Series 1934, No. 16 Issued December 1939

Soil Survey

Bonner County Idaho

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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
In cooperation with the
University of Idaho College of Agriculture
and Agricultural Experiment Station

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SOIL SURVEY OF BONNER COUNTY, IDAHO

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United States Department of Agriculture in cooperation with the University of Idaho College of Agriculture and Agricultural Experiment Station

COUNTY SURVEYED

Bonner County extends across the narrow northern panhandle section of Idaho (fig. 1). Its western boundary coincides with the Washington State line, and its eastern boundary, with the Montana State line. Boundary County separates it from the Canadian border. Sandpoint, the county seat, is about 75 miles northeast of Spokane, Wash. The total area of the county is 1,748 square miles, or 1,118,720 acres, of which 14,038 acres, 480,922 acres, and 36,334 acres, respectively, lie within the Coeur d'Alene, Kaniksu, and Kootenai National Forests. Pend Oreille Lake, which is almost wholly within the county, covers a large part of its surface. The land included in the survey is mostly outside the national forests. This survey covers an area of 870 square miles, or 556,800 acres. The area joins Kootenai County on the south and Spokane County, Wash., on the west, of which surveys were made in 1919 and in 1917, respectively (*4*, *8*).[2]

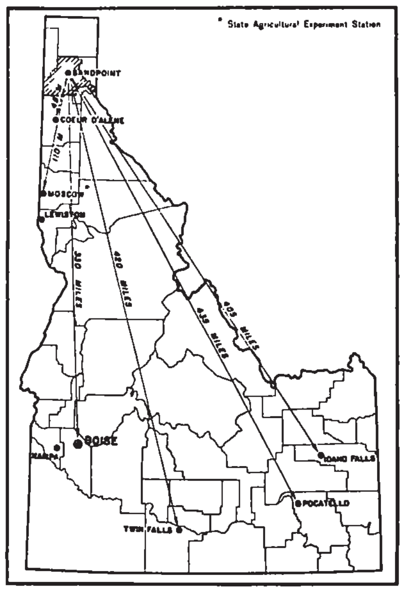

FIGURE 1.—Sketch map showing location of Bonner County, Idaho.

The greater part of the county is mountainous, interrupted by the flat-bottomed valleys of the main streams which wind between and around the larger mountain ranges. Drainage of the mountainous areas is through a dendritic system of tributary streams flowing through steep-sided valleys. The original trend of the larger valleys, as defined in preglacial times, was generally in a southerly direction, but this has been modified materially by subsequent glacial erosion and deposition.

Purcell trench, a long comparatively narrow depression (or valley) extending southward from Canada, passes through Bonner County.

[1] The Soil Survey Division was transferred to the Bureau of Plant Industry July 1, 1939.
[2] Italic numbers in parentheses refer to Literature Cited, p. 66.

At its northern entrance to the county, near Elmira, the trench is narrow—about 1½ miles wide. From this point southward, delta materials spread fanwise to the northern shore of Pend Oreille Lake where the trench widens to more than 8 miles. Here the trench divides. The most deeply excavated branch is occupied by Pend Oreille Lake, and the other branch comprises Cocolalla Valley. This trench originally was carved by preglacial stream erosion but later was altered by glacial excavation and deposition during the Spokane and Wisconsin glacial periods (*1*).

East of the trench are the Cabinet and Coeur d'Alene Mountains which rise to elevations exceeding 6,500 feet above sea level within this county. These mountains are mostly within national forests, however, and were not surveyed. West of the trench are the equally high Selkirk Mountains which lie mostly within the area surveyed. These ranges were almost entirely overridden by the continental ice sheet of the Spokane period. Subsequent glaciation, by both the alpine and the Wisconsin ice lobes, have materially modified the glacial till deposits and have caused poorly defined broken drift plains, fluvioglacial outwash plains, and, in a few places, recessional moraines (*1*).

Glaciation and deposition of glacial drift and outwash materials have so modified the drainage that many of the major streams have been diverted completely from their preglacial and prebasalt courses. The streams now find a westward outlet to Columbia River through Pend Oreille River. The larger tributaries which flow through important agricultural valleys are Pack River and Sandpoint, Cocolalla, and Hoodoo Creeks. Owing to the porous character of the glacial deposits, drainage is good to excessive throughout the county, except in places where trapped drainage is brought about by abandoned stream channels and basins of glacial origin. Streams discharge from the mountains, disappear in the gravel or are trapped in these basins, and cause temporary and permanent seepy areas, swamps, and lakes.

