fans, has smooth radial slopes extending downward from the fan apex to the valley floor. All slopes are steepest near the apex and gradually become more gentle toward the margins. In addition, some fans have an undulating surface and a few shallow kettles. Of 1,118 acres mapped, between elevations of 1,800 feet in the Granby Valley and 2,700 near Kerr Creek, 926 acres are arable, 103 are rough-broken, and 89 are excessively stony.

The fans were formed by deposits of streams tributary to the main river channel. Upon entering the main valley, the streams dropped their loads where the gradient decreased abruptly. The coarser materials were deposited near the fan apex, and the finer ones graded out on the fan apron. Most of the fan deposits overlie gravelly terraces.

The fan deposits vary, but in general from 12 to 20 inches of finer-textured sediments overlie roughly stratified sands, angular and rounded gravels, cobbles, and stones. The surface layer is mainly sandy loam, but loamy sand may occur near the fan apex. Gravels are scattered throughout the solum and become increasingly numerous with depth. Surface stoniness is from light to moderate except at the fan apex, which has heavier concentrations.

The rapidly drained, neutral to mildly alkaline Fiva sandy loam is a Degraded Brown Wooded soil. It occupies fans in the grassland-forest transition. There is only a light cover of ponderosa pine, Douglas fir, and larch. The undercover is composed chiefly of pinegrass, but includes bunchgrasses, kinnikinnick, saskatoon, soopolallie, squaw current, Oregon grape, and weeds. A representative profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | ½ – 0 | Forest litter of needles, grass, and moss. |
| Aej | 0 – 4 | Light brownish gray (10YR 6/2, dry) or dark grayish brown (10YR 4/2, moist) loam. Weak, platy structure near surface and remainder granular. Soft when dry. Volcanic dust in lenses, pockets, and flecks. Occasional fine gravel. Many fine roots. pH 6.5. |
| AB | 4 – 10 | Pale-brown (10YR 6/3, dry) or dark-brown (10YR 4/3, moist) sandy loam. Weak, subangular blocky and granular structure. Soft when dry. Wavy bottom boundary. Occasional fine gravel. Many fine roots. pH 6.7. |
| Btj | 10 – 13 | Light yellowish brown (10YR 6/4, dry) or dark yellowish brown (10YR 4/4, moist) sandy loam. Weak subangular blocky breaking to granular structure. Slightly hard when dry. Numerous gravels, occasional cobbles. Many fine roots. pH 6.8. |
| IIBtj | 13 – 21 | Yellowish-brown (10YR 5/4, dry) or dark yellowish brown (10YR 4/4, moist) gravelly sandy loam. Fine blocky structure. Some peds with grayish coatings. Hard to slightly hard when dry. Very gravelly and cobbly. pH 7.0. |
| IIBC | 21 – 31 | Light brownish gray to grayish-brown (2.5Y 5.5/2, dry) or dark grayish brown (2.5Y 4/2, moist) loamy sand in matrix of gravels and cobbles. Single-grained and loose in pockets, weakly cemented and slightly hard elsewhere. A few fine roots. pH 7.2. |
| IIC | 31+ | Roughly stratified coarse sand, gravels, and cobbles. Most gravels and cobbles coated with silica on undersides, occasionally with lime. A few roots. |

*Agriculture*

The Fiva sandy loam supports fairly good forest range. The dry climate and coarse profile make this soil submarginal for dry farming, but with irrigation it would produce most climatically suited crops. Sprinkler irrigation is recommended to avoid seepage losses, and to prevent erosion on the steeper slopes. No acreage was cultivated at the time of the survey (1957).

Irrigation and domestic water is available from the nearby rivers, or from tributary streams associated with some of the fans. The farm delivery requirement for sprinklers is about 40 acre-inches. Preparation of the land for cultivation involves removal of the light forest and the scattered stones. The soil is only fair for agriculture, because of the shallow solum, low moisture-holding capacity, a restricted rooting zone, and low cation exchange capacity. In places steep topography would prevent use of the land for row crops. Of the area suitable for irrigation, 149 acres are third-, 623 are fourth-, and 154 are fifth-class land.

## Gleyed Brown Wooded Soils

### *Coteay Sandy Loam*

The Coteay sandy loam is confined to the bottoms of three abandoned glacial stream channels on the plateau, near North Ninemile Creek. It is derived from 10 to 18 inches of sandy loam that overlies gravelly outwash, which in turn lies upon glacial till. The smooth-bottomed, gently sloping channels, which are up to a quarter of a mile wide, were excavated in glacial till. The elevations are from 4,100 to 4,130 feet. Only 132 acres were mapped, all of which are arable.

This is an imperfectly drained Gleyed Brown Wooded soil. Where the water table is high, the soil grades to Dark Gray Gleysolic and to swamp. In places where the water table recedes below 15 inches, the trees are chiefly lodgepole pine and larch, mixed with aspen and willow. There is a thick undercover of pinegrass, ground dogwood, kinnikinnick, pachystima, twinflower, and dwarf blueberry. In areas of higher water table, the trees are scrub aspen and willow, with ground cover of wild rose and moss. A profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–F | 1 – 0 | Dark-brown (10YR 4/3, moist) organic remains. Partly decomposed fine roots, needles, twigs, and grass. Fluffy, white mycelia throughout. |
| Bm1 | 0 – 2½ | Pale-brown (10YR 6/3, dry) or dark-brown (10YR 4/3, moist) sandy loam. Weak granular structure. Spots of volcanic dust near surface and some pockets extending into horizon below. Friable when moist. Porous. Many fine roots. pH 5.3. |
| Bm2 | 2½ – 7 | Pale-brown (10YR 6/3, dry) or dark yellowish brown (10YR 4/4, moist) sandy loam. Very weak, subangular blocky breaking to granular structure. Friable when moist. Occasional gravel. Many fine roots. pH 6.1. |
| Bfgj | 7 – 15 | Light yellowish brown (10YR 6/4, dry) or yellowish-brown (10YR 5/5, moist) sandy loam. Weak, medium, subangular blocky structure. Friable when moist. Scattered gravels. A few small mottles in lower part. pH 6.5. |
| IICg1 | 15 – 27 | Roughly stratified gravels and cobbles mixed with fine sand in upper part, grading to coarse sand below. Pale-brown to light yellowish brown (10YR 6/3.5, dry) or yellowish-brown (10YR 5/4, moist). Many prominent strong-brown (7.5YR 5/6, moist) mottles. pH 6.2. |
| IICg2 | 27+ | Coarse sand, gravels, and some cobbles. Iron stains in upper part, fading with depth. Mottling not as prominent as in horizon above. Many fine white particles of quartz. pH 6.2. |

On August 26, 1955, the water table in the above profile was below 30 inches, with the soil moist. It stood at 28 inches on July 29, 1957. Mottling occurred within 10 inches of the surface in the most poorly drained areas. A layer of volcanic dust up to four inches thick may occur in undisturbed locations.

*Agriculture*

The Coteay sandy loam provides good summer grazing when grass on better-drained land has become dormant. To develop the soil for farming, for which it is only fair, drainage is required. The drainage water could be used for irrigation in late summer. The farm water requirement for sprinkler irrigation is about 12 acre-inches. A supply of water for livestock could be obtained from dugouts.

Preparation of the land for cultivation involves clearing a moderate growth of trees. Farming should be confined to hardy crops, chiefly hay and pasture, because this soil is confined to depressional areas subject to frost. Though suitable for irrigation, the entire 132 acres are fifth-class land.

## Gray Wooded Soils

Gray Wooded soils develop from medium-textured, calcareous parent materials in the cooler parts of the surveyed area, where there is enough precipitation to cause leaching. Beneath a surface layer of forest litter, there is a horizon of eluviation (Ae) in turn underlain by an illuvial horizon of clay accumulation (Bt); these are the prominent features of the profile. Any other A or B horizons are transitional, and named according to closest relationship with the one above or below. In coarse-textured profiles the Bt horizon may consist only of one or more thin clay layers separated by Ae horizon material. A Cca horizon is generally absent, owing to the low lime content of parent materials in the surveyed area. Two subgroups were found:

*Orthic Gray Wooded* soils have a surface layer of forest litter, a light-gray to pale-brown Ae horizon and a yellowish-brown Bt horizon. The Bt horizon has blocky structure. Transitional AB and BC horizons may or may not be present. A horizon of calcium carbonate accumulation is rarely found. Conkle silt loam, Spion loamy sand, Wilkinson silt loam, and Carmi sandy loam were classified as Orthic Gray Wooded soils.

*Brunisolic Gray Wooded* soils differ from the Orthic subgroup by having a brightly colored horizon in the upper part of the Ae horizon. This may be considered a Bf horizon. The Brunisolic Gray Wooded soils are Hoolan sandy loam and Thone silt loam.

### Orthic Gray Wooded Soils

#### *Conkle Silt Loam*

The Conkle silt loam is derived from stratified glaciolacustrine deposits that show no evidence of varving. It occurs in small, scattered areas along Ninemile and McCoy creeks on the plateau, near the mouth of Boundary Creek, in the Granby Valley, and near Cascade.

The topography, though chiefly undulating, varies from level to rolling and gullied. Most slopes are from five to 15 percent. The mapped areas range in elevation from 1,700 feet near Cascade to 3,850 on the plateau. Of a total of 2,392 acres, 1,782 are arable and 610 are rough-broken.

The parent material consists of neutral to mildly alkaline, light olive gray to white silty sediments from six to 12 feet and occasionally up to 50 feet thick; it overlies glacial till. In deposits of more than average depth, the lower parts are composed mainly of stratified fine sands.

The average texture of the surface layer is silt loam, with minor variation to fine sandy loam. Scattered ice-rafted cobbles and boulders may be found. Small patches of stones occur where erosion has exposed underlying till. The soil is well drained except in a few small depressions.

This Orthic Gray Wooded soil developed under a medium stand of Douglas fir containing a few larch and ponderosa pine. Recent burns are occupied by dense stands of young lodgepole pine and larch. Depressions contain thick stands of spruce, alpine fir, willow, and scrub alder. The medium to dense undercover is composed of saskatoon, snowberry, Oregon grape, pussytoes, kinnikinnick, pinegrass, and others. A representative profile is described as follows:

| Horizon | Depth Inches | Description |
|---|---|---|
| L–H | ½ – 0 | Forest litter of needles, twigs, and dead grass. Dark brown and decomposed in the lower part. |
| Ae1 | 0 – 7 | Light brownish gray (10YR 6/2, dry) or dark-gray to dark grayish brown (10YR 4/1.5, moist) silt loam. Moderate, fine subangular blocky breaking to granular structure. Slightly hard when dry. Scattered fine roots. pH 6.2. |
| Ae2 | 7 – 19 | Light brownish gray (10YR 6/2, dry) or dark grayish brown to very dark grayish brown (10YR 3.5/2, moist) silt loam. Granular and some very weak, subangular blocky structure. Soft when dry. Occasional fine gravel. Numerous roots. pH 6.4. |
| AB | 19 – 23 | Pale-yellow (5Y 7/3, dry) or light yellowish brown (2.5Y 6/4, moist) silt loam. Coarse subangular blocky structure. Slightly hard when dry. Scattered roots. pH 6.5. |
| Bt | 23 – 33 | Pale-olive (5Y 6/4, dry) or olive (5Y 5/3, moist) silt loam. Strong blocky structure. Hard when dry. The peds have pale-yellow (5Y 8/3, dry) coatings. Occasional gravel. A few roots. pH 6.5. |
| BC | 33 – 45 | Light olive-gray (5Y 6/2, moist) silt loam. Blocky structure. Slightly hard when dry. pH 6.7. |
| C | 45+ | Light-gray (2.5Y 7/2, dry) or grayish-brown (2.5Y 5/2, moist) stratified sediments of silt loam to loamy fine sand. pH 7.2. |

*Agriculture*

The natural vegetation is of value for the ranging of livestock and production of timber. The soil is fair to marginal if dry-farmed, and productive when irrigated. An irrigation water supply may be scarce on the plateau. Since the soil erodes easily, water should be piped or flumed to distribution points. For sprinkler irrigation the farm delivery requirement is about 15 acre-inches.

Reclamation consists of removal of a medium forest cover, scattered stones where till is exposed, and irrigation works. All climatically suited crops may be grown under irrigation. The deep, medium-textured solum has fairly good moisture-holding and good rooting capacity. Of areas suitable for irrigation, there are 115 acres of second-, 1,357 of third-, 236 of fourth-, and 74 of fifth-class land.

### *Spion Loamy Sand*

The Spion loamy sand, which is derived from sandy terraces, occurs in small, scattered areas in the Kettle River valley downstream from Fiva Creek, and in the southern part of the Granby Valley. The topography is from level to gently undulating and moderately sloping, with occasional hummocky micro-relief. The lowest elevation, 1,700 feet, is near Cascade and the highest, 2,300 feet, is about four miles north of Westbridge. This soil occupies 1,335 acres, of which 14 are rough-broken.

The parent material is composed of neutral to moderately alkaline sandy terrace deposits. The sands, which often are only four or five feet thick, may overlie gravels or lacustrine silts. The surface layer is mainly loamy sand, but minor areas of sandy loam were included. The texture coarsens with depth, grading to sand in the lower part of the solum. Gravels and cobbles are absent except at contact with an underlying gravelly stratum. The soil is well to moderately well drained, depending on depth to porous or impervious material.

The Spion loamy sand is an Orthic Gray Wooded soil. The tree cover is chiefly Douglas fir and ponderosa pine, with some larch, lodgepole pine, and willow. The dominant shrubs are soopolallie, saskatoon, rose, Oregon grape, and kinnikinnick, and the herbs are pinegrass, timber vetch, and pussytoes. The profile (Figure 20) was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 1½ – 0 | Forest litter of needles, twigs, and cones, decomposed in the lower part. Charcoal at contact with the mineral soil beneath. pH 6.2. |
| Ae1 | 0 – 6 | Light brownish gray (10YR 6/2, dry) or grayish-brown to dark grayish brown (10YR 4.5/2, moist) light sandy loam or loamy sand containing white (10YR 8/2, dry) flecks and pockets of volcanic dust. Weak, medium granular structure. Soft when dry, very friable when moist. Many fine roots. pH 6.4. |
| Ae2 | 6 – 17 | Pale-brown (10YR 6/3, dry) or brown (10YR 5/3, moist) loamy sand. Moderate, medium, subangular blocky structure. Slightly hard when dry. Numerous fine roots. pH 6.4. |
| A and B | 17 – 42 | Ae horizon material very pale brown to light yellowish brown (10YR 7/3–2.5Y 6/4, dry) or light olive brown (2.5Y 5/4–5/6, moist) loamy sand. Faint, common mottles. Weak to moderate, medium blocky structure. Slightly hard when dry. Bt horizon material in two nearly horizontal layers totalling two inches in thickness and often connected by thin vertical and oblique tongues. Light yellowish brown (10YR 6/4, dry) or dark-brown (10YR 4/3, moist) sandy loam. Fine blocky structure. Hard when dry. Scattered roots. pH 5.8 to 6.5. |
| Bt | 42 – 43 | Light yellowish brown (10YR 6/4, dry) or dark yellowish brown (10YR 4/4, moist) sandy loam. Fine blocky structure. Hard when dry. Scattered roots. Occasional tongues up to half an inch thick connecting with Bt horizon material in horizon above. pH 6.6. |
| BCg | 43 – 60 | Light yellowish brown (2.5Y 6/4, dry) or light olive brown (2.5Y 5/6, moist) loamy sand with many distinct mottles. Massive. Soft when dry. Micaceous. Scattered roots. pH 7.7. |
| IICca | 60+ | Roughly stratified coarse sand, gravels, and scattered cobbles. Weak lime cementation in the upper part. pH 9.1. |

*Agriculture*

The native vegetation is used for grazing and timber. This soil is submarginal for dry farming but would produce all climatically suited crops when irrigated. The porous soil favors sprinkler irrigation to conserve and properly distribute the water. None of this soil was farmed at the time of the survey (1957).

With all areas near a river, irrigation and domestic water are available, though pumping lifts may be up to 150 feet. For sprinklers the farm delivery requirement is about 35 acre-inches.

Preparing the land for cultivation requires removal of light forest. Thereafter a soil improvement program should be undertaken. Forage crops in a rotation with cash crops is recommended. Since all of the land is in the southern part of the surveyed area, it has a comparatively long frost-free period and it warms rapidly in the spring. The area suitable for irrigation consists of 1,162 acres of third-, 124 of fourth-, and 35 of fifth-class land.

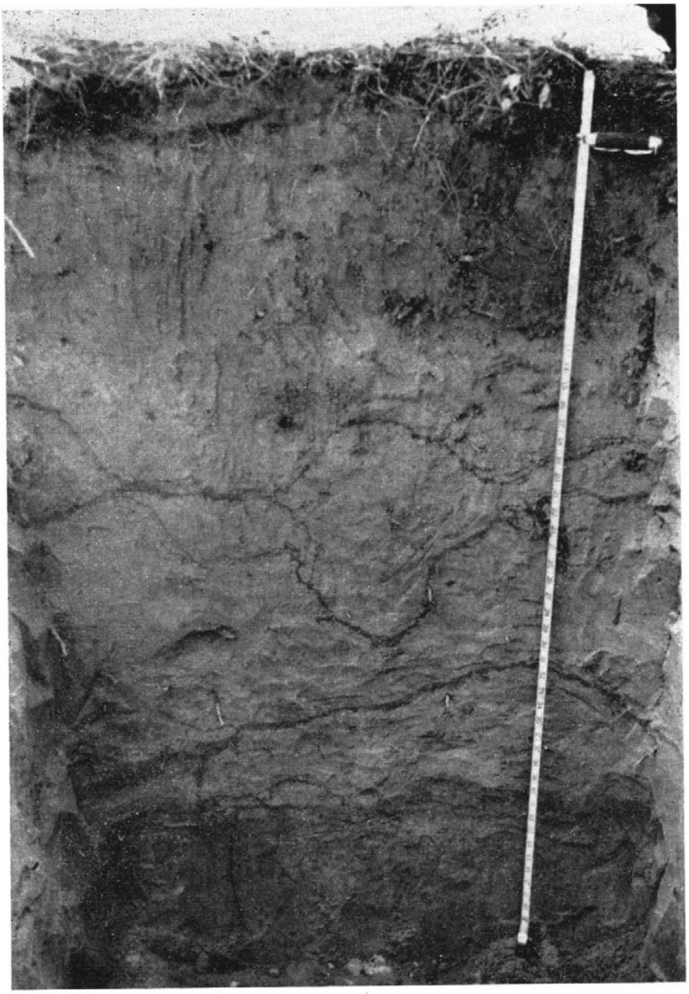

FIGURE 20. Profile of Spion loamy sand, an Orthic Gray Wooded soil, near Westbridge. The subsoil contains thin, irregular Bt horizons.