In the larger valleys the relief is broken by scattered poorly defined moraines and jutting outcrops of bedrock. Outwash plains and terraces lie at various elevations. The terraces reach a maximum elevation of about 2,600 feet above sea level. The average elevation of Pend Oreille Lake is about 2,050 feet, but it fluctuates within a range of probably 30 feet during the year. Spring floodwaters of Clark Fork are checked in this extensive natural reservoir, causing yearly overflow and inundation of contiguous low-lying lands. The elevation of Sandpoint, situated on a delta or lake terrace, is 2,100 feet, which is the same as the elevation of practically all the important lower lying agricultural lands along Clark Fork and Pend Oreille River, except those in the extreme west. Poorly defined morainic deposits occur above the general level of the terrace throughout the valleys and skirt the valley sides formed by high hills and semimountainous terrain.

West of Pend Oreille Lake, Pend Oreille River cuts across the Selkirk Mountains in a very narrow valley skirted with glacial terrace deposits, crosses into Washington, turns north, and finds its way into Columbia River just north of the international boundary. Mount Casey in the Selkirk Mountains has an elevation of 6,735 feet, south of the valley Huckleberry Mountain attains an elevation of 4,552 feet, and Curtis (Hoodoo) Mountain is 5,091 feet high. The last two mountains lie on either side of Hoodoo Valley which is a southward preglacial extension of Priest River Valley. West of Curtis Mountain, Hoodoo Valley is paralleled by a valley extending from north to south along the Idaho-Washington State line.

The native vegetation was a dense growth of conifers. Most of the land has been logged, and a second growth of conifers—in most places of inferior types of trees, such as western larch (tamarack) and lodgepole pine—is becoming established. No artificial reseeding or planting is practiced. Farm areas either are cleared of stumps, or grasses and legumes are seeded among them for pasture.

The great range in elevation within short distances materially affects the temperature and precipitation in this section. These factors, together with soil and drainage conditions, control the growth of vegetation. The dominant factor in the vegetal cover seems to be the supply of moisture, as there is a striking difference between the forests of the northern and southern parts of the county and between the forests of the low and the high elevations. The low valleys in the southern part are the most arid parts, and they mark a transition between the prairie region to the south and the more humid and densely forested region to the north.

The more open forest growth in the southern part is dominated by ponderosa (western yellow) pine (*Pinus ponderosa*),[3] and lodgepole pine (*P. contorta*) (*2*). Associated with these but more dominant to the north are western larch (*Larix occidentalis*) and Douglas-fir (*Pseudotsuga taxifolia*). An undercover of scattered brush in the southern part consists of common snowberry (*Symphoricarpos albus*), rose (mostly *Rosa nutkana*), snowbush (sticky laurel) (*Ceanothus velutinus*), Oregon-grape (*Odostemon aquifolium*), bearberry (kinnikinnick) (*Arctostaphylos uva-ursi*), myrtle boxleaf (mountain lover) (*Pachistima myrsinites*), Scouler willow (*Salix scouleriana*), oceanspray (*Holodiscus discolor ariaefolius*), and mallow ninebark (*Opulaster malvaceus*). The grass cover consists mostly of pinegrass (*Calamagrostis rubescens*), downy chess (downy bromegrass) (*Bromus tectorum*), bluebunch wheatgrass (*Agropyron spicatum*), slender wheatgrass (*A. pauciflorum*), western fescue (*Festuca occidentalis*), buffalo bunchgrass (bunch fescue) (*F. scabrella*), and Idaho fescue (*F. idahoensis*). Strawberries grow in many of the grass-covered areas. On the more droughty soils are found a species of phlox (*Phlox douglasi*), roundleaf alumroot (*Heuchera cylindrica*), pussytoes (*Antennaria confinus*), and sedge (*Carex concinnoides*).