### *Wilkinson Silt Loam*

This soil type is derived from alluvial terraces in the river valleys and the major tributary creek valleys.

The topography varies from level to gently sloping and gently undulating. Slight inward and downstream slopes are common. Abandoned stream channels are the cause of the undulations. The elevations are from 1,600 feet near Cascade to 2,850 in the Wilkinson Creek valley west of Carmi. The total area is 1,418 acres, of which 1,384 are arable and 34 are rough-broken.

The parent material consists of silty deposits from 24 to 60 inches thick, overlying gravelly substrata. The terraces on which the soil occurs lie from

10 to 30 feet above river level. The surface layer is mainly silt loam, but small areas of loam occur. Gravels and stones are absent except at contact with underlying strata. Gravel bars protrude to the surface in some areas. The soil varies from slightly acid at the surface to moderately alkaline in the lower part of the solum. Though the profile is well to moderately well drained, the Bt horizon restricts the downward movement of water somewhat.

FIGURE 21. Fir, larch, and spruce forest on Wilkinson silt loam near Crouse Creek in the Kettle Valley.

This Orthic Gray Wooded soil developed under a medium to heavy forest of Douglas fir, larch, spruce, lodgepole pines, and aspen. Ponderosa pine replaces spruce in the most arid areas. The principal herbs and shrubs are pinegrass, kinnikinnick, pachystima, twinflower, spirea, and ground dogwood (Figure 21). The profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 1 – 0 | Forest litter of needles, twigs, and moss, well decomposed in the lower part. |
| Ae | 0 – 7 | Light brownish gray (10YR 6/2, dry) or brown (10YR 5/3, moist) silt loam. Medium, platy structure. Lenses and pockets of white (10YR 8/2, dry) volcanic dust. Soft when dry. Numerous roots. pH 5.9. |
| AB | 7 – 13 | Light-gray (10YR 7/2, dry) or grayish-brown (10YR 5/2, moist) silt loam. Medium blocky and some weak, platy structure. Slightly hard when dry. Vesicular. Occasional thin clay layers. Numerous roots. pH 6.5. |
| Bt | 13 – 18 | Yellowish-brown (10YR 5/4, dry) or dark yellowish brown (10YR 4/4, moist) silt loam. Medium blocky structure. The peds have pale-brown (10YR 6/3, dry) coatings. Slightly hard when dry. pH 6.8. |
| BC | 18 – 23 | Light yellowish brown (2.5Y 6/4, dry) or olive-brown (2.5Y 4/4, moist) silt loam. Medium blocky structure. Slightly hard when dry. Scattered roots. pH 7.8. |

| Horizon | Depth Inches | Description |
|---|---|---|
| Ck | 23 – 30 | Light-gray to light brownish gray (2.5Y 6.5/2, dry) or light olive brown (2.5Y 5/4, moist) silt loam. Breaking to pseudoblocky structure. Slightly hard when dry. Spotted with lime. Root mats. pH 8.2. |
| Cca | 30 – 40 | Light-gray (2.5Y 7/2, dry) or light yellowish brown to light olive brown (2.5Y 5.5/4, moist) silt loam. Breaking to pseudoblocky structure. Some nodular forms. Very hard when dry. Some iron stains. Calcareous, heaviest lime concentration in lower two inches. pH 8.4. |
| IIC1 | 40 – 49 | Pale-yellow (2.5Y 7/4, dry) or light yellowish brown (2.5Y 6/4, moist) medium sand. Single-grained, loose. Some iron staining. pH 8.2. |
| IIC2 | 49+ | Clean coarse sand of variegated colors. Single-grained, loose. pH 8.2. |

The Cca horizon described above is not always present. In many profiles free lime is not encountered (Figure 22).

*Agriculture*

The natural vegetation produces good timber but scanty range. Small acreages are dry-farmed in the Kettle and Boundary Creek valleys. The yields of forage are fair to good, but grain crops are only fair. This soil occurs near streams from which water is available for irrigation and domestic use. For sprinkler irrigation the farm delivery requirement is about 25 acre-inches.

The high cost of clearing the forest hinders reclamation, but this is one of the best soils in the surveyed area when irrigated. It is capable of producing all climatically suited crops. Of the areas suitable for irrigation, 46 acres are first-, 642 second-, 611 third-, and 85 fourth-class land.

### *Carmi Sandy Loam*

The Carmi sandy loam is derived from medium-textured alluvial-colluvial fan sediments. Scattered areas occur in the Kettle, Westkettle, Wilkinson Creek, Boundary Creek, and Granby valleys. From their apexes the fans slope smoothly downward, the gradient gradually decreasing toward the margins. All slopes are moderate enough for cultivation. The mapped areas occur from 1,950 feet elevation near Lynch Creek in the Granby Valley to 3,200 near Cookson Flat, north of Carmi. A total of 1,330 acres were mapped, all being arable.

The fans were formed by small temporary streams tributary to the main rivers. The streams eroded and sorted glacial deposits, mainly till, and redeposited the materials on terraces and till. The fan materials are graded; the coarser textures are near the apex and the finer ones downslope toward the fan apron. The unweathered part of the soil profile may vary from neutral to moderately alkaline.

The average surface layer is sandy loam, but small areas of loam occur. There is an increase in sands, gravels, and stones with depth. Stoniness is light over most of the lower part of the fan surface.

The Carmi sandy loam is a well-drained Orthic Gray Wooded soil. It developed under a medium-heavy forest of Douglas fir, larch, spruce, lodgepole pine, aspen and willow, with scattered ponderosa pine on dry sites.

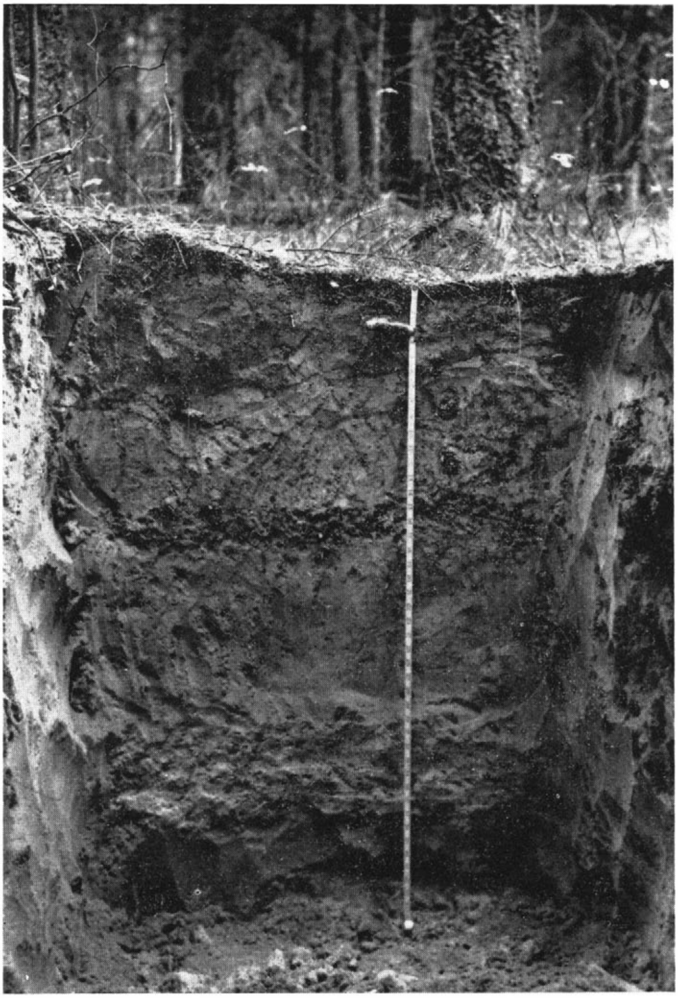

FIGURE 22. Profile of Wilkinson silt loam, an Orthic Gray Wooded soil, near Crouse Creek in the Kettle Valley.

The shrubs include soopolallie, saskatoon, kinnikinnick, and pachystima. The most common species of the rich herb growth are pinegrass, ricegrass, and dogbane. A typical profile is described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 1 – 0 | Forest litter of needles, twigs, and leaves, well decomposed in the lower part. pH 5.9. |
| Ae | 0 – 9 | Very pale brown (10YR 7/3, dry) or pale-brown (10YR 6/3, moist) sandy loam. Weakly platy in top two inches and then weak granular structure. Soft when dry, friable when moist. Many fine roots. pH 5.6. |
| AB | 9 – 16 | Pale-brown (10YR 6/3, dry) or yellowish-brown (10YR 5/4, moist) sandy loam. Granular and some weak, subangular blocky structure. Hard when dry. Occasional thin clay layer. pH 6.1. |

| Horizon | Depth Inches | Description |
|---|---|---|
| Bt1 | 16 – 25 | Light yellowish brown (10YR 6/4, dry) or yellowish-brown (10YR 5/6, moist) sandy loam. Strong, medium blocky structure. Very hard when dry. Thin grayish coatings on peds. pH 6.3. |
| Bt2 | 25 – 34 | Light yellowish brown (10YR 6/4, dry) or yellowish-brown (10YR 5/6, moist) loam. Medium blocky structure. Very hard when dry. Soft lenses of sand and fine gravel. pH 6.2. |
| BC | 34 – 39 | Pale-brown (10YR 6/3, dry) or light olive brown to olive-brown (2.5Y 4.5/4, moist) loam. Weak blocky structure. Slight clay accumulation. Hard when dry. pH 6.5. |
| C–IIC | 39+ | Sand and fine gravel alternating with layers of loam. Cobbles and stones increasing with depth. |

*Agriculture*

In undeveloped areas the Carmi sandy loam has value for timber, Christmas trees, and forest range. Several small areas are dry-farmed for hay, but yields are light. Optimum yields can only be obtained with irrigation. Water for domestic and irrigation use is obtainable in nearby creeks and rivers. For sprinklers the farm delivery requirement is about 20 acre-inches.

The cost of removing the forest delays agricultural development of this soil. With irrigation the deep solum would provide adequate nutrients and moisture for farming. On some fans there are fairly steep slopes that should not be planted to row crops. Forage crops in a rotation with grain are most suitable at the higher elevations. Of the areas suitable for irrigation, there are 136 acres of first-, 139 of second-, 780 of third-, 117 of fourth-, and 158 of fifth-class land.

## Brunisolic Gray Wooded Soils

### *Hoolan Sandy Loam*

The sandy terraces from which the Hoolan sandy loam is derived occur mainly north of Westbridge in the Kettle and Westkettle valleys. There are a few small areas in the Boundary Creek valley north of Greenwood.

The terraces have gentle to moderately undulating slopes, though a gently undulating microrelief also occurs. The elevations are from 2,200 feet near Fiva Creek to 2,800 in the upper Boundary Creek valley. A total of 388 acres were mapped, all being arable.

The parent material consists of neutral to slightly alkaline, medium to fine sands containing lenses of gravels and cobbles. Gravels and cobbles are scattered in the solum. The surface layer is usually sandy loam, but small areas of loamy sand occur. The texture coarsens with depth, grading to loamy sand or fine sand in the lower part of the solum.

The Hoolan sandy loam is a well-drained Brunisolic Gray Wooded soil that developed under forest. Most areas have been logged or burned, and support immature lodgepole pine, Douglas fir, larch, willow, and scrub alder. The shrubs and herbs include soopolallie, spirea, kinnikinnick, prince's pine, twinflower, and pinegrass. A profile in the Boundary Creek valley is described as follows:

| Horizon | Depth Inches | Description |
|---|---|---|
| L–F | 1½ – 0 | Forest litter of decomposed needles, twigs, and leaves. |
| | | A discontinuous layer of volcanic dust up to one inch thick. |

| Horizon | Depth Inches | Description |
|---|---|---|
| Ael(Bf1) | 0 – 7 | Pale-brown (10YR 6/3, dry) or brown to dark-brown (10YR 4/3, moist) sandy loam. Weak, fine, subangular blocky breaking to granular structure. Friable when moist. Some flecks of volcanic dust. Many fine roots. pH 6.0. |
| Ae2 (Bf2) | 7 – 17 | Very pale brown (10YR 7/4, dry) or yellowish-brown (10YR 5/4, moist) sandy loam. Weak, fine, subangular blocky breaking to granular structure. Friable but firmer than above horizon. Scattered fine gravels. Numerous roots. pH 6.4. |
| Ae3 | 17 – 26 | Light-gray (10YR 7/2, dry) or grayish-brown (2.5Y 5/2, moist) sandy loam or loamy sand. Very weak, subangular blocky breaking to single-grained structure. Friable when moist. Numerous gravels and roots, scattered cobbles. pH 7.0. |
| Bt1 | 26 – 35 | Pale-brown (10YR 6/3, dry) or brown to dark-brown (10YR 4/3, moist) gravelly sandy loam. Moderate, medium blocky structure. Slightly firm when moist. Many gravels and a few cobbles. Scattered roots. pH 7.5. |
| Bt2 | 35 – 48 | Light yellowish brown (10YR 6/4, dry) or dark yellowish brown (10YR 4/4, moist) gravelly sandy loam. Strong, medium blocky structure. Firm when moist. Many gravels and a few cobbles. pH 7.3. |
| BC | 48 – 65 | Pale-yellow (2.5Y 7/4, dry) or yellowish-brown (10YR 5/4, moist) sandy loam or loamy sand. Weak, medium, subangular blocky structure. Slightly firm when moist. Faint mottling. A few gravels and cobbles. pH 7.0. |
| C | 65+ | Pale-yellow (2.5Y 7.5/4, dry) or olive-brown (2.5Y 4/4, moist) loamy sand. Single-grained. A few gravels and cobbles and a cobble layer at 75 inches. Some iron staining. pH 7.4. |

*Agriculture*

Undeveloped areas have limited value for timber and ranging cattle. There was no farmed acreage in 1957. The land is marginal for dry farming and arable for cool-season crops when irrigated. Domestic and irrigation water is available from nearby creeks and rivers, but owing to percolation losses it should not be conveyed in earth ditches. The farm delivery requirement for sprinklers is about 20 acre-inches.

Preparing the land for farming requires removal of a moderate forest, including old logs and stumps. Little stone removal is necessary. With irrigation the soil is fair to good for agriculture. Mixed farming with emphasis on sod crops is recommended. Of the areas suitable for irrigation, 186 acres are third-, 12 fourth-, and 190 fifth-class land.

### *Thone Silt Loam*

Thone silt loam, derived from fine-textured river terraces, occurs in the Kettle Valley between Thone and Panturages creeks. Though the surface is comparatively level, there are gentle downstream and inward slopes. The abandoned stream channels generally run along the inner margins of the terraces. A total of 92 acres, all of which are arable, were mapped between elevations of 2,350 and 2,400 feet.

The parent materials are silty deposits 36 inches or more thick, overlying sandy and gravelly substrata. The silty overlays on the terraces are remnants of former floodplains, abandoned as the Kettle River reduced its elevation. The surface layer is usually silt loam, but small areas of loam also occur. The stone- and gravel-free solum is slightly acid near the surface and mildly alkaline in the lower part. The terraces are from 10 to 20 feet above river level and there is a water table at these depths. The solum has slightly restricted internal drainage, as a well-developed Bt horizon checks the downward movement of moisture.

The Thone silt loam is a Brunisolic Gray Wooded soil that developed under a heavy forest of spruce, larch, Douglas fir, birch, Rocky Mountain maple, and willow. The water table is within reach of tree roots, and its influence is reflected in the density of growth. Thimbleberry is prominent in the heavy shrub layer. Prince's pine, ground dogwood, columbine, twinflower, queen's cup, and bracken were also observed (Figure 23). A profile under this heavy vegetative cover (Figure 24) is described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 2 – 0 | Forest litter of needles, leaves, and wood. Well decomposed in the lower part. |
| | 0 – ½ | White (10YR 8/2, dry) or grayish-brown (10YR 5/2, moist) volcanic dust of fine sandy loam texture. Very weak, fine, platy structure. In pockets up to one inch thick. Very friable when moist. pH 5.4. |
| Ae1(Bf1) | ½ – 3 | Pale-brown (10YR 6/3, dry) or dark yellowish brown (10YR 4/4, moist) silt loam. Weak, fine granular structure. Lenses and pockets of volcanic dust. Very friable when moist. Many fine roots. pH 5.8. |
| Ae2(Bf2) | 3 – 6 | Light yellowish brown (10YR 6/4, dry) or dark yellowish brown (10YR 4/4, moist) silt loam. Weak, medium platy structure. Very friable when moist. Many roots. pH 6.2. |
| Ae3 | 6 – 10 | Light brownish gray (10YR 6/2, dry) or brown (10YR 5/3, moist) silt loam. Coarse platy structure. Friable when moist. Slightly vesicular. Scattered roots. pH 6.4. |
| BA | 10 – 14 | Pale-brown (10YR 6/3, dry) or brown to yellowish-brown (10YR 5/3.5, moist) silty clay loam. Coarse blocky structure. Very firm when moist. Vesicular. Slightly degraded. A few roots. pH 6.2. |
| Bt1 | 14 – 22 | Pale-brown (10YR 6/3, dry) or yellowish-brown (10YR 5/4, moist) silty clay loam. Coarse prismatic, breaking to very coarse blocky structure. Very firm when moist. A few roots. pH 6.2. |
| Bt2 | 22 – 30 | Pale-brown (10YR 6/3, dry) or dark yellowish brown (10YR 4/4, moist) silty clay loam. Coarse to medium blocky structure. Firm when moist. A few roots. pH 6.5. |
| BC | 30 – 45 | Very pale brown (10YR 7/3, dry) or yellowish-brown (10YR 5/4, moist) silt loam. Medium blocky structure. Friable when moist. Slightly vesicular. Pockets of lime. A few roots. pH 7.8. |
| Cg1 | 45 – 65 | Light olive brown (2.5Y 5/4, moist) silt loam. Massive. Very firm when moist. Strong-brown (7.5YR 5/6, moist) mottles. Weakly calcareous. pH 7.9. |
| Cg2 | 65+ | Light brownish gray (2.5Y 6/2, moist) fine sandy loam. Massive. Common strong-brown mottling as in horizon above. pH 7.8. |

FIGURE 23. Mature forest on Thone silt loam, a Brunisolic Gray Wooded soil, in the Kettle Valley near Stewartson Creek.

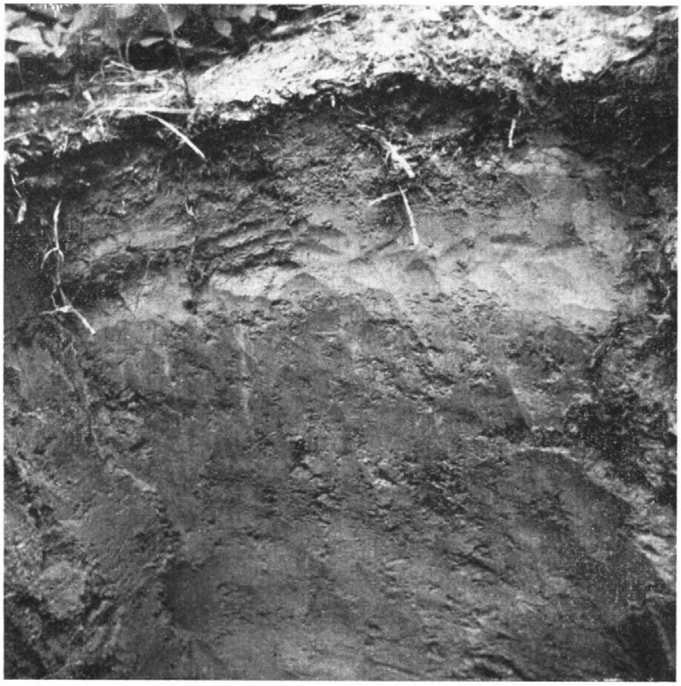

FIGURE 24. Profile of Thone silt loam in the Kettle Valley near Stewartson Creek.

*Agriculture*

The Thone silt loam is one of the best soils for farming in the surveyed area. Water for domestic and irrigation use is available from wells or the nearby river. The farm delivery requirement for sprinkler irrigation is about 18 acre-inches.

The cost of clearing the heavy forest has so far limited reclamation. No stone removal is necessary. This soil is good for dry farming and excellent under irrigation. The fine-textured solum stores adequate moisture. Slow internal drainage requires careful irrigation to prevent puddling. Late-spring and early-fall frosts are common. Farming is restricted to hardy crops, chiefly hay and pasture. The 92 acres of Thone silt loam are in the second-class category for irrigation.

## Brown Wooded–Gray Wooded Soil Intergrade

This intergrade consists of a group of forested soils having profiles similar in appearance to those classed as Brunisolic Gray Wooded. They differ from Brunisolic Gray Wooded soils in that the upper sequum is a recent overlay rather than the product of normal soil development.

The lower part of the profile, derived from glacial till, is a Gray Wooded soil. This soil was covered by a stratum up to 20 inches thick, composed of loess and volcanic dust. A Brown Wooded soil developed in the overlay. This is high in bases and shows little evidence of leaching.

The Brown Wooded soil has a thin L-H horizon of forest litter at the surface, and pale-brown to yellowish-brown Bm and Bf horizons beneath. The Gray Wooded soil has grayish Ae and yellowish-brown Bt horizons. A Cca horizon of calcium carbonate accumulation is usually present. Sidley silt loam is the only representative in the surveyed area.

### *Sidley Silt Loam*

The Sidley silt loam developed on medium-textured glacial till. Most of the acreage is near Kerr Creek and Jewel Lake. Small areas are found near Wallace Lake northeast of Carmi.

The topography of areas suitable for farming varies from undulating to strongly rolling. Most of the area is hilly and eroded. Of a total of 1,905 acres mapped between 2,700 and 3,300 feet elevations, only 568 are suitable for cultivation.

The parent material is glacial till of loam to silt loam texture containing moderate quantities of gravels, cobbles, and boulders. The till is overlain by loess and volcanic dust averaging 16 inches deep and ranging from 12 to 20 inches. A small percentage of the till, gravels, and stones were mixed with the overlay by solifluction and uprooting trees, but gravels and stones are fewer than in the till beneath.

The till has weathered to depths of about four or five feet, beneath which the unweathered till is hard and impervious, with pseudoplaty structure. The soil varies from slightly acid at the surface to mildly and moderately alkaline in the lower solum and upper part of the unweathered till.

The Sidley silt loam, a well to moderately well drained Brown Wooded–Gray Wooded Intergrade soil, developed under medium-dense Douglas fir, larch, spruce, lodgepole pine, and scattered aspen and willow. The undercover contains snowberry, spirea, Oregon grape, kinnikinnick, twinflower, heart-leaved arnica, pinegrass, and others. The following is a typical profile:

| Horizon | Depth Inches | Description |
|---|---|---|
| L–H | 1½ – 0 | Forest litter. Needles, twigs, cones, and leaves. Black and well decomposed in the lower part. |
| | 0 – 1 | Very pale brown (10YR 8/4, dry) or light yellowish brown (10YR 6/4, moist) volcanic dust of silt loam texture mixed with some mineral soil. Moderate, fine platy structure. Soft when dry, friable when moist. Many roots. pH 6.5. |
| Bm | 1 – 5 | Pale-brown (10YR 6/3, dry) or dark yellowish brown (10YR 4/4, moist) silt loam. Weak, fine, subangular blocky breaking to weak granular structure. Soft when dry, friable when moist. Specks of volcanic dust. Many roots. pH 6.2. |
| Bf | 5 – 14 | Light yellowish brown (10YR 6/4, dry) or yellowish-brown (10YR 5/4, moist) silt loam. Weak, fine, subangular blocky breaking to granular structure. Soft when dry, friable when moist. A few fine gravels. Numerous roots. pH 6.3. |
| IIAe | 14 – 22 | Pinkish-gray (7.5YR 7/2, dry) or grayish-brown (10YR 5/2, moist) loam to silt loam. Moderate, fine, subangular blocky structure. Firm when moist. Highly vesicular. Many gravels, a few cobbles. Occasional roots. pH 6.5. |
| IIBt1 | 22 – 29 | Pale-brown (10YR 6/3, dry) or yellowish-brown to dark yellowish brown (10YR 4.5/4, moist) silt loam. Strong, fine blocky structure. Peds with grayish coatings. Firm when moist. Vesicular. Scattered gravels; a few cobbles and roots. pH 6.8. |
| IIBt2 | 29 – 33 | Pale-brown (10YR 6/3, dry) or grayish-brown to yellowish-brown (10YR 5/2–5/4, moist) silt loam. Moderate, fine, subangular blocky structure. Firm when moist. Gravels and a few cobbles. In lower part free carbonates in root channels. pH 7.1. |
| IICca1 | 33 – 40 | Light-gray (10YR 7/2, dry) or grayish-brown (2.5Y 5/2, moist) silt loam. Weak, pseudosubangular blocky to massive structure. Friable when moist. Vesicular. Gravels and a few cobbles. Layers and pockets of carbonate. An occasional root. pH 7.8. |
| IICca2 | 40 – 50 | Light-gray to light brownish gray (10YR 6.5/2, dry) or grayish-brown to dark grayish brown (10YR 4.5/2, moist) silt loam. Slightly weathered, pseudoplaty till. Very firm when moist. Many gravels and cobbles, some stones and boulders. Layers of carbonate. pH 8.3. |
| IIC | 50+ | Grayish-brown till of silt loam texture. Pseudoplaty. Very hard when dry. Many gravels, a few stones and boulders. Impervious. pH 7.9. |

*Agriculture*

The undeveloped arable acreage and rough-broken areas have value for timber, Christmas trees, and forest range. This soil is marginal for dry farming, but arable with irrigation. In 1957 a limited acreage was irrigated near Kerr Creek, and a good yield of hay was obtained. Sprinkler irrigation is recommended to avoid water loss and limit erosion on the steeper slopes. A water supply may be obtained from small creeks. Limited domestic water is secured from wells dug in seepage areas. In places dugouts could be used to store snowmelt. The farm delivery requirement for sprinkler irrigation is about 20 acre-inches.

Reclamation includes land clearing of forest and light stone content, and irrigation works. Though the Sidley silt loam is best suited to forage crops, row crops may be produced where the topography is gentle. Of the areas suitable for irrigation, there are 16 acres of third-, 358 of fourth-, and 194 of fifth-class land.

## Gray Forested Soils

Gray Forested soils occupy areas dominated by Douglas fir and larch on the plateau and near Carmi and Wallace Lake. Beneath an L-H horizon of forest litter there is a thick Ae horizon of eluviation. This in turn is underlain by a thick horizon consisting mainly of bleached Ae horizon material but with pockets or thin layers of darker-colored clay. This horizon may be underlain by a B horizon of brighter color. The solum is mostly medium to high in bases, and the parent material is always high. The parent materials are medium to moderately coarse in texture.

Only the Orthic subgroup was found.

### Orthic Gray Forested Soils

#### *Taurus Loam*

The Taurus loam is derived from medium-textured glacial till. It occurs chiefly in a few scattered areas between Bridesville and Rock Creek. There are other small areas near Myers Creek, Carmi, and Wallace Lake. The arable area has a smooth to irregular surface that varies from gently undulating and sloping to rolling (Figure 25). There is also a steeply sloping and very hilly phase. The elevations lie between 2,200 feet near Myers Creek and 3,700 southeast of Bridesville. Of a total area of 1,584 acres, 897 are arable and 687 rough-broken.

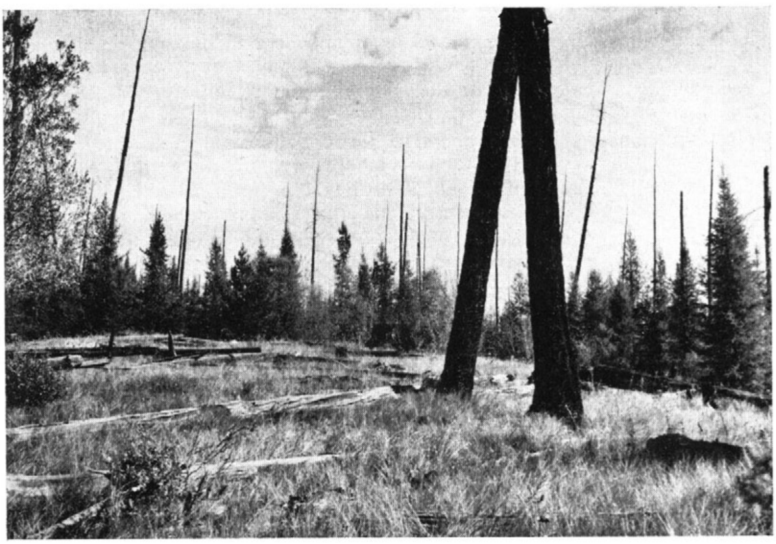

FIGURE 25. Landscape of Taurus loam near Bridesville.

The parent material is glacial till of loam texture, with a moderate content of gravels and cobbles. The surface mineral layer has been modified by solifluction and downslope wash. This redistributed material is from 12 to 24 inches thick, and may be up to four feet thick in places. Beneath is a layer of weathered till, in turn underlain by hard, impervious, unweathered till. A pebble line often occurs along the contact between the modified layer and the weathered till. The hard, unweathered till is olive-brown and slightly alkaline, and breaks to pseudoplaty structure. The thickness of the till, which generally overlies bedrock, is from a few to 50 feet or more.

The surface mineral layer is usually loam, with variation to sandy loam. The subsoil is usually loam, but it may grade to sandy loam and rarely to clay loam. The soil has a slightly higher clay content than the Gregoire loam, which is derived from similar but less calcareous parent material. The overlay is less stony than the till, and surface stoniness is light.

This is a well to moderately well drained soil, depending on the topography. The overlay is soft and porous and absorbs water rapidly. In the Carmi and Wallace Lake areas, small patches of Brunisolic Gray Wooded soil occur within areas mapped as Taurus loam.

The Taurus loam is an Orthic Gray Forested soil. On the plateau it is adjacent to and intermingled with the Stevens loam in areas where coniferous forest borders the natural grassland. The forest is composed chiefly of Douglas fir and larch. Dense stands of lodgepole pine and young larch, associated with aspen and willow, are found in burned and recently logged areas. The main shrubs are soopolallie, saskatoon, and rose. The heavy herb layer includes pinegrass, lupine, and fireweed. An undisturbed profile is described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 1 – 0 | Forest litter of needles, twigs, cones, and decayed grass. |
| | 0 – 1 | Light-gray (10YR 7/1, dry) or gray (10YR 5/1, moist) volcanic dust of silt loam texture. Medium platy structure. Soft when dry. pH 6.0. |
| Ae | 1 – 19 | Light brownish gray (10YR 6/2, dry) or dark grayish brown (10YR 4/2, moist) loam. Weak subangular blocky breaking to granular structure. Soft when dry. Scattered gravels. Many fine roots. pH 6.1. |
| IIA and B | 19 – 27 | Pale-brown (10YR 6/3, dry) or dark grayish brown (10YR 4/2, moist) loam with dark yellowish brown (10YR 4/4, dry) or dark-brown (10YR 3/3, moist) clay remnants inside peds. Weak blocky structure. Slightly hard when dry. Vesicular. Scattered gravels and roots. pH 6.8. |
| Bfj | 27 – 36 | Light yellowish brown (10YR 6/4, dry) or dark yellowish brown (10YR 4/4, moist) loam. Coarse blocky structure. Hard when dry. Scattered gravels and cobbles. A few roots. pH 6.7. |
| BC | 36 – 42 | Light yellowish brown (10YR 6/4, dry) or very dark yellowish brown (10YR 3/4, moist) sandy loam or loam. Medium to coarse blocky structure. Hard when dry. Scattered gravels and cobbles. A few roots. pH 6.8. |
| C | 42+ | Pale-olive (5Y 6/3, dry) or olive (5Y 5/3, moist) loam-textured till. Pseudoplaty. Slightly weathered in the upper part. Very hard when dry. Impervious. Scattered gravels, cobbles, and boulders. Root mats at the top. pH 7.1. |

*Agriculture*

The undeveloped areas are used for grazing and forestry. At the time of the survey (1957), about 20 acres were dry-farmed on the plateau; there was no irrigated land. The crop yield compared favorably with that from dry-farmed Stevens loam. With moisture the chief limiting factor under dry farming, crop yields depend on the variable rainfall. With irrigation this soil would give moderate yields of all climatically suited crops. The farm delivery requirement for sprinkler irrigation is about 18 acre-inches. Water for domestic use may be available from springs or wells in seepages. In areas of sufficient catchment, snowmelt could be stored in dugouts.

The cost of clearing the forest is the main limiting factor to land development. The light surface stoniness is of little hindrance to cultivation. Summer-fallowing is necessary when the soil is dry-farmed, and erosion is a problem during the years of soil exposure. With irrigation, legumes and legume-grass mixtures should be the main crops, but cash crops such as potatoes could be produced. The soil is fair to good for agriculture. Of the areas suitable for irrigation, 58 acres are third-, 324 fourth-, and 515 fifth-class land.

## Brown Wooded–Gray Forested Soil Intergrade

This intergrade is composed of forested soils with bisequa profiles in which the upper sequum is a recent overlay rather than the product of normal soil development. The lower part of the profile, derived from glacial till, underwent podzolization and developed into a Gray Forested soil. Thereafter it was covered by a layer of loess and volcanic dust up to 24 inches thick. The overlay developed into a Brown Wooded soil high in bases, showing little evidence of leaching.

The Brown Wooded soil is characterized by a thin L-H horizon of forest litter on the surface, underlain by pale-brown to yellowish-brown Bm and Bf mineral horizons. The Gray Forested soil beneath is distinguished by a deeply leached and grayish Ae horizon underlain by a thick horizon consisting mainly of bleached Ae material but with pockets or thin layers of darker-colored clay. In the surveyed area, the Gregoire loam is the only soil of this intergrade.

### *Gregoire Loam*

The Gregoire loam developed on medium-textured glacial till. It occurs extensively on the plateau, and elsewhere it is scattered in the surveyed area. The topography varies from gently undulating and sloping to strongly rolling and very hilly. The elevation ranges from 2,200 feet northwest of Grand Forks to 4,500 near Camp McKinney. Of a total of 24,989 acres mapped, 12,119 are arable. Of the remaining 12,870 acres, 9,730 have rough-broken topography and 3,140 are excessively stony.

The parent material is mainly loam-textured till with a moderate content of gravels and cobbles. The till is overlain by loess and volcanic dust averaging about 18 but ranging from 12 to 24 inches thick. Some of the material derived from till has been mixed with the overlay by wind-thrown trees and solifluction, introducing gravels and cobbles, but these are fewer than in the till beneath. A stone-line often bounds the two types of materials.

The till is weathered to a depth of five or six feet from the surface. The unweathered till beneath has pseudoplaty structure and a higher pH than the solum above. The impervious, unweathered till is from one to 50 feet thick, and is underlain by bedrock and in places by unconsolidated materials.

Though the surface mineral layer is mainly loam, there is some variation to sandy loam. The subsoil grades from loam to sandy loam and occasionally to loamy sand or clay loam. Surface stone is light to moderate, except in areas of many bedrock outcroppings and near rough mountainous land. Although mostly well to moderately well drained, this soil includes a minor acreage of poorly drained depressions.