The forest in the northern part of the county is more dense and consists of a wider range of timber trees, compared with the forest in the southern part. It includes western white pine (*Pinus monticola*), great silver fir (white fir) (*Abies grandis*), western larch, Douglas-fir, western red cedar (*Thuja plicata*), lodgepole pine, and western hemlock (*Tsuga heterophylla*). A scattered growth of western yellow pine, Engelmann spruce (*Picea engelmanni*), and Colo-

[3] Plants were identified by J. H. Christ, state coordinator, U S Soil Conservation Service, Moscow, Idaho. So far as possible these identifications have been checked by F. J. Hermann, associate botanist, U. S. Bureau of Plant Industry.

rado juniper (*Juniperus scopulorum*) also grow in this section. The undergrowth of shrubs and grass generally is less dense than in the southern part. Scouler willow, oceanspray, common snowberry, Oregon-grape, mountain lover, kinnikinnick, Nutka rose, sticky laurel, redstem ceanothus (red laurel) (*C. sanguineus*), big whortleberry, locally called huckleberry (*Vaccinium membranaceum*), grouse whortleberry, also locally called huckleberry (*V. scoparium*), thimbleberry (*Rubus parviflorus*), trailing blackberry (dewberry) (*R. macropetalus*), common red raspberry (*R. strigosus*), whitebark raspberry (blackcap) (*R. leucodermis*), strawberry, and western bracken (*Pteridium aquilinum pubescens*) compose the shrubby growth, and pinegrass, bluejoint (Macouns' reedgrass) (*Calamagrostis canadensis*), and junegrass (*Koeleria cristata*) are the principal grasses. Introduced grasses and clovers also grow to a considerable extent on these lands.

The stream bottoms and many of the wet areas scattered throughout the county support the following vegetation: Quaking aspen (*Populus tremuloides aurea*), balsam poplar (cottonwood) (*P. balsamifera*), alder (*Alnus tenuifolia*), western paper birch (*Betula papyrifera occidentalis*), black hawthorn (thornbush) (*Crataegus douglasi*), dwarf maple (*Acer glabrum douglasi*), blueberry elder (elderberry) (*Sambucus coerulea*), and Menzies spiraea (*Spiraea menziesi*).

The principal grasses and sedges on the overflow lands are tufted hairgrass (*Deschampsia caespitosa*), spike rush (*Eleocharis palustris*), marsh horsetail (joint rush) (*Equisetum palustre*), and reed canary grass (*Phalaris arundinacea*).

This county abounds in recreational facilities. Large game animals include white-tailed and mule deer, elk, goat, bear, and cougar. Furbearing animals, such as beaver, muskrat, mink, marten, weasel, skunk, and coyote, are found in various parts of the county. The principal game birds are ruffed grouse, blue grouse, Mongolian pheasant, and Hungarian pheasant.

The streams and lakes contain both native and introduced fish, such as cutthroat trout, Dolly Varden trout, rainbow trout, eastern brook trout, whitefish, bass, perch, crappie, and catfish.

Settlement of the section now included in Bonner County dates from the time that David Thompson, representing the Northwest Company of Canada, under the British flag, established a short-lived station near Hope in 1809. In the period following, transient trappers, miners, and prospectors composed the population. Not until the eighties and the period of intensive railroad construction did permanent settlement take place. The pioneers of this period settled on the meadows where hay was available for livestock and subsistence crops could be grown. The number of inhabitants increased rapidly with the beginning of logging about 1900. The lumber industry stimulated the demand for farm produce, and more land was cleared for farm crops, although only a small proportion of the population engaged in agricultural pursuits. Bonner County was organized from a part of Kootenai County in 1907, and a part was taken from it to form Boundary County in 1915. The population of the county, as reported by the 1930 census, is 13,152.

Sandpoint, the county seat and largest town, had a population of 3,290 in 1930. Priest River is the second largest town, with 949 inhabitants. These towns, as well as the other towns and villages, owe their size to the lumber industry. Kootenai, Dover, Hope, Clark Fork, Laclede, and Granite have at some time been sites for lumber mills. Mills still operate part time at Sandpoint, Colburn, and Newport.

Aside from logging, the supplying of cedar for poles, piling, posts, and shingles and of tamarack for piling, are important enterprises. Creameries at Sandpoint, Clark Fork, and Priest River and a meat-packing plant at Sandpoint are among the minor industries. A few people are engaged in mining.