The Gregoire loam is a Brown Wooded–Gray Forested soil that developed under coniferous forest. The tree cover consists of Douglas fir and larch of light to medium density. Recently burned areas have thick stands of young lodgepole pine and larch. Aspen, willow, and alder are common. In the humid sections of the upper Boundary Creek valley and around Eholt, a balsam fir–spruce zone replaces the Douglas fir. There is a variable ground cover of pinegrass, kinnikinnick, soopolallie, dwarf blueberry, huckleberry, Oregon grape, spirea, and others. A range of elevation exceeding 2,000 feet provides sufficient climatic variation for several biotic zones. A profile representing the average conditions for Gregoire loam was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 1 – 0 | Forest litter. Pinegrass, needles, twigs, cones, wood, etc. Loose and fluffy on top; decomposed in the lower part. Some charcoal. pH 5.9. |
| | | Discontinuous, thin layer of white volcanic dust. |
| Bm | 0 – 6 | Pale-brown (10YR 6/3, dry) or dark-brown (10YR 4/3, moist) loam. Very weak, subangular blocky breaking to granular structure. Soft when dry. Scattered gravels. Pockets and flecks of volcanic dust. Many fine roots. pH 6.6. |
| Bf | 6 – 16 | Light yellowish brown (10YR 6/4, dry) or yellowish-brown to dark yellowish brown (10YR 4.5/4, moist) loam. Weak subangular blocky breaking to granular structure. Soft when dry. Scattered gravels and cobbles in lower part. A moderate number of roots. pH 6.9. |
| IIAe | 16 – 35 | Light-gray (10YR 7/2, dry) or grayish-brown to dark grayish brown (2.5Y 4.5/2, moist) gravelly sandy loam or gravelly loam. Fine blocky structure. Hard when dry. Much fine gravel. Concentration of cobbles and boulders in upper part. A few roots. pH 6.9. |
| IIA and B | 35 – 63 | Light brownish gray (2.5Y 6/2, dry) or dark grayish brown (2.5Y 4/2, moist) sandy loam. Moderate, fine blocky structure. Very hard when dry. Mostly bleached and vesicular with pockets of clay. Scattered gravels and cobbles. A few roots. pH 7.2. |
| IIC | 63 – 80 | Pale-olive (5Y 6/3, dry) or dark grayish brown to olive-brown (2.5Y 4/3, moist) loam-textured till. Pseudoplaty. Very hard when dry. Scattered gravels and cobbles which become more numerous with depth. Occasional roots in upper part. pH 7.5. |

In places of slight surface disturbance, white volcanic dust occurs as a discontinuous layer up to two inches thick. Generally enough disturbance has occurred to mix the volcanic dust into the soil to depths of 12 to 18 inches. Mottling is sometimes found in the lower part of the solum, indicating a temporary water table.

*Agriculture*

Large areas are used for cattle range. Most of the mature timber has been logged. At the time of the survey (1957) only a few small parcels were cultivated. There are dry periods during the growing season, due to the summer-dry climate, and crop production requires irrigation. Small irrigation projects could be undertaken by damming streams and depressions for the storage of freshet water. Under sprinkler irrigation the farm delivery requirement is about 18 acre-inches. Springs could be used as sources of domestic water, and wells are productive in sepage areas. Dugouts may be used for the storage of meltwater where underlying till is thick and impervious and there is adequate tributary catchment.

The clearing of the forest is expensive, but stones should be of little hindrance to cultivation. When dry-farmed the soil is less productive than the Stevens loam, but it is used for the production of the same crops. Yields depend on rainfall during the growing season and vary from year to year.

With irrigation the Gregoire loam is productive for all climatically suitable forage crops. Of the soils suitable for irrigation, 1,209 acres are third-, 6,676 are fourth-, and 4,234 are fifth-class land.

## Acid Brown Wooded Soils

This group of soils developed under forest in the most humid section of the surveyed area. The soils are found on coarse-textured silica-rich deposits in the northern part of the Boundary Creek valley. The solum is brownish, medium to slightly acid, and low in clay and sesquioxides.

Only the Orthic subgroup was found. The solum is characterized by an L-H horizon of forest litter, and a light yellowish brown Bf horizon beneath. A transitional BC horizon may be present. The Orthic subgroup is represented by the Hulme gravelly sandy loam.

### Orthic Acid Brown Wooded Soils

#### *Hulme Gravelly Sandy Loam*

This soil type is derived from gravelly river terraces in the Boundary Creek valley north of Windfall Creek. The topography varies from smooth to irregular, very gentle to moderate slopes. Elevations range between 3,300 and 3,550 feet. A total of 368 acres were mapped, of which 33 are rough-broken.

The parent material, which is from 14 to 20 inches thick, is gravelly sandy loam grading to gravelly sand at contact with the underlying substrata. The substrata are composed of roughly stratified sands, gravels, and cobbles, chiefly granitic, containing a high percentage of silica. The stone content at the surface varies from light to moderate. The solum is slightly to moderately acid.

The Hulme gravelly sandy loam is a rapidly drained Orthic Acid Brown Wooded soil that developed under fairly moist forest conditions. The vegetation is composed of moderately dense lodgepole pine with an understory of young spruce and balsam fir. The main shrubs are shepherdia, spirea, dwarf huckleberry, and kinnikinnick. Pinegrass and others make up a dense herb layer. A profile in the Boundary Creek valley was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| L–H | 1½– 0 | Forest litter of needles, twigs, cones, and grass. Well decomposed in the lower part. |
| | 0– 1 | Very pale brown (10YR 8/4, dry) volcanic dust of sandy loam texture. Fine platy structure. Very friable when moist. Abrupt change to horizon beneath. pH 5.3. |

| Horizon | Depth Inches | Description |
|---|---|---|
| Bf1 | 1 – 5 | Light yellowish brown (10YR 6/4, dry) or yellowish-brown (10YR 5/6, moist) gravelly sandy loam. Very weak, subangular blocky breaking to weak granular structure. Soft when dry, very friable when moist. Many roots. pH 6.3. |
| Bf2 | 5 – 13 | Very pale brown (10YR 7/4, dry) or yellowish-brown (10YR 5/8, moist) gravelly sandy loam. Weak, medium, subangular blocky structure. Friable when moist. A few cobbles. Many roots. pH 6.4. |
| IIBC | 13 – 20 | Very pale brown (10YR 7/3, dry) or light yellowish brown (10YR 6/4, moist) gravelly sand. Single-grained, loose. Much gravel, some cobbles and stones. A few roots. pH 6.1. |
| IIC | 20+ | Light-gray (10YR 7/2, dry) coarse sand and fine gravel containing moderate amounts of cobbles and stones. A few roots. pH 6.1. |

*Agriculture*

Forest and limited range are the only uses of this soil under natural conditions. The entire acreage was within a forest management licence and forested at the time of the soil survey (1957). Though in a humid region, the soil is too coarse-textured and porous for dry farming. All areas are adjacent to Boundary Creek; water is available for domestic use and irrigation. Sprinkler irrigation is recommended and the farm delivery requirement is about 30 acre-inches.

Reclamation involves clearing the heavy forest and removing some stones. Once prepared, the soil is fair to poor for agriculture, even under irrigation. The shallow solum limits the rooting zone, promotes leaching of nutrients, and limits moisture-holding capacity. The cool climate and short frost-free period restrict crops to legumes, legume–grass mixtures, other hay, and grain. Of the areas suitable for irrigation, 171 acres are fourth- and 164 fifth-class land.

## Humic Gleysol Soils

These soils occur in depressions in the region of the Black soils, chiefly on the plateau between Rock Creek and Anarchist Mountain. The depressions support a mixed deciduous tree cover. The poorly drained solum is characterized by an accumulation of organic matter in the surface horizons, which imparts a dark color. The subsoil is gleyed and mottled.

The only subgroup of the Humic Gleysol soils in the surveyed area is the Carbonated Rego Humic Gleysol. The solum is distinguished by a calcareous, gray to dark-gray Ahk horizon with a gleyed, calcareous Cg horizon beneath. A transitional AC horizon and a Cca horizon usually occur. This subgroup is represented by the Myncaster silt loam.

### Carbonated Rego Humic Gleysol Soils

#### *Myncaster Silt Loam*

The Myncaster silt loam is derived from slopewash that accumulated in depressions in areas underlain by glacial till. The depressions, which are comparatively small, occur chiefly on the plateau between Rock Creek and Anarchist Mountain. A few other areas were mapped on the highland west of Grand Forks.

The depressions occupy temporary drainage channels. The topography is characterized by gentle to moderate, smooth sideslopes and by gentle to moderate downslopes. A total of 653 acres were mapped between elevations of 2,000 west of Grand Forks and 4,050 feet near the summit of Highway No. 3 on Anarchist Mountain (Figure 26).

FIGURE 26. A northward view of the plateau landscape. Bridesville in right center. Myncaster silt loam in forested depressions.

The parent material consists of medium-textured sediments, which eroded from the surrounding soils. It is gravel- and stone-free and of variable thickness. The underlying, impervious till is generally close enough to the surface to maintain a high water table, which influences soil development. The surface layer is mainly silt loam, but may include some loam; the subsoil may vary from sandy loam to clay loam.

When surrounding soils are saturated by snowmelt, the excess water drains downslope on the underlying till and collects in the depressions. Temporary streams flow from some of the depressions in the spring. Lime and minor quantities of salts come with the seepage water and precipitate in the profile, making it calcareous and moderately alkaline. In a few places, dark-colored surface spots indicate the presence of sodium carbonate.

The Myncaster silt loam, a poorly drained Carbonated Rego Humic Gleysol soil, developed under aspen, birch, and willow. The groundcover is composed of grasses and weeds, and includes timothy, redtop, mint, aster, stinging nettle, and Canada thistle. Giant wild ryegrass is found on sunny exposures. A profile (Figure 27) was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| Ahk1 | 0 – 4 | Dark-gray (10YR 4/1, dry) or black (10YR 2/1, moist) silt loam. Medium granular structure. Very friable when moist. Numerous worms and worm castings. Many fine roots. Conductivity[4] 1.01. pH 7.5. |
| Ahk2 | 4 – 10 | Gray (10YR 5/1, dry) or very dark brown (10YR 2/2, moist) silt loam. Medium blocky structure. Firm when moist. Many worms, burrows, and castings; some small snail shells. White flecks of lime. Numerous fine roots. Conductivity 0.53. pH 7.8. |
| ACk | 10 – 16 | Light brownish gray (10YR 6/2, dry) or very dark grayish brown (10YR 3/2, moist) loam. Medium blocky structure. Firm when moist. Worms and worm castings end in this horizon. Numerous roots. Conductivity 0.46. pH 7.9. |
| Ccag | 16 – 22 | White to light-gray (10YR 7.5/1, dry) or light-gray to gray (10YR 7/2–5/1, moist) silt loam. Massive. Marly. Numerous roots. Conductivity 0.49. pH 7.8. |
| IICg1 | 22 – 29 | Pale-yellow (2.5Y 8/4, dry) or pale-olive to olive-yellow (5Y 6/5, moist) heavy silt loam. Massive. Scattered gravels and cobbles. A few roots in the upper part. Conductivity 0.43. pH 7.8. |
| IICg2 | 29+ | Pale-yellow (5Y 8/3, dry) or olive (5Y 5/4, moist) till of silt loam texture. Numerous gravels and cobbles, scattered boulders. Impervious. Conductivity 0.47. pH 7.9. |

*Agriculture*

In 1957, about half of the mapped acreage was dry-farmed. There were good yields of oats, but those of wheat and barley were poor. Wheat and coarse grains are the main crops, with summerfallow on alternate years. The soil is fair to poor for dry farming, depending on moisture and alkalinity in the different areas. In some cases underdrainage and in others irrigation would improve crop yields. For sprinklers the farm delivery requirement is about five acre-inches. Domestic water, hard and limy, is available from wells that intercept seepage.

Soil tests should be undertaken to determine the worth of different areas before reclamation. Being in natural drainageways the areas are subject to gully erosion when in fallow. Forage crops should be used to protect the soil from erosion. Of the areas suitable for irrigation, 16 acres are third-, 206 fourth-, and 431 fifth-class land.

## Gleysol Soils

These soils occur in depressions scattered in the forested part of the surveyed area. The depressions are subject to seepage and a fluctuating water table that approaches the surface in the freshet season. The poor drainage favors accumulation of forest litter and gleying of the mineral soil beneath.

[4] Conductivity of an extract from a saturated paste, expressed as millimhos per cubic centimeter at 25° C. The values shown are low throughout the profile and would not be injurious to plants.

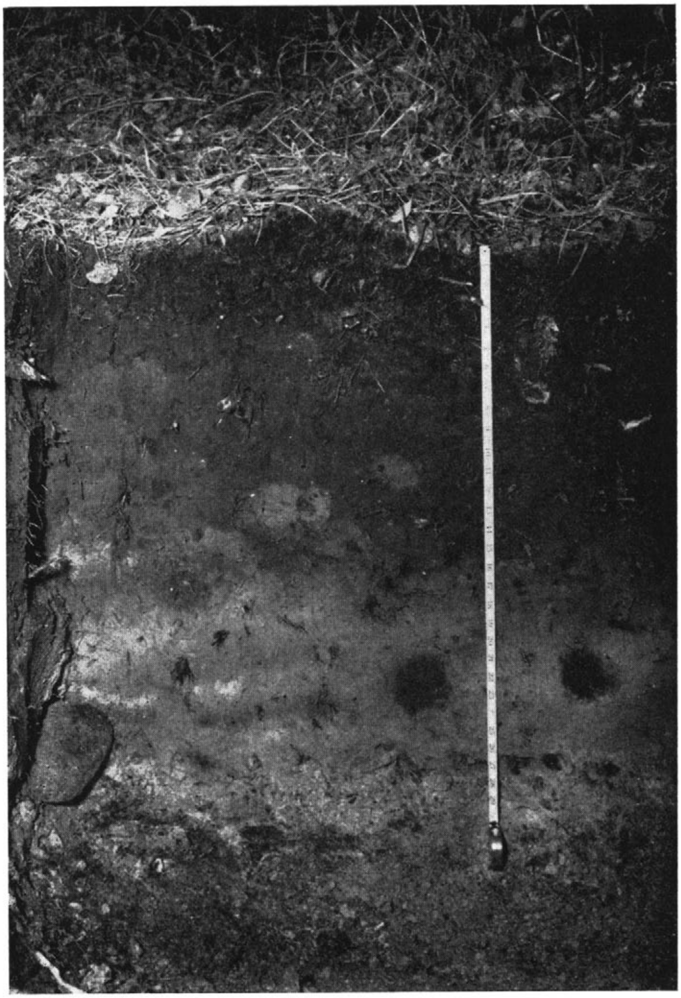

FIGURE 27. Profile of Myncaster silt loam about four miles west of Bridesville. The round, filled areas are crotovinas.

The Gleysol soils are represented by the Peaty Rego Gleysol subgroup. This subgroup is recognized by an L-H organic layer from six to 12 inches thick, underlain by a gleyed Cg horizon that may be mottled. An Ah horizon less than three inches thick may be present. The only representative is Wilgress muck.

## PEATY REGO GLEYSOL SOILS

### *Wilgress Muck*

The Wilgress muck occurs in scattered depressions. The larger areas are on the plateau, and near Eholt and Beaverdell. The topography, which is level to gently sloping, has hummocky microrelief in forested areas. A total of 1,479 acres were mapped between elevations of 1,950 and 4,100 feet.

The muck deposits, which are from six to 12 inches thick, overlie a variety of mineral soil materials. The organic matter is derived chiefly from forest litter, which accumulated under conditions of poor internal and external drainage. The litter, undecomposed at the surface, is progressively more humified with depth, grading to muck in the lower part. The gleyed mineral soil beneath was deposited as stream alluvium or wash from adjacent slopes. The deposits are usually in layers that vary from silt loam to gravelly sand. Scattered cobbles and stones are found where wash-in material thinly overlies glacial till.

The Wilgress muck is a Peaty Rego Gleysol soil. It supports a dense forest of cedar, spruce, cottonwood, willow, and alder. Shrubs and herbs include red-osier dogwood, salmonberry, ground dogwood, twinflower, and grasses. A representative profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| F1 | 12 – 10 | Very dark brown (10YR 2/2, dry) or black (5YR 2/1, moist), partly decomposed litter of twigs, needles, wood, and charcoal. Moist. Friable. Many roots. Earthworms. pH 6.4. |
| | 10 – 8 | White (10YR 8/1, dry) or light brownish gray (10YR 6/2, moist) volcanic dust of fine sandy loam texture. Massive. Friable. pH 6.7. |
| F2 | 8 – 4 | Gray (10YR 5/1, dry) or black (5YR 2/1, moist), semidecomposed organic material with some identifiable plant remains. Moist. Friable. Scattered roots. pH 6.7. |
| H | 4 – 0 | Brown (10YR 5/3, dry) or dark-brown (7.5YR 3/2, moist), well-decomposed organic matter containing some mineral material and volcanic dust. Moist. Friable. Occasional roots. pH 7.0. |
| Cg | 0+ | Light brownish gray (2.5Y 6/2, dry) or dark grayish brown (2.5Y 4/2, moist) layers of fine sand and gravelly sand having common, distinct yellowish-brown (10YR 5/6, moist) mottles. Water table at 30 inches in September. pH 7.0. |

*Agriculture*

Undeveloped areas provide light grazing and timber; in 1957 only a small acreage was cultivated. With drainage this soil would produce clover, hay, and pasture. The expense of clearing heavy forest and drainage makes reclamation costly. However, in view of the high yields obtainable without irrigation, the expense may be justified. When cultivated, the surface material decomposes rapidly to produce a friable topsoil.

## Organic Soils

Deposits of peat occur in poorly drained depressions in which a high water table favors accumulation of organic residues. The deposits are more than 12 inches thick. The plant remains in the various deposits are derived chiefly from trees and sedges. The materials are partly decomposed and fibrous. They are from slightly acid to neutral at the surface, becoming more acid at depths. The organic deposits are underlain by gleyed mineral soil material. They occupy a limited acreage, and were mapped as peat.

### *Peat*

Four bogs comprising a total of 414 acres were mapped between elevations of 2,600 and 2,900 feet. Two of the bogs occupy 186 acres near Eholt. One, 40 acres, is near Wallace Lake, and the other, 188 acres, is in the Beaver Creek valley. These bogs developed in very poorly drained depressions. They are accumulations of partly decomposed sedges, rushes, leaves, needles, woody material, and some moss. Common features of the different bogs are similarity of the plant remains and stage of decomposition. The organic materials, which vary from one to 10 feet thick, overlie mineral sediments. In undisturbed places a thin layer of volcanic dust occurs between six inches and a foot from the surface.

The surface is generally level to depressional, with hummocky microtopography. Usually the high water table is maintained by a small creek entering at one end of the bog. The forest is chiefly spruce, with some willow, alder, and bog birch. Shrubby cinquefoil and hardhack are common. The ground is covered by sedges, twinflower, ground dogwood, and moss.

Where the land has not been cultivated, the yellowish-brown plant remains are only slightly decomposed. Layers of mineral soil occur near the bog margins, where slope wash has spread over the organic material. A drained and cultivated profile was described as follows:

| *Horizon* | *Depth Inches* | *Description* |
|---|---|---|
| 1 | 0 – 8 | Very dark brown (10YR 2/2, dry) or black (10YR 2/1, moist), semidecomposed peat containing specks and lenses of volcanic dust. Many fine roots. pH 6.5. |
| 2 | 8 – 118 | Dark yellowish brown (10YR 4/4, moist) to very dark brown and black (10YR 2/2–2/1, moist) woody peat. Fairly raw, fibrous; many bits and pieces of partly decomposed wood. September water table 30 inches from surface. pH 6.0 at top, 5.3 below 100 inches. |
| IICg | 118+ | Gray (10YR 5/1, moist), very fine sand. Some organic stains in the top few inches. pH 6.9 at top, 6.5 at 155 inches. |

*Agriculture*

The undeveloped areas of peat have no value for grazing or forestry. A small acreage between Eholt and Greenwood is drained and cultivated, and gives a moderate yield of hay and pasture. Inadequate drainage results in spring flooding, and the drowning of domesticated grasses. The reduced competition allows sedges and other water-tolerant species to take over.

The peat requires adequate drainage and fertilization for good crop yields, and crops grown should be frost-hardy. Hay, pasture, oats in rotation, and specialized crops could be produced. The bog soils do not require irrigation.

## Miscellaneous Land Types

### *Swamps*

Swamps occur in small, scattered depressions in the surveyed area and occupy a total of 943 acres. These depressions, which support marsh vegetation, have shallow depths of water for the greater part of the year. The swamps are usually bottomed with a variable thickness of organic remains. In their natural state they have value as sources of browse and water for livestock.

### *Ponds*

Ponds occur in small depressions and occupy 288 acres. These bodies of open water are too deep to support aquatic plants, except near the edges. They are valued as a source of water for livestock.

### *Smelter and Concentrator Dumps*

This land type occurs near Carmi, Beaverdell, Greenwood, and Grand Forks. The areas near Carmi and Beaverdell consist of lead-zinc concentrator waste, and occupy 49 acres. Those near Greenwood and Grand Forks cover 134 acres. They are composed of consolidated and granular slag from copper smelters. All of these areas are barren of vegetation.

### *Bluffs and Ravines*

The bluffs and ravines occupy areas of steeply sloping, broken relief having gradients of more than 30 percent. Such areas chiefly border deeply incised river and creek channels and occupy 12,195 acres. Much of the acreage is precipitous and has no value for agriculture or forestry. Areas having more moderate relief have limited value for grazing and timber.

**Table 5.—Approximate Acreages of the Arable and Nonarable Soils and Land Types[1]**

| Soil | Arable | Nonarable | Total |
|---|---|---|---|
| Beaverdell gravelly sandy loam | 11,362 | 14,077 | 25,439 |
| Bluffs and ravines | - | 12,195 | 12,195 |
| Bolduc gravelly sandy loam | 287 | 75 | 362 |
| Bubar sandy loam | 1,549 | 28 | 1,577 |
| Bubar loamy fine sand | 2,015 | 19 | 2,034 |
| Bubar sand | 852 | 25 | 877 |
| Burrell sandy loam | 1,069 | - | 1,069 |
| Carmi sandy loam | 1,330 | - | 1,330 |
| Conkle silt loam | 1,782 | 610 | 2,392 |
| Coteay sandy loam | 132 | - | 132 |
| Ferroux sandy loam | 3,942 | 4,836 | 8,778 |
| Fiva sandy loam | 926 | 192 | 1,118 |
| Gregoire loam | 12,119 | 12,870 | 24,989 |
| Hoolan sandy loam | 388 | - | 388 |
| Hulme gravelly sandy loam | 335 | 33 | 368 |
| Ingram silt loam | 500 | - | 500 |
| Kermel silt loam | 700 | 309 | 1,009 |
| Marble sand | 1,400 | - | 1,400 |
| McCoy gravelly sandy loam | 3,813 | 960 | 4,773 |
| Mires gravelly sandy loam | 1,725 | 825 | 2,550 |
| Mogul very fine sandy loam | 150 | 11 | 161 |
| Myncaster silt loam | 653 | - | 653 |
| Peat | 414 | - | 414 |
| Phoenix sandy loam | 715 | 119 | 834 |
| Ponds | - | 288 | 288 |
| Republic gravelly sandy loam | 977 | 367 | 1,344 |
| Saunier soil complex | 17,620 | 406 | 18,026 |
| Sidley silt loam | 568 | 1,337 | 1,905 |
| Smelter and concentrator dumps | - | 183 | 183 |
| Spion loamy sand | 1,321 | 14 | 1,335 |
| Stevens loam | 8,329 | 3,324 | 11,653 |
| Swamp | - | 943 | 943 |
| Taurus loam | 897 | 687 | 1,584 |
| Thone silt loam | 92 | - | 92 |
| Tuzo gravelly sandy loam | 785 | 24 | 809 |
| Wilgress muck | 1,479 | - | 1,479 |
| Wilkinson silt loam | 1,384 | 34 | 1,418 |
| Zamora loamy sand | 2,480 | 238 | 2,718 |
| Total | 84,090 | 55,029 | 139,119 |

[1]All of the arable soils require irrigation except Peat and Wilgress Muck.

# CLASSES OF SOILS ACCORDING TO SUITABILITY FOR IRRIGATION

During the survey the soils were rated according to suitability for irrigation (16, 17). The irrigable land in each soil type or complex was differentiated into classes. Maps showing the distribution of soil types and land classes were supplied to the Water Resources Division, Canada Department of Northern Affairs and National Resources, Vancouver, B. C., and the Department of Agriculture, Victoria, B. C. These unpublished maps are useful as bases for more detailed surveys of irrigation proposals.

Only the relevant soil and landscape features were used to determine the irrigation classes. The classes, as given in Table 6, may need revision as more detailed information on soils and crops becomes available. The water requirements of the various soils, given with each soil description, are estimates. The estimated water requirement for the total of 82,197 irrigable acres in the surveyed area is 178,301 acre-feet per year (18). The classes are as follows:

## Class 1 Soils

Class 1 soils are deep, uniform, well-drained soils of medium to moderately fine texture, including fine sandy loam, loam, silt loam, and silty clay loam. They are the best suited to irrigation practices and are capable of producing all commercial crops that can be grown in the region.

## Class 2 Soils

Class 2 soils include well-drained clays and all soils of medium to moderately fine texture with moderate limitations due to stones, gravels, alkalinity, salinity, or adverse topography. Most of these soils are suited to the same crops as those of Class 1, but are rated lower because they vary more.

## Class 3 Soils

These soils are similar in texture to those in classes 1 and 2, but have moderate to severe limitations because of stones, gravels, alkalinity, salinity, impeded drainage, or adverse topography. Class 3 soils also include moderately well drained heavy clays and gravelly river channels and terraces with reasonably deep and comparatively stone-free overlays. These soils are limited to fewer crops than the first two classes, or they are more difficult to irrigate.

## Class 4 Soils

Class 4 soils include heavy clays with alkaline subsoils, flat topography, and impeded drainage, and all soils with depressional topography subject to flooding. When the soils are drained they may be assigned to a higher class. This class also includes thin, gravelly river terraces, channel bottoms, and soils having limited use; in a more detailed survey the poorer portions of this group may be placed in Class 5.

## Class 5 Soils

Class 5 soils are stony, gravelly, or shallow, or have very limited use because of rough topography, high alkalinity, or salinity. These soils may not be worth developing under present conditions.

**Table 6.—Classes and Acreages of Soils According to Suitability for Irrigation**

| Soil | Class | | | | | Total |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| Beaverdell gravelly sandy loam | – | – | 947 | 6,334 | 4,081 | 11,362 |
| Boldue gravelly sandy loam | – | – | 42 | 52 | 193 | 287 |
| Bubar sandy loam | 84 | 1,037 | 418 | 10 | – | 1,549 |
| Bubar loamy fine sand | – | – | 1,991 | 24 | – | 2,015 |
| Bubar sand | – | – | – | 781 | 71 | 852 |
| Burrell sandy loam | – | – | 944 | 60 | 65 | 1,069 |
| Carmi sandy loam | 136 | 139 | 780 | 117 | 158 | 1,330 |
| Conkle silt loam | – | 115 | 1,357 | 236 | 74 | 1,782 |
| Coteay sandy loam | – | – | – | – | 132 | 132 |
| Ferroux sandy loam | – | 84 | 330 | 1,927 | 1,601 | 3,942 |
| Fiva sandy loam | – | – | 149 | 623 | 154 | 926 |
| Gregoire loam | – | – | 1,209 | 6,676 | 4,234 | 12,119 |
| Hoolan sandy loam | – | – | 186 | 12 | 190 | 388 |
| Hulme gravelly sandy loam | – | – | – | 171 | 164 | 335 |
| Ingram silt loam | 307 | 193 | – | – | – | 500 |
| Kermel silt loam | – | 63 | 173 | 287 | 177 | 700 |
| Marble sand | – | – | – | 1,132 | 268 | 1,400 |
| McCoy gravelly sandy loam | – | – | 646 | 2,174 | 993 | 3,813 |
| Mires gravelly sandy loam | – | 48 | 313 | 78 | – | 439 |
| Mires gravelly sandy loam, shallow phase | – | – | 379 | 537 | 370 | 1,286 |
| Mogul very fine sandy loam | – | 16 | 11 | 123 | – | 150 |
| Myncaster silt loam | – | – | 16 | 206 | 431 | 653 |
| Phoenix sandy loam | – | 11 | 149 | 279 | 276 | 715 |
| Republic gravelly sandy loam | – | 112 | 270 | 377 | 218 | 977 |
| Saunier soil complex | – | 119 | 8,316 | 5,964 | 3,221 | 17,620 |
| Sidley silt loam | – | – | 16 | 358 | 194 | 568 |
| Spion loamy sand | – | – | 1,162 | 124 | 35 | 1,321 |
| Stevens loam | – | – | 307 | 4,094 | 3,928 | 8,329 |
| Taurus loam | – | – | 58 | 324 | 515 | 897 |
| Thone silt loam | – | 92 | – | – | – | 92 |
| Tuzo gravelly sandy loam | – | – | 328 | 375 | 82 | 785 |
| Wilkinson silt loam | 46 | 642 | 611 | 85 | – | 1,384 |
| Zamora loamy sand | – | – | 43 | 1,927 | 510 | 2,480 |
| Total | 573 | 2,671 | 21,151 | 35,467 | 22,335 | 82,197 |

# CLASSES OF LAND FOR DRY FARMING

Dry farming is most common in the Black soil areas on parts of the plateau west of Rock Creek and the Midway Mountains, but is also practiced in the valleys. The largest area is on the plateau around Bridesville. There are smaller highland areas in the Midway Mountains south of Rock Creek, north of Midway, and between July Creek and Grand Forks. It is doubtful if water could be made available to irrigate any but small, scattered parcels of this land. Land in the valleys of the Kettle River and its tributaries is near water supplies and is or could be irrigated. About 6,740 acres are irrigated and a larger acreage is dry-farmed.

None of the dry-farmed soils are excellent or even very good for the purpose; all would benefit from irrigation. This is due to a combination of factors such as low moisture-holding capacity, adverse topography, stoniness, and hot, dry summers.

In the Kettle River valley between Westbridge and Midway, and also between Carson and Laurier, the summers are too hot and dry to permit dry farming. In the rest of the surveyed area, dry farming can be practiced on the most drought-resistant soils, owing to higher elevations, greater precipitation, and less summer heat.

Criteria for land use classes are based on climate, soil, and landscape features that affect land use and crop yields. Soil factors are type of profile, texture, stoniness, and depth of solum, all of which may be used to estimate moisture-holding capacity and natural soil fertility. The topography is the most important feature of the landscape, because it affects tillage, including energy used, and the degree of erosion that may be expected. Slopes exceeding 30 percent are too great for cultivation. Soils on slopes between 15 and 30 percent should be kept under sod crops.

Only the relevant soil and landscape features were used to evaluate the soils for dry farming, and the groupings are tentative. Revision may become necessary when more detailed information is available on the soils and crop yields. Changes in methods of management, crop varieties, and economic conditions may also affect the suitability of a soil for a given purpose, and thus change its rating. The soils were rated in the following classes (Table 7) on the basis of probable productivity. Though crop yields were not available for use in the ratings, the yields may be expected to correspond with them.

### Class 1: Very Good to Excellent

None of the surveyed soils were considered to have the properties necessary to be included in Class 1. Such soils should have high moisture-holding capacity resulting from deep solums and moderately fine to fine textures. They require good physical condition and must be high in organic matter and natural fertility. Little or no handicap is imposed by adverse topography, restricted drainage, gravel, or stones.

### Class 2: Good

Class 2 soils have less favorable soil and landscape features than those in Class 1, lower moisture-holding capacity due to coarser texture, lower natural fertility, and less favorable topography.

### Class 3: Fair

Class 3 soils have medium to moderately coarse texture and deep solums. The topography is mainly level to undulating and stoniness is not a problem. These soils occupy most of the acreage dry-farmed with a reasonable degree of success.

### Class 4: Poor

Class 4 soils include those of medium texture but with adverse topography; slopes generally exceed 10 percent. Also included are soils of moderately coarse texture with thinner solums or coarser-textured subsoils than those of Class 3. These soils require good management, particularly to prevent erosion on the steeper slopes, and to provide drainage where natural drainage is poor. Crop growth depends more on appropriately spaced falls of rain than in the higher classes. Since the distribution of rainfall varies widely, there are wide differences in yield from year to year. Both soil texture and depth are more uneven than in the higher classes, and crop growth is often spotty.

## Class 5: Unsuitable

All soils in Class 5 are considered unsuitable for dry farming. These include coarse- and moderately coarse-textured soils with thin solums over gravelly substrata. Also included are very stony soils and soils with topography too steep for cultivation. Some of these soils are suitable for grazing; others should be kept under forest. During the survey, abandoned farms were found on these soil types.

**Table 7.—Classes and Acreages of Soils According to Suitability for Dry Farming**

| Soil | Topography or phase | Acres | |
|---|---|---|---|
| | *Class 2: Good* | | |
| Stevens loam | Gently sloping, undulating | 307 | |
| Thone silt loam | | 92 | |
| | | | 399 |
| | *Class 3: Fair* | | |
| Burrell sandy loam | Gently sloping, undulating | 944 | |
| Carmi sandy loam | Gently, moderately sloping | 1,055 | |
| Conkle silt loam | Level, undulating | 1,472 | |
| Gregoire loam | Undulating | 1,209 | |
| Kermel silt loam | Level, undulating | 236 | |
| Mires gravelly sandy loam | Level, undulating | 301 | |
| Mogul very fine sandy loam | Level, undulating | 27 | |
| Myncaster silt loam | Gently sloping | 222 | |
| Phoenix sandy loam | Gently sloping | 160 | |
| Republic gravelly sandy loam | Gently sloping | 382 | |
| Saunier soil complex | Medium texture | 8,435 | |
| Sidley silt loam | Undulating | 16 | |
| Stevens loam | Rolling | 4,094 | |
| Taurus loam | Undulating | 58 | |
| Wilkinson silt loam | | 1,384 | |
| | | | 20,055 |
| | *Class 4: Poor* | | |
| Burrell sandy loam | Rolling | 125 | |
| Carmi sandy loam | Steeply sloping | 117 | |
| Conkle silt loam | Rolling, strongly rolling | 310 | |
| Coteay sandy loam | | 132 | |
| Ferroux sandy loam | Gently, moderately sloping | 2,341 | |
| Gregoire loam | Rolling, strongly rolling | 10,910 | |
| Hoolan sandy loam | Gently sloping, undulating | 198 | |
| Ingram silt loam | | 500 | |
| Kermel silt loam | Rolling, strongly rolling | 464 | |
| Mires gravelly sandy loam | Rolling | 78 | |
| Mires gravelly sandy loam | Shallow phase; level, undulating | 916 | |
| Mogul very fine sandy loam | Rolling | 123 | |
| Myncaster silt loam | Moderately sloping, alkali | 431 | |
| Peat | | 414 | |
| Phoenix sandy loam | Moderately, steeply sloping | 279 | |
| Republic gravelly sandy loam | Moderately, steeply sloping | 377 | |
| Saunier soil complex | Moderately coarse texture | 9,185 | |
| Stevens loam | Strongly rolling | 3,928 | |
| Sidley silt loam | Rolling, strongly rolling | 552 | |
| Taurus loam | Rolling, strongly rolling | 839 | |
| Wilgress muck | | 1,479 | |
| | | | 33,698 |

| Soil | Topography or phase | Acres | |
|---|---|---|---|
| *Class 5: Unsuitable* | | | |
| Beaverdell gravelly sandy loam | | 25,439 | |
| Boldue gravelly sandy loam | | 362 | |
| Bubar series | | 4,488 | |
| Carmi sandy loam | Very steeply sloping | 158 | |
| Conkle silt loam | Rough-broken | 610 | |
| Ferroux sandy loam | Steeply sloping, rough-broken | 6,437 | |
| Fiva sandy loam | | 1,118 | |
| Gregoire loam | Rough-broken | 12,870 | |
| Hoolan sandy loam | | 190 | |
| Hulme gravelly sandy loam | | 368 | |
| Kermel silt loam | Rough-broken | 309 | |
| Marble sand | | 1,400 | |
| McCoy gravelly sandy loam | | 4,773 | |
| Mires gravelly sandy loam | Shallow phase; rolling, rough-broken | 1,195 | |
| Mogul very fine sandy loam | Rough-broken | 11 | |
| Phoenix sandy loam | Very steeply sloping, rough-broken | 395 | |
| Republic gravelly sandy loam | Very steeply sloping, rough-broken | 585 | |
| Saunier soil complex | Coarse textures, rough-broken | 406 | |
| Sidley silt loam | Rough-broken | 1,337 | |
| Spion loamy sand | | 1,335 | |
| Stevens loam | Rough-broken | 3,324 | |
| Taurus loam | Rough-broken | 687 | |
| Tuzo gravelly sandy loam | | 809 | |
| Wilkinson silt loam | Rough-broken | 34 | |
| Zamora loamy sand | | 2,718 | |
| | | | 71,358 |
| Total | | | 125,510 |

# SOIL MANAGEMENT

In the surveyed area, good management requires the prevention of erosion and maintenance of organic matter and plant nutrients. Irrigation should be practiced wherever possible. If it is necessary to farm without irrigation, management should aim at conserving moisture and ensuring maximum infiltration of snowmelt and rainfall. Fortunately, certain measures that help to conserve moisture also reduce the erosion hazard.