Four railroads serve the county. The Northern Pacific Railway enters the south-central part near Granite and turns eastward at Sandpoint, skirting the northern shore of Pend Oreille Lake and Clark Fork to the Montana State line; the Great Northern and the Spokane International Railways traverse the county in a southwest-northeast direction; and the Chicago, Milwaukee, St. Paul & Pacific Railroad crosses the extreme southwestern part. A steamboat line contacts the principal towns and community centers on Pend Oreille Lake.

United States Highway No. 95 follows the Northern Pacific Railway northward from Granite to Sandpoint, is joined there by United States Highway No. 195 which crosses the Washington State line at Newport and continues northward through Elmira. A State highway roughly parallels the Northern Pacific Railway eastward from Sandpoint to the Montana line. These highways serve as trunk roads for transportation. Most of the other roads are kept in fair repair. The more remote sections are accessible only by old logging roads and horse trails.

The larger towns have electric power and telephone service. High schools and graded schools are situated in the towns and in the established rural-school districts. The towns and community centers have churches or assembly halls.

CLIMATE

Bonner County has a modified continental climate. The oceanic influence brought by westerly winds from the Pacific Ocean modifies temperatures and increases precipitation where these winds meet the mountains. The mountains likewise divert the colder waves of the eastward continental interior. The summers are comparatively short and cool, and extremes of cold winter temperature are of short duration.

Comparatively little rain falls during the summer. July and August are the driest months of the year. The heaviest precipitation occurs from November to April, and much of it is in the form of snow. Exceptionally deep snowfalls occur at the higher elevations.

Within the county, the ranges of the Selkirk, Cabinet, and Coeur d'Alene Mountains cause marked climatic differences within very short distances, owing to great local differences in elevation. Thus, temperature and precipitation records from any one location are not representative of an extensive area.

The most complete available climatic data in the county are those of the United States Weather Bureau station at Sandpoint, which are presented in table 1, and less complete data from other parts of the county are tabulated, for comparison, in table 2.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Sandpoint, Bonner County, Idaho*

[Elevation, 2,100 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1929)	Total amount for the wettest year (1927)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	28.0	58	−21	4.06	5.97	2.74	21.7
January	25.4	54	−20	3.93	1.18	4.59	27.7
February	29.1	50	−12	3.40	.83	5.92	15.4
Winter	27.5	58	−21	11.39	7.98	13.25	64.8
March	37.3	71	0	2.84	2.71	2.44	10.7
April	45.7	79	14	2.12	2.87	1.29	1.4
May	52.7	85	24	2.43	.77	2.13	(1)
Spring	45.2	85	0	7.39	6.35	5.86	12.1
June	59.2	94	28	2.10	1.73	1.84	(1)
July	65.1	99	33	.93	(1)	.59	.0
August	63.7	97	32	1.13	.18	2.05	.0
Summer	62.7	99	28	4.16	1.91	4.48	(1)
September	54.6	89	21	1.92	.39	7.70	.0
October	45.5	78	11	2.83	1.30	4.92	1.4
November	35.5	64	−2	5.02	.00	5.85	6.2
Fall	45.2	89	−2	9.77	1.69	18.47	7.6
Year	45.2	99	−21	32.71	17.93	42.06	84.5

[1] Trace.

TABLE 2.—*Selected climatic data for several points in Bonner County, Idaho*

Location	Elevation	Mean annual temperature	Mean annual precipitation	Snowfall	Frost-free period
	Feet	°F.	*Inches*	*Inches*	*Days*
Sandpoint	2,100	45.2	32.71	84.5	116
Priest River	2,078		29.61		125
Priest River Experiment Station	2,380	43.3	33.22	92.0	90
Lakeview	2,250	45.4	29.12	66.0	151
Clark Fork	2,084		33.18		

The moderating influence of Pend Oreille Lake is apparent from these data. It will be observed that the mean annual temperatures at Sandpoint and Lakeview are several degrees higher than at the Priest River Experiment Station, which does not have this influence. Likewise the frost-free season in the vicinity of the lake is several weeks longer than in most other sections of the county, making it possible to grow vegetables and fruits here successfully, whereas the production of such crops is extremely hazardous elsewhere.

Although the average temperature is lower at the higher altitudes, the frost danger to crops is greater in low-lying valleys where frost may occur during any month of the year, owing to the fact that the cold air is trapped in these depressions. Such frost areas occur especially in Priest River Valley, Hoodoo Valley, Blanchard