Though summerfallowing controls weeds and rests the land for the succeeding crop, it leaves the soil vulnerable to erosion. In fallow years the erosion hazard can be reduced by contour cultivation and strip cropping where the land is not level. Clean cultivation of slopes should be avoided by leaving crop residue on the surface. Such measures reduce the rate of runoff, and permit the soil to absorb additional moisture.

Another means of conserving moisture is to build up and maintain a good supply of organic matter. Cultivation speeds the decomposition of organic matter and should be avoided when possible. Cover crops help to increase or maintain the organic matter in the soil, thereby increasing the moisture-holding capacity. Organic matter also improves soil structure and tilth, and is a source of available nitrogen and phosphorus.

In the surveyed area, soils reclaimed from forest are deficient in organic matter, nitrogen, and sometimes other nutrient elements. Fertilization and the use of legume–grass mixtures to build up the organic matter content is necessary from the time of reclamation. On the other hand, soils that developed under natural grass usually contain a good supply of organic matter and available nutrients. Good crops may be produced for many years without addition of fertilizers, but in time deficiencies begin to appear. Such is now the case in the surveyed area, and additions of nitrogen and phosphorus are necessary for the optimum growth of cereals and hay.

Soil types subject to high, fluctuating water tables or restricted water movement should be drained to maintain the water table at appropriate depths. After drainage, such soils often require fertilizer for the best results.

Individuals interested in more details on the management of any of the soils described in this report should consult the District Agriculturist.

# ANALYSES OF THE SOILS

## pH

The pH of each soil was determined by the Beckman pH meter, with a saturated paste. The pH values for the various horizons of eight selected soils are given in Table 8. The values for all the soils are given in descriptions of the profiles.

Most of the soil types are slightly acid to neutral in the surface horizons, and from neutral to mildly alkaline in the upper part of the parent material. The pH of the solum is therefore generally within the limits considered optimum for plant growth. In the surveyed area the highest pH (9.0 to 9.4) was found in the C horizon of Kermel silt loam, an Orthic Dark Brown soil. This may be troublesome where erosion has exposed the parent material.

### Cation Exchange Capacity and Exchangeable Bases

The cation exchange capacity depends on the organic matter content and the amount and kind of clay minerals in the soil. The cation exchange capacities given in Table 8 were determined by the method of Atkinson *et al.* (19), with the following modifications: Excess ammonium acetate was washed from ammonia-saturated soil in a Buchner funnel with a mixture of 85 percent ethyl and 15 percent methyl alcohol. Ammonia was then extracted with a sodium chloride solution and distilled in a micro-Kjeldahl unit.

The A horizons have the highest cation exchange capacity, largely because of the greater content of organic matter. However, clay accumulations give a high cation exchange capacity in the Bt horizons of the Wilkinson and Sidley silt loams, which are Orthic Gray Wooded and Brown Wooded–Gray Wooded soils respectively.

The exchangeable bases (Table 8) were extracted with neutral, normal ammonium acetate. The Beckman B flame spectrophotometer was used to determine sodium and potassium. Calcium and magnesium were determined by versenate titration.

Of all the soils studied, only Hulme gravelly sandy loam, an Orthic Acid Brown Wooded soil, is deficient in exchangeable calcium, magnesium, and potassium. All the other soils contain a moderate to high content of these exchangeable bases, and appear able to satisfy the needs of most crops. Sodium is at a low and safe level in all of the soils.

### Organic Matter

Organic matter content (Table 9) was determined by the wet-combustion method of Walkley and Black, as described by Atkinson *et al.* (19).

**Table 8.—Cation Exchange Capacities, Percentage Base Saturations, and Exchangeable Cations in the Horizons of Eight Virgin Soils[1]**

| Horizon | Depth Inches | Exchange capacity M.e.[2]/100 grams | Base saturation % | Exchangeable cations M.e./100 grams | | | | pH |
|---|---|---|---|---|---|---|---|---|
| | | | | Ca | Mg | K | Na | |
| | | | | *Bubar loamy fine sand* Orthic Dark Brown soil | | | | |
| Ah | 0–8 | 6.8 | 100.0 | 6.8 | 0.9 | 0.4 | 0.1 | 7.0 |
| AB | 8–15 | 4.8 | 100.0 | 4.2 | 0.9 | 0.4 | 0.1 | 7.5 |
| Bm | 15–26 | 3.6 | 100.0 | 2.4 | 1.1 | 0.3 | trace | 7.6 |
| BC | 26–33 | 2.7 | 100.0 | 2.8 | 0.1 | 0.2 | trace | 7.9 |
| C | 33+ | 2.5 | 100.0 | 1.7 | 0.8 | 0.2 | trace | 8.1 |
| | | | | *Stevens loam* Orthic Black soil | | | | |
| Ah1 | 0–15 | 18.3 | 100.0 | 15.6 | 4.5 | 0.9 | 0.3 | 6.7 |
| Ah2 | 15–21 | 13.5 | 100.0 | 9.2 | 3.8 | 0.5 | 0.2 | 6.6 |
| AB | 21–24 | 7.4 | 93.1 | 4.3 | 2.2 | 0.3 | 0.1 | 6.4 |
| IIBm1 | 24–33 | 6.1 | 100.0 | 3.9 | 2.4 | 0.2 | 0.1 | 6.6 |
| | 33–42 | 7.3 | 100.0 | 4.7 | 3.1 | 0.2 | 0.1 | 6.6 |
| IIBm2 | 42–50 | 8.2 | 100.0 | 5.4 | 3.7 | 0.3 | 0.1 | 6.9 |
| IIC | 50+ | 6.9 | 100.0 | 6.7 | 3.1 | 0.2 | 0.2 | 7.6 |
| | | | | *Beaverdell gravelly sandy loam* Orthic Brown Wooded soil | | | | |
| –[3] | 0–2 | 14.4 | 85.2 | 8.5 | 2.7 | 1.0 | 0.1 | 6.1 |
| Bf1 | 2–7 | 9.1 | 87.7 | 5.6 | 1.1 | 1.1 | 0.2 | 6.5 |
| Bf2 | 7–13 | 6.8 | 91.7 | 4.3 | 1.1 | 0.6 | 0.3 | 6.5 |
| IIBC | 13–17 | 4.5 | 100.0 | 3.3 | 1.0 | 0.2 | 0.2 | 6.4 |
| IIC | 17+ | 3.0 | 100.0 | 2.2 | 0.9 | 0.1 | 0.1 | 6.6 |
| | | | | *Fiva sandy loam* Degraded Brown Wooded soil | | | | |
| Aej | 0–4 | 18.9 | 93.8 | 11.9 | 4.7 | 1.0 | 0.1 | 6.5 |
| AB | 4–10 | 17.8 | 88.6 | 11.6 | 3.1 | 0.9 | 0.1 | 6.7 |
| Btj | 10–13 | 13.2 | 92.7 | 8.3 | 3.1 | 0.7 | 0.2 | 6.8 |
| IIBtj | 13–21 | 11.7 | 100.0 | 7.4 | 4.3 | 0.4 | 0.1 | 7.0 |
| IIBC | 21–31 | 10.1 | 100.0 | 6.8 | 4.5 | 0.4 | 0.2 | 7.2 |
| IIC | 31+ | 9.4 | 100.0 | 6.6 | 4.4 | 0.3 | 0.2 | – |
| | | | | *Wilkinson silt loam* Orthic Gray Wooded soil | | | | |
| Ae | 0–7 | 10.0 | 92.6 | 5.8 | 3.0 | 0.4 | 0.1 | 5.9 |
| AB | 7–13 | 9.2 | 86.9 | 5.8 | 1.7 | 0.5 | 0.1 | 6.5 |
| Bt | 13–18 | 14.3 | 92.9 | 9.0 | 3.3 | 0.4 | 0.5 | 6.8 |
| | | | | *Sidley silt loam* Brown Wooded–Gray Wooded Intergrade | | | | |
| –[3] | 0–1 | 11.5 | 96.8 | 8.3 | 1.9 | 0.7 | 0.1 | 6.5 |
| Bm | 1–5 | 11.1 | 85.8 | 6.8 | 1.9 | 0.8 | 0.1 | 6.2 |
| Bf | 5–14 | 11.0 | 81.7 | 6.4 | 1.8 | 0.7 | 0.1 | 6.3 |
| IIAe | 14–22 | 7.0 | 96.8 | 4.1 | 2.3 | 0.2 | 0.1 | 6.5 |
| IIBt1 | 22–29 | 12.6 | 100.0 | 6.0 | 6.5 | 0.3 | 0.3 | 6.8 |
| IIBt2 | 29–33 | 13.0 | 100.0 | 6.3 | 6.9 | 0.4 | 0.4 | 7.1 |
| IICca1 | 33–40 | 11.2 | 100.0 | 18.3 | 9.8 | 0.2 | 0.3 | 7.8 |
| IICca2 | 40–50 | 6.8 | 100.0 | – | – | 0.3 | 0.6 | 8.3 |
| IIC | 50+ | 7.2 | 100.0 | 8.0 | 4.2 | 0.2 | 0.4 | 7.9 |
| | | | | *Gregoire loam* Brown Wooded–Gray Forested Intergrade | | | | |
| Bm | 0–6 | 10.2 | 100.0 | 8.5 | 1.7 | 0.5 | 0.1 | 6.6 |
| Bf | 6–16 | 8.9 | 100.0 | 7.0 | 1.2 | 0.6 | 0.1 | 6.9 |
| IIAe | 16–35 | 6.2 | 100.0 | 5.2 | 1.5 | 0.2 | 0.1 | 6.9 |
| IIA and B | 35–63 | 6.2 | 100.0 | 4.8 | 2.4 | 0.2 | 0.1 | 7.2 |
| IIC | 63–80 | 11.6 | 100.0 | 13.0 | 5.3 | 0.1 | 0.6 | 7.5 |

| Horizon | Depth Inches | Exchange capacity M.e.[2]/100 grams | Base saturation % | Exchangeable cations M.e./100 grams Ca | Mg | K | Na | pH |
|---|---|---|---|---|---|---|---|---|
| | | | *Hulme gravelly sandy loam* Orthic Acid Brown Wooded soil | | | | | |
| —[3] | 0– 1 | 9.3 | 9.2 | 0.4 | 0.2 | 0.2 | 0.1 | 5.3 |
| Bf1 | 1– 5 | 14.7 | 21.4 | 2.6 | 0.3 | 0.2 | 0.1 | 6.3 |
| Bf2 | 5–13 | 12.6 | 20.4 | 2.0 | 0.3 | 0.2 | 0.1 | 6.4 |
| IIBC | 13–20 | 2.4 | 22.3 | 0.4[4] | | 0.1 | trace | 6.1 |
| IIC | 20+ | 1.8 | 42.0 | 0.6[4] | | 0.1 | trace | 6.1 |

[1]On an ovendry basis.
[2]Milliequivalents.
[3]Volcanic dust horizon.
[4]Calcium and magnesium combined.

In all soils, the highest organic matter content occurs in the surface horizons, decreasing to a very low level in the subsoils. The Bubar series contains less organic matter than is usual in Dark Brown soils, but the Stevens loam typifies the high content common in Black soils. The forested soils show some variation in organic matter content of the surface horizons, but except for the upper one or two inches the content is moderately low.

Soils that developed under natural grass have a narrow carbon-nitrogen ratio, as indicated by the Stevens and Bubar profiles. In comparison, the forested soils have wider carbon-nitrogen ratios, particularly in the surface horizons.

## Total Nitrogen

Total nitrogen (Table 9) was determined by the method of Metson (20). The nitrogen content of a soil depends on the amount of organic matter present.

Excepting the Orthic Black Stevens loam, the soils analyzed are low in nitrogen. They would require addition of manure, crop residues, and nitrogen fertilizers when farmed.

## Total Phosphorus

Total phosphorus (Table 9) was determined by digesting five grams of soil in 30 ml. of 60 percent perchloric acid for one hour; color was developed by the Sherman method (21).

The levels of phosphorus are highest in the surface horizons except in the Wilkinson silt loam, an Orthic Gray Wooded soil; in this soil, phosphorus increases with depth. In the C horizons, phosphorus content varies considerably. The levels of available phosphorus were not determined, but the total phosphorus values are similar to those in the soils of the Okanagan Valley, where phosphorus fertilizers are applied to crops other than tree fruits.

## Totals of Other Constituents

Total calcium, magnesium, silica, iron, aluminum, and titanium were determined by sodium carbonate fusion, as outlined by Atkinson *et al.* (19). The calcium and magnesium contents (Table 9) do not vary appreciably between horizons in the Gregoire loam, a Brown Wooded–Gray Forested intergrade, or in the Stevens loam, an Orthic Black soil. The calcium content increases with depth in the Wilkinson and Sidley silt loams, Orthic Gray Wooded and Brown Wooded–Gray Wooded soils respectively.

**Table 9.—Total Organic Matter, Nitrogen, Phosphorus, Calcium, and Magnesium in the Horizons of Six Virgin Soils[1]**

| Horizon | Depth Inches | Organic matter % | Organic carbon % | N % | C/N % | P % | Ca % | Mg % |
|---|---|---|---|---|---|---|---|---|
| *Bubar loamy fine sand* Orthic Dark Brown soil | | | | | | | | |
| Ah | 0–8 | 1.55 | 0.90 | 0.06 | 15.8 | 0.08 | – | – |
| AB | 8–15 | 0.58 | 0.34 | 0.03 | 13.1 | 0.07 | – | – |
| Bm | 15–26 | 0.18 | 0.10 | 0.01 | 8.3 | 0.07 | – | – |
| BC | 26–33 | 0.11 | 0.06 | 0.01 | – | 0.07 | – | – |
| C | 33+ | 0.09 | 0.05 | 0.01 | – | 0.07 | – | – |
| *Stevens loam* Orthic Black soil | | | | | | | | |
| Ah1 | 0–15 | 6.33 | 3.67 | 0.22 | 16.3 | 0.10 | 2.24 | 1.15 |
| Ah2 | 15–21 | 3.87 | 2.25 | 0.15 | 15.4 | 0.11 | 2.17 | 1.28 |
| AB | 21–24 | 1.31 | 0.76 | 0.04 | 16.9 | 0.08 | 2.18 | 1.44 |
| IIBm1 | 24–33 | 0.69 | 0.40 | 0.03 | 14.8 | 0.07 | 2.27 | 1.60 |
| | 33–42 | 0.61 | 0.35 | 0.03 | 13.5 | 0.07 | 2.36 | 1.79 |
| IIBm2 | 42–50 | 0.43 | 0.25 | 0.02 | 15.6 | 0.08 | 2.38 | 1.87 |
| IIC | 50+ | 0.28 | 0.16 | 0.01 | – | 0.10 | 2.54 | 1.95 |
| *Beaverdell gravelly sandy loam* Orthic Brown Wooded soil | | | | | | | | |
| –[2] | 0–2 | 6.02 | 3.49 | 0.13 | 26.4 | 0.16 | – | – |
| Bf1 | 2–7 | 2.98 | 1.74 | 0.06 | 27.2 | 0.13 | – | – |
| Bf2 | 7–13 | 1.11 | 0.68 | 0.04 | 16.1 | 0.07 | – | – |
| IIBC | 13–17 | 0.47 | 0.27 | 0.01 | 19.3 | 0.05 | – | – |
| IIC | 17+ | 0.32 | 0.18 | trace | – | 0.05 | – | – |
| *Wilkinson silt loam* Orthic Gray Wooded soil | | | | | | | | |
| Ae | 0–7 | 1.68 | 0.97 | 0.04 | 23.1 | 0.06 | 1.94 | 0.63 |
| AB | 7–13 | 0.67 | 0.39 | 0.02 | 18.6 | 0.06 | 1.94 | 0.63 |
| Bt | 13–18 | 0.58 | 0.33 | 0.02 | 16.5 | 0.09 | 1.94 | 0.76 |
| BC | 18–23 | 0.47 | 0.27 | 0.01 | 19.3 | 0.19 | 2.73 | 0.89 |
| Ck | 23–30 | 0.71 | 0.41 | 0.03 | 15.2 | 0.20 | 5.52 | 0.86 |
| Cca | 30–40 | 0.82 | 0.48 | 0.03 | 17.1 | 0.14 | 7.62 | 0.98 |
| IIC1 | 40–49 | 0.15 | 0.09 | trace | – | 0.08 | – | – |
| *Sidley silt loam* Brown Wooded–Gray Wooded Intergrade | | | | | | | | |
| –[2] | 0–1 | 2.71 | 1.58 | 0.07 | 24.0 | 0.14 | 1.77 | 0.60 |
| Bm | 1–5 | 1.82 | 1.06 | 0.05 | 21.7 | 0.13 | 1.64 | 0.69 |
| Bf | 5–14 | 1.50 | 0.87 | 0.04 | 22.3 | 0.12 | 1.68 | 0.81 |
| IIAe | 14–22 | 0.15 | 0.09 | 0.01 | 11.2 | 0.12 | 1.88 | 0.85 |
| IIBt1 | 22–29 | 0.39 | 0.23 | 0.01 | 17.7 | 0.13 | 1.89 | 1.00 |
| IIBt2 | 29–33 | 0.36 | 0.21 | 0.01 | 15.0 | 0.14 | 2.01 | 1.13 |
| IICca1 | 33–40 | 0.31 | 0.18 | 0.01 | 16.4 | 0.16 | 3.43 | 0.89 |
| IICca2 | 40–50 | 0.41 | 0.24 | 0.01 | 17.1 | 0.15 | 6.04 | 0.57 |
| IIC | 50+ | 0.08 | 0.05 | trace | – | 0.14 | 3.75 | 0.35 |
| *Gregoire loam* Brown Wooded–Gray Forested Intergrade | | | | | | | | |
| Bm | 0–6 | 2.18 | 1.27 | 0.05 | 27.0 | 0.11 | 1.51 | 1.05 |
| Bf | 6–16 | 1.41 | 0.82 | 0.03 | 24.1 | 0.12 | 1.53 | 1.16 |
| IIAe | 16–35 | 0.59 | 0.34 | 0.01 | 34.0 | 0.04 | 1.32 | 1.32 |
| IIA and B | 35–63 | 0.58 | 0.34 | 0.01 | – | 0.05 | 1.49 | 1.32 |
| IIC | 63–80 | 0.40 | 0.23 | 0.01 | – | 0.06 | 1.45 | 1.93 |

[1]On an ovendry basis.
[2]Volcanic dust horizon.

The silica and sesquioxide contents (Table 10) are useful mainly in classifying soils. They reflect the degree of weathering and translocation within the soil profile. Under the prevailing conditions, silica is the most resistant constituent, followed by aluminum and then iron. Comparison of the aluminum and iron contents in each horizon with that of silica indicates the degree of leaching of the more soluble constituents.

Little to no movement of aluminum or iron is evident in the Black and Brown Wooded soils. Some movement, particularly of iron, has taken place in the Gray Wooded soils, as shown by an accumulation in the Bt horizon.

Titanium (Table 10) forms compounds very resistant to weathering. The variations in titanium content from one horizon to another are due to dilution of the soil mass by organic matter, calcium carbonate, and other transient substances, or to variations in parent materials.

## Particle Size

Mechanical analyses were undertaken by the method of Kilmer and Alexander (22) with the following modification: After washing to remove electrolytes, the samples were dispersed in a soil dispersion mixer, using distilled water to which Calgon had been added.

The percentages of sand, silt, and clay in the horizons of selected soils are listed in Table 11. Clay has accumulated in the Bt horizons of the Gray Wooded soils due to soil-forming processes. In the remaining soils, little clay movement is evident. In these the distribution pattern of particle sizes is due to variations in the parent materials.

**Table 10.—Silica, Sesquioxides, and Titanium in the Horizons of Six Virgin Soils[1]**

| Horizon | Depth Inches | $SiO_2$ % | $Fe_2O_3$ % | $Al_2O_3$ % | $R_2O_3$ % | $TiO_2$ % | $SiO_2/R_2O_3$ ratio |
|---|---|---|---|---|---|---|---|
| | | | *Stevens loam* Orthic Black soil | | | | |
| Ah1 | 0–15 | 65.0 | 4.3 | 13.6 | 17.9 | 0.6 | 3.6 |
| Ah2 | 15–21 | 65.4 | 4.3 | 14.8 | 19.1 | 0.7 | 3.4 |
| AB | 21–24 | 67.1 | 5.2 | 14.4 | 19.6 | 0.7 | 3.4 |
| IIBm1 | 24–33 | 67.6 | 5.2 | 15.0 | 20.2 | 0.4 | 3.4 |
| | 33–42 | 67.0 | 6.0 | 14.3 | 20.3 | 0.3 | 3.3 |
| IIBm2 | 42–50 | 66.5 | 6.0 | 14.8 | 20.8 | 0.4 | 3.2 |
| IIC | 50+ | 65.8 | 6.1 | 14.3 | 20.4 | 0.8 | 3.2 |
| | | | *Burrell sandy loam* Orthic Brown Wooded soil | | | | |
| –[2] | 0– 3 | 66.0 | 3.2 | 15.6 | 18.8 | 0.3 | 3.5 |
| Bf1 | 3– 8 | 64.9 | 3.8 | 16.1 | 19.9 | 0.3 | 3.3 |
| Bf2 | 8–12 | 65.2 | 4.0 | 15.8 | 19.8 | 0.2 | 3.3 |
| Bm | 12–19 | 67.3 | 3.8 | 15.9 | 19.7 | 0.3 | 3.4 |
| | 19–26 | 68.2 | 3.8 | 15.6 | 19.4 | 0.3 | 3.5 |
| | | | *Conkle silt loam* Orthic Gray Wooded soil | | | | |
| Ae1 | 0– 7 | 69.8 | 2.9 | 15.4 | 18.3 | 0.4 | 3.8 |
| Ae2 | 7–19 | 70.0 | 2.7 | 15.2 | 17.9 | 0.4 | 3.9 |
| AB | 19–23 | 70.3 | 2.7 | 15.2 | 17.9 | 0.4 | 3.9 |
| Bt | 23–33 | 69.6 | 3.0 | 15.5 | 18.5 | 0.4 | 3.8 |
| BC | 33–45 | 71.4 | 2.2 | 15.5 | 17.7 | 0.4 | 4.0 |
| | | | *Wilkinson silt loam* Orthic Gray Wooded soil | | | | |
| Ae | 0– 7 | 68.4 | 2.8 | 14.6 | 17.4 | 0.5 | 4.0 |
| AB | 7–13 | 68.4 | 3.2 | 15.3 | 18.5 | 0.5 | 3.7 |
| Bt | 13–18 | 69.1 | 4.0 | 16.1 | 20.1 | 0.6 | 3.4 |
| BC | 18–23 | 62.8 | 3.6 | 17.2 | 20.8 | 0.6 | 3.0 |
| Ck | 23–30 | 58.0 | 3.4 | 14.8 | 18.2 | 0.6 | 3.2 |
| Cca | 30–40 | 54.8 | 3.2 | 14.6 | 17.8 | 0.5 | 3.1 |
| IIC1 | 40–49 | 70.0 | – | – | – | – | – |
| | | | *Sidley silt loam* Brown Wooded–Gray Wooded Intergrade | | | | |
| –[2] | 0– 1 | 67.6 | 3.3 | 16.2 | 19.5 | 0.4 | 3.5 |
| Bm | 1– 5 | 66.8 | 3.8 | 16.8 | 20.6 | 0.4 | 3.2 |
| Bf | 5–14 | 66.0 | 3.9 | 17.0 | 20.9 | 0.4 | 3.2 |
| IIAe | 14–22 | 66.7 | 4.7 | 17.1 | 21.8 | 0.4 | 3.1 |
| IIBt1 | 22–29 | 64.2 | 4.9 | 17.4 | 22.3 | 0.4 | 2.9 |
| IIBt2 | 29–33 | 63.8 | 4.7 | 17.8 | 22.6 | 0.3 | 2.8 |
| IICca1 | 33–40 | 63.4 | 4.8 | 16.3 | 21.1 | 0.6 | 3.0 |
| IICca2 | 40–50 | 59.3 | 4.4 | 14.1 | 18.5 | 0.6 | 3.2 |
| IIC | 50+ | 64.0 | 4.1 | 19.7 | 23.8 | 0.6 | 2.7 |
| | | | *Gregoire loam* Brown Wooded–Gray Forested Intergrade | | | | |
| Bm | 0– 6 | 68.6 | 4.2 | 14.7 | 18.9 | 0.4 | 3.6 |
| Bf | 6–16 | 67.5 | 4.6 | 15.4 | 20.0 | 0.4 | 3.4 |
| IIAe | 16–35 | 70.8 | 4.5 | 14.0 | 18.5 | 0.3 | 3.8 |
| IIA and B | 35–63 | 69.3 | 4.6 | 13.7 | 18.4 | 0.4 | 3.8 |
| IIC | 63–80 | 66.0 | 6.5 | 15.2 | 21.7 | 0.5 | 3.0 |

[1]On an ovendry basis.
[2]Volcanic dust horizon.

**Table 11.—Percentages of Sand, Silt, and Clay in the Horizons of Eight Virgin Soils**

| Horizon | Depth Inches | Sand 1.0–.05 mm. % | Silt .05–.002 mm. % | Clay Less than .002 mm. % | Texture |
|---|---|---|---|---|---|
| | | *Bubar loamy fine sand* Orthic Dark Brown soil | | | |
| Ah | 0– 8 | 73.6 | 24.4 | 2.0 | Loamy fine sand |
| AB | 8–15 | 76.1 | 22.3 | 1.6 | Loamy fine sand |
| Bm | 15–26 | 81.7 | 16.8 | 1.5 | Loamy fine sand |
| BC | 26–33 | 87.0 | 12.7 | 0.3 | Fine sand |
| C | 33+ | – | – | – | |
| | | *Stevens loam* Orthic Black soil | | | |
| Ah1 | 0–15 | 39.5 | 43.5 | 17.0 | Loam |
| Ah2 | 15–21 | 45.1 | 42.4 | 12.5 | Loam |
| AB | 21–24 | 47.4 | 40.4 | 12.2 | Loam |
| IIBm1 | 24–33 | 46.0 | 41.9 | 12.1 | Loam |
| | 33–42 | 46.2 | 41.7 | 12.1 | Loam |
| IIBm2 | 42–50 | 46.3 | 41.6 | 12.1 | Loam |
| IIC | 50+ | 48.5 | 39.3 | 12.2 | Loam |
| | | *Beaverdell gravelly sandy loam* Orthic Brown Wooded soil | | | |
| –[1] | 0– 2 | 46.1 | 49.7 | 4.2 | Sandy loam |
| Bf1 | 2– 7 | 63.7 | 32.1 | 4.2 | Sandy loam |
| Bf2 | 7–13 | 69.8 | 26.2 | 4.1 | Sandy loam |
| IIBC | 13–17 | 81.4 | 16.6 | 2.0 | Loamy sand |
| IIC | 17+ | – | – | – | Gravelly sand |
| | | *Conkle silt loam* Orthic Gray Wooded soil | | | |
| Ae1 | 0– 7 | 33.0 | 54.7 | 12.3 | Silt loam |
| Ae2 | 7–19 | 34.1 | 61.8 | 4.1 | Silt loam |
| AB | 19–23 | 14.0 | 57.9 | 8.1 | Silt loam |
| Bt | 23–33 | 19.4 | 68.6 | 12.1 | Silt loam |
| BC | 33–45 | 31.1 | 64.9 | 4.0 | Silt loam |
| C | 45+ | 43.2 | 55.3 | 1.5 | Silt loam |
| | | *Wilkinson silt loam* Orthic Gray Wooded soil | | | |
| Ae | 0– 7 | 29.3 | 58.4 | 12.3 | Silt loam |
| AB | 7–13 | 30.5 | 53.2 | 16.3 | Silt loam |
| Bt | 13–18 | 27.0 | 52.6 | 20.4 | Silt loam |
| BC | 18–23 | 30.6 | 63.8 | 5.6 | Silt loam |
| Ck | 23–30 | 35.2 | 58.0 | 6.8 | Silt loam |
| Cca | 30–40 | 19.6 | 71.0 | 9.4 | Silt loam |
| IIC1 | 40–49 | 90.3 | 8.3 | 1.4 | Sand |
| | | *Sidley silt loam* Brown Wooded–Gray Wooded Intergrade | | | |
| –[1] | 0– 1 | 21.7 | 61.8 | 16.5 | Silt loam |
| Bm | 1– 5 | 24.3 | 59.2 | 16.5 | Silt loam |
| Bf | 5–14 | 24.8 | 62.9 | 12.3 | Silt loam |
| IIAe | 14–22 | 38.1 | 49.8 | 12.1 | Loam/silt loam |
| IIBt1 | 22–29 | 27.6 | 52.1 | 20.3 | Silt loam |
| IIBt2 | 29–33 | 26.8 | 60.5 | 12.7 | Silt loam |
| IICca1 | 33–40 | 14.8 | 76.7 | 8.5 | Silt loam |
| IICca2 | 40–50 | 45.7 | 51.1 | 3.2 | Silt loam |
| IIC | 50+ | 44.8 | 51.6 | 3.6 | Silt loam |

| Horizon | Depth Inches | Sand 1.0–.05 mm. % | Silt 05–.002 mm. % | Clay Less than .002 mm. % | Texture |
|---|---|---|---|---|---|
| | | *Gregoire loam* Brown Wooded–Gray Forested Intergrade | | | |
| Bm | 0– 6 | 42.5 | 45.1 | 12.4 | Loam |
| Bf | 6–16 | 46.3 | 41.4 | 12.3 | Loam |
| IIAe | 16–35 | 52.3 | 35.6 | 12.1 | Loam/sandy loam |
| IIA and B | 35–63 | 55.8 | 35.6 | 8.7 | Sandy loam |
| IIC | 63–80 | 48.9 | 40.6 | 10.5 | Loam |
| | | *Hulme gravelly sandy loam* Orthic Acid Brown Wooded soil | | | |
| —[1] | 0– 1 | 62.5 | 35.0 | 2.5 | Sandy loam |
| Bf1 | 1– 5 | 69.2 | 23.9 | 6.9 | Sandy loam |
| Bf2 | 5–13 | 74.4 | 16.8 | 8.8 | Sandy loam |
| IIBC | 13–20 | 91.2 | 3.3 | 5.5 | Gravelly sand |
| IIC | 20+ | 95.4 | 3.3 | 1.3 | Gravelly sand |

[1]Volcanic dust horizon.

# REFERENCES


1. BAUERMAN, H. Boundary Commission Expedition, 1859-61. Report on the geology of the country near the 49th parallel of north latitude, west of the Rocky Mountains. Geological Survey of Canada, Ottawa. 1882-84.
2. BROCK, R. W. Preliminary report on the Boundary District, B.C. Geological Survey of Canada, Ottawa. 1902.
3. COCKFIELD, W. E. Lode gold deposits of Fairview Camp, Camp McKinney, and Vidette Lake area, and the Dividend-Lakeview property near Osoyoos, B.C. Geological Survey of Canada Memoir 179. Ottawa, 1935.
4. CAIRNES, C. E. Mineral deposits of the west half of the Kettle River area. B.C. Geological Survey of Canada Paper 37-21. Ottawa. 1937.
5. BOUNDARY HISTORICAL SOCIETY, First annual report. Grand Forks, B.C. 1958.
6. LEROY, O. E. Geology and ore deposits of Phoenix, B.C. Geological Survey of Canada Memoir 21, Ottawa. 1912.
7. GOSNELL, R. E. Yearbook of British Columbia, and manual of provincial information. King's Printer, Victoria, B.C. 1911.
8. ANONYMOUS. Rossland the golden city. Rossland Miner Ltd., Rossland, B.C. 1949.
9. HARRIS, R. G. District Engineer, Water Rights Service, Department of Lands, Forests and Water Resources, Kelowna, B.C. Personal communication.
10. FRASER, G. J. The story of Osoyoos, September, 1811, to December, 1952. Osoyoos, B.C.
11. ANONYMOUS. The Doukhobors of British Columbia. J. M. Dent & Sons (Canada) Ltd. 1955.
12. BRITISH COLUMBIA DEPARTMENT OF AGRICULTURE. Victoria. Annual reports. 1945-61.
13. BAKER, O. E. Atlas of American agriculture. United States Department of Agriculture, Washington, D.C. 1936.
14. GEOLOGICAL SURVEY OF CANADA. Map 6-1957, Sheet 82E, Kettle River (east half). Ottawa. 1957.
15. CANADA DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES. Pacific drainage, British Columbia and Yukon Territory. Water Resources Paper No. 118. Ottawa. 1952-54.
16. BOWSER, W. E., AND H. C. MOSS. A soil rating and classification for irrigation lands in Western Canada. Scientific Agriculture 30: 165-171. 1950.
17. BRITISH COLUMBIA DEPARTMENT OF AGRICULTURE. Proceedings of the reclamation committee, brief 22. Kelowna, B.C. 1953.
18. BRITISH COLUMBIA DEPARTMENT OF AGRICULTURE. Proceedings of the reclamation committee, brief 35. Kelowna, B.C. 1958.
19. ATKINSON, H. J., G. R. GILES, A. J. MACLEAN, AND J. R. WRIGHT. Chemical methods of soil analysis. Canada Department of Agriculture, Science Service, Chemistry Division, Ottawa. 1958.
20. METSON, A. J. Methods of chemical analysis for soil survey samples. New Zealand Department of Scientific and Industrial Research. Soil Bureau Bull. 12. Soil Bureau, Private Bag, Lower Hutt, New Zealand. 1956.
21. SHERMAN, M. S. Colorimetric determination of phosphorus in soils. *In* Industrial and engineering chemistry, analytical edition 14: 182-185. 1942.
22. KILMER, V. J., AND L. T. ALEXANDER. Methods of making analyses of soils. Soil Science 68: 15-24. 1949.
23. B.C. DEPARTMENT OF AGRICULTURE. Climate of British Columbia. Victoria, B.C. 1962.
24. U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU. Climatological data, State of Washington, annual summary, 1954. Vol. 58, No. 13. Asheville, Washington. 1955.
25. CANADA DEPARTMENT OF TRANSPORT, Meterological Division. The frost-free season in British Columbia. Toronto. 1949.

**Appendix Table A.—Average Monthly and Annual Temperatures (Degrees Fahrenheit) at Five Meteorological Stations in the Kettle River Valley for the Years of Record (23, 24)**

| Station | Elevation Feet | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Year | No. of years |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carmi | 4,084 | 17 | 23 | 29 | 39 | 48 | 53 | 60 | 59 | 52 | 41 | 28 | 22 | 39 | 1941–62 |
| Greenwood | 2,490 | 20 | 25 | 34 | 44 | 53 | 58 | 64 | 61 | 54 | 43 | 32 | 23 | 43 | 1914–62 |
| Rock Creek | 2,000 | 18 | 24 | 36 | 46 | 54 | 60 | 67 | 65 | 57 | 46 | 32 | 22 | 44 | 1921–47 |
| Grand Forks | 1,746 | 20 | 25 | 37 | 48 | 56 | 61 | 68 | 66 | 58 | 46 | 33 | 25 | 45 | 1912–62 |
| Laurier | 1,644 | 22 | 27 | 37 | 48 | 56 | 62 | 69 | 68 | 58 | 46 | 34 | 25 | 46 | 1910–54 |

**Appendix Table B.—The Frost-free Periods at Five Meteorological Stations in the Kettle River Valley (25)**

| | Carmi | Rock Creek | Greenwood | Midway | Grand Forks |
|---|---|---|---|---|---|
| Elevation, feet | 4,084 | 1,970 | 2,466 | 1,915 | 1,746 |
| Years of record | 8 | 26 | 12 | 8 | 36 |
| Last spring frost | | | | | |
| average | May 31 | June 3 | June 5 | June 4 | May 19 |
| earliest | May 18 | May 10 | Apr. 18 | May 17 | Apr. 16 |
| latest | June 12 | June 23 | July 11 | June 21 | June 28 |
| First fall frost | | | | | |
| average | Sept. 24 | Sept. 9 | Aug. 28 | Sept. 8 | Sept. 26 |
| earliest | Sept. 7 | Aug. 2 | Aug. 6 | Aug. 13 | Aug. 17 |
| latest | Oct. 12 | Oct. 13 | Sept. 19 | Oct. 15 | Oct. 23 |
| Average frost-free period, days | 116 | 96 | 84 | 96 | 130 |

**Appendix Table C.—Average Monthly and Annual Precipitation for Various Periods at Eight Meteorological Stations in the Kettle River Valley (23, 24)**

| Station | Elevation Feet | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Year | No. of years |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carmi | 4,084 | 2.48 | 2.00 | 1.53 | 1.44 | 2.01 | 2.41 | 1.43 | 1.43 | 1.34 | 1.78 | 1.93 | 2.32 | 22.10 | 1942–62 |
| Beaverdell | 3,000 | 2.08 | 1.43 | 1.08 | 0.95 | 1.25 | 1.84 | 1.15 | 0.86 | 1.36 | 1.23 | 1.55 | 2.16 | 16.94 | 1915–39 |
| Bridesville | 3,490 | 1.59 | 1.62 | 0.92 | 1.39 | 2.29 | 1.49 | 0.72 | 1.19 | 1.21 | 1.45 | 1.88 | 1.16 | 16.91 | 1958–62 |
| Rock Creek | 2,000 | 1.43 | 0.92 | 0.78 | 0.97 | 1.26 | 1.95 | 1.07 | 0.83 | 1.08 | 0.97 | 1.17 | 1.42 | 13.85 | 1913–47 |
| Greenwood | 2,490 | 1.76 | 1.30 | 1.16 | 1.10 | 1.94 | 2.50 | 0.97 | 0.96 | 1.03 | 1.40 | 1.46 | 1.54 | 17.12 | 1914–62 |
| Lynch Creek | 1,800 | 2.16 | 1.29 | 1.27 | 1.23 | 1.41 | 2.11 | 0.93 | 0.84 | 1.30 | 1.69 | 1.90 | 2.36 | 18.49 | 1915–48 |
| Grand Forks | 1,746 | 1.94 | 1.42 | 1.14 | 0.96 | 1.54 | 2.03 | 0.74 | 0.94 | 1.04 | 1.68 | 1.61 | 2.09 | 17.13 | 1912–62 |
| Laurier | 1,644 | 1.94 | 1.27 | 1.16 | 1.32 | 1.62 | 1.96 | 0.93 | 0.91 | 1.23 | 1.51 | 1.93 | 2.07 | 17.85 | 1910–54 |

# GLOSSARY

*Acre-foot*—The amount of irrigation water required to cover an acre to a depth of one foot.

*Aggregate (soil)*—A single mass or cluster of soil consisting of many soil particles held together as a prism, granule, crumb, or other form.

*Alluvial fan*—A fan-shaped deposit of outwash at the toe of a slope where a tributary valley enters a main valley.

*Available plant nutrients*—Nutrients in the soil in condition to be taken up by plant roots.

*Base saturation (percentage)*—The percentage of the total cation exchange capacity of a soil that is satisfied by cations other than hydrogen.

*Boulders*—Fragments of rock over two feet in diameter.

*Calcareous material*—Material containing free calcium carbonate. It effervesces when treated with dilute hydrochloric acid.

*Cation exchange capacity*—A measure of the adsorptive capacity of a soil for cations (hydrogen plus bases), or the amount of cations that can be adsorbed by a stated quantity of soil; usually expressed as milliequivalents per 100 grams of dry soil. A soil with a fairly high cation exchange capacity is preferred to one having low exchange capacity because it retains more plant nutrients and is less subject to leaching or exhaustion.

*Cleavage*—The capacity of a soil on shrinkage to separate along certain planes more readily than along others.

*Cobble*—A fragment of rock from three to ten inches in diameter.

*Colluvial material*—Poorly sorted rock fragments and soil accumulated at the bases of steep slopes by the influence of gravity.

*Consistence (soil)*—The mutual attraction of the particles in a soil mass, or their resistance to separation or deformation. Consistence is described as loose, soft, friable, firm, hard, sticky, plastic, or cemented.

*Creep*—Mass movement of soil or soil material down slopes, primarily by gravity but facilitated by saturation with water and alternate freezing and thawing.

*Crotovinas*—Filled-in burrows of rodents; a feature found chiefly in natural grassland soils.

*Drumlin*—A narrow, often spoon-shaped, hill formed as part of a ground moraine. There is usually an abrupt slope at the end facing the source of the ice and a gentle slope in the direction of ice movement.

*Dune*—A mound or ridge of sand piled by the wind.

*Eluvial horizon*—A soil horizon from which material has been removed in solution or water suspension.

*Erosion*—The wearing away of the land surface by running water, wind, or other forces. It includes sheet, rill, and gully erosion.

*Esker*—A long, narrow, crooked, sharp ridge of fluvioglacial drift deposited in an ice-walled crevice or tunnel in stagnant or near-stagnant ice.

*Farm water requirement*—The amount of irrigation water required per acre by a given soil type during the irrigation season, expressed in acre-inches or acre-feet. Sometimes referred to as the duty of water.

*First bottom*—A low-lying river deposit with vegetative cover and subject to annual inundation.

*Floodplain*—A nearly flat river deposit subject to overflow. A floodplain is characterized by a low levee along the river channel and a gentle down-slope to a generally swamped inner margin.

*Friable*—Easily crushed between thumb and forefinger, and nonplastic. Used to describe soil aggregates.

*Glacial drift*—Material moved and deposited by glacial action. It includes both sorted outwash and till.

*Glaciolacustrine deposits*—Sediments deposited in former glacial lakes.

*Gleyed*—Modified by a reduction process brought about by saturation of a soil with water for long periods in the presence of organic matter.

*Gravel*—Rock fragments from two millimeters to three inches in diameter.

*Horizon*—A layer in the soil profile approximately parallel to the land surface with more or less well-defined characteristics that have been produced by soil-forming processes. The major organic horizons are defined as follows:

L— A layer of organic matter in which the plant remains can be identified.

F— A layer of partly decomposed organic matter. The plant remains can be identified, but with difficulty.

H— A layer of well-decomposed organic matter. The plant remains cannot be identified.

The major mineral horizons are defined as follows:

A— A mineral horizon or horizons formed at or near the surface in the zone of maximum removal of materials in solution and suspension and/or of maximum accumulation of organic matter. It includes (1) horizons in which organic matter has accumulated as a result of biological activity (Ah); (2) horizons that have been eluviated of clay, iron, aluminum, and/or organic matter (Ae); (3) horizons dominated by (1) and (2) above but transitional to the underlying B or C (AB or AC); (4) horizons markedly disturbed by cultivation or pasturing (Ap).

B— As used in this report, a mineral horizon or horizons characterized by one or more of the following: (1) an enrichment of silicate clay, iron, and aluminum (Bt, Bf), and (2) an alteration by hydrolysis or oxidation to give a change in color or structure but not meeting the requirements of (1) above (Bm).

C— A mineral horizon or horizons relatively unaffected by the pedogenetic processes operative in A and B, excepting (1) the process of gleying (Cg) and (2) the accumulation of carbonates (Cca).

The mineral soil horizons described in this report are denoted by the following lower-case suffixes:

ca—A horizon with secondary carbonate enrichment, the concentration of lime being higher than in the unenriched parent material.

e— A horizon characterized by the removal of clay, iron, aluminum, or organic matter. Usually lighter-colored than the layer below.

f— A horizon enriched with hydrated iron.

g— A horizon characterized by reduction and gray colors, often mottled.

h— A horizon enriched with organic matter.

j— A horizon whose characteristics are weakly expressed.

k— A horizon in which the presence of carbonates is indicated by visible effervescence with dilute acid.

m— A horizon slightly altered by hydrolysis and/or solution to give a change in color and/or structure.

p— A layer disturbed by man's activities, i.e., by cultivation or pasturing. Used only with the A horizon.

t— A horizon enriched with silicate clay.

If three contrasting layers are derived from different materials, the roman numerals II and III are prefixed to the names of the lower two layers.

If more than one lower-case suffix is used and if one only is a weak expression, then that suffix is linked to the j with a bar, i.e., Bf$\overline{\text{gj}}$.

*Horizon boundary*—The width of boundaries between soil horizons is defined as follows:

Abrupt—Less than 1 inch wide.

Clear—From 1 to 2 inches wide.

Gradual—From 2½ to 5 inches wide.

Diffuse—More than 5 inches wide.

*Hummocky*—Topography characterized by an uneven surface due to small knolls.

*Humus*—The well-decomposed, more or less stable part of the soil organic matter.

*Ice-margin lakes*—Lakes impounded by ice dams.

*Ice-rafted*—Transported and deposited by floating ice. Used of stones or other material.

*Illuvial horizon*—A horizon that has received material in solution from some other part of the soil profile.

*Interglacial*—Between two successive glaciations, and therefore having a moderate climate.

*Kame*—A more or less conical or irregular knoll, hummock, or terrace-like deposit, usually composed of sand and/or gravel, originally deposited in irregular channels along the margin of a valley glacier, or in a crevasse in the ice.

*Kettle*—A depression formed in outwash by collapse of the surface after the melting of buried ice. Kettles vary in size. Some are dry; others contain ponds, swamps, or bogs.

*Laminated*—In very thin layers within strata.

*Leaching*—The removal of constituents from the soil by percolating water.

*Levee*—A natural embankment along a river channel in a floodplain.

*Lime-plate*—Coated with calcium carbonate.

*Loess*—Material of silty to very fine sand texture produced by the grinding action of glaciers and distributed by the wind.

*Marginal soils*—Soils of doubtful value for a given purpose.

*Marl*—A deposit consisting chiefly of calcium carbonate mixed with clay and other impurities. Marl is deposited at the mouths of springs and in areas of seepage.

*Microrelief*—Small differences of relief that have significance in soil-forming processes, to the growth of plants, or in the preparation of the soil for cultivation.

*Miner's inch*—In British Columbia, 1.68 cubic feet of water per minute over a weir, or 0.028 cubic feet per second.

*Moraine*

Lateral—A drift ridge formed along a lateral margin of a valley glacier from material plucked from the valley sides.

Ground—Drift accumulated on the sole of the glacier, sometimes forming a rolling or drumlinized plain in mountain valleys. The drift consists chiefly of till, and sands and gravels weathered from till.

Terminal or end—Ridge-like accumulations of drift found at the terminal margin of a glacier.

*Mottled*—Irregularly marked with spots of different colors. Mottling of soils usually indicates poor aeration and a fluctuating water table.

*Muck*—Dark-colored organic material accumulated in poorly drained areas. There may be a relatively high mineral content, and the bulk of the plant remains are decomposed beyond recognition.

*Orthic*—A term used to define the subgroup of soils considered to be the central concept of a great soil group. Other subgroups are departures from the Orthic.

*Parent material*—The geological material from which a soil is derived.

*Peat*—Undecomposed to partly decomposed organic material with recognizable plant remains. Peat accumulates in bogs and seepage areas under very moist conditions.

*Ped*—An individual natural soil aggregate.

*Percolation*—Downward movement of water through the soil, especially the downward flow of water in saturated or nearly saturated soil.

*Permeability*—The ease with which water and air pass through the soil to all parts of the profile. It is described as rapid, moderate, or slow.

*pH*—A logarithmic designation of the intensity of acidity or alkalinity of soil or other materials. A pH of 7.0 indicates the neutral condition. Higher values indicate alkalinity and lower ones acidity.

*Plant nutrients*—The elements taken in by the plant, essential to its growth and used by it in the elaboration of its food and tissue. These include nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, copper, boron, and perhaps others obtained from the soil; and carbon, hydrogen, and oxygen obtained chiefly from air and water.

*Plastic*—Capable of being molded or modeled without rupture when moist.

*Podzolization*—The process by which, under good or imperfect drainage, forested soils develop light-colored eluviated (Ae) horizons and illuvial (B) horizons with accumulations of sesquioxides, organic matter, clay, or any combination of these.

*Porosity*—The percentage of the total soil volume not occupied by soil particles.

*Relief*—The elevation or inequalities of the land surface when considered collectively.

*Second bottom*—The river terrace that is just above the level of annual inundation and that is subject to flooding in years of exceptionally high water.

*Seepage*—Saturation of the soil by movement of ground-water to the surface, generally at the toe of a slope.

*Soil drainage*—The frequency and duration of periods when the soil is not saturated. The following drainage classes are used in this report:

Rapidly drained—Soil moisture seldom exceeds field capacity except immediately after water additions. The soil profile is free of mottles.

Well drained—Moisture in excess of field capacity does not remain in the solum for long periods. There is no mottling in the A and B horizons.

Moderately well drained—Moisture in excess of field capacity remains for a short period. The soils are mottled in the B and C horizons, and the Ae horizon may be slightly mottled.

Imperfectly drained—Moisture exceeds field capacity in the B and C horizons for a significant period. Mottling occurs in the B and C horizons and sometimes in the Ae horizon, if present.

Poorly drained—Moisture exceeds field capacity in all horizons for a large part of the year. The soils are mottled immediately beneath the forest litter or Ah horizon.

Very poorly drained—Free water remains within 12 inches of the surface most of the year. The soils usually have a mucky or peaty surface horizon and a grayish, gleyed subsoil with or without mottles.

*Soil profile*—A vertical section of a soil through all its horizons and extending into the parent material.

*Soil separates*—The particle sizes on which the textural classes of soils are based. These are as follows:

| | *Diameter in millimeters* |
|---|---|
| Very coarse sand | 2.0 to 1.0 |
| Coarse sand | 1.0 to 0.5 |
| Medium sand | 0.5 to 0.25 |
| Fine sand | 0.25 to 0.10 |
| Very fine sand | 0.10 to 0.05 |
| Silt | 0.05 to 0.002 |
| Clay | Below 0.002 |

*Soil structure*—The aggregation of primary soil particles into compound particles, which are separated from adjoining aggregates by surfaces of weakness. The following kinds of structure are mentioned in this report:

Blocky—Having block-like aggregates with sharp, angular corners.

Granular—Having more or less rounded aggregates, with no smooth faces or edges.

Massive—In a cohesive mass, with no observable aggregation of particles.

Platy—In thin, horizontal plates; the horizontal axis is longer than the vertical one.

Prismatic—Having large aggregates with the vertical axis longer than the horizontal. The surfaces and edges are well defined and the tops are usually flat.

Single-grained—Each grain by itself, as in sand.

Subangular blocky—Having block-like aggregates with rounded corners. The horizontal and vertical axes are about the same length.

*Soil Texture*—The percentages of sand, silt, and clay in a soil determine its texture. The ranges of each in the different textural classes are shown in Figure 28. The abbreviations used in the figure for the textural classes are: C, clay; SiC, silty clay; SC, sandy clay; SiCL, silty clay loam; CL, clay loam; SCL, sandy clay loam; Si, silt; SiL, silt loam; L, loam; SL, sandy loam; LS, loamy sand; S, sand.

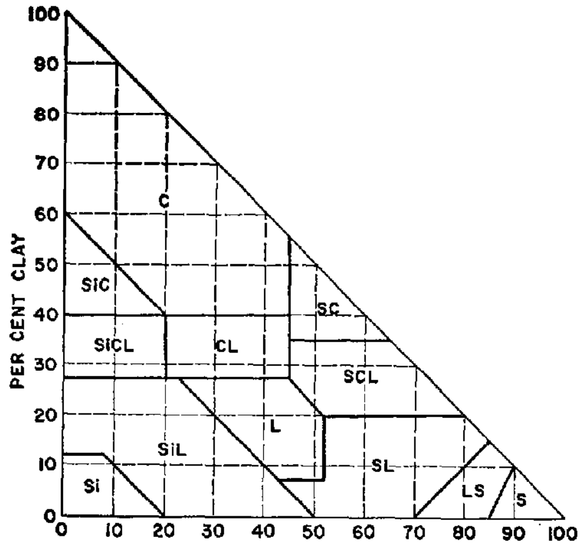


FIGURE 28. Percentages of clay and sand in the main textural classes of soils; the remainder in each class is silt. See Toogood, J. A., Can. J. Soil Sci. 38:54-55, 1958. The limits between classes are as in Soil Survey Manual, U.S.D.A. Handbook, 1951.

*Solifluction*—The downslope flow or slip of surface material.

*Solum*—The upper, weathered part of the soil profile, in which the processes of soil formation are active. The A and B horizons.

*Stones*—Rock fragments over ten inches and less than two feet in diameter.

*Strath*—The more or less flat bottomland in a river valley.

*Stratified*—Composed of or arranged in strata or layers. The term is applied to water-sorted geological materials from which soils are derived.

*Stream braiding*—In shallow water a stream loaded with fine sediments may choke its channel with deposits, then overflow and cut new channels. When repeated this process is called *braiding*.

*Submarginal soils*—Soils that are unsuitable for a given purpose.

*Swamp*—A shallow, water-filled depression overgrown with rushes, tulees, and other water-loving plants.

*Talus*—Rock fragments and soil material accumulated at the foot of a cliff or steep slope, chiefly by gravity.

*Terrace*—A flat, undulating, or gently sloping plain of varying size bordering a river or lake. Some streams have a series of terraces at different levels, indicating that floodplains were present at several stages of downcutting of the stream valleys.

*Texture*—Soil texture is based on the percentages of sand, silt, and clay that a soil may have. *See* soil texture.

*Till*—An unsorted, generally unconsolidated mixture of stones, gravels, sand, silt, and clay that was produced and transported by glaciers and deposited during the melting and recession of the ice front.

*Tillplain*—A land surface covered chiefly by glacial till, including some sorted material. The topography is variable.

*Varves*—Annual layers of a sediment, generally found in glacial lake deposits. Varves consist of two layers of differing composition, one laid down in summer and the other in winter when the lake is frozen over. The winter layer is thinner, darker coloured, and of finer texture than the summer layer.

*Volcanic dust*—Fine volcanic ash, consisting mostly of particles less than a quarter of a millimeter in diameter.

*Water table*—The upper limit of ground water in the soil profile or underlying material.

*Weathering*—The physical and chemical disintegration and decomposition of rocks and minerals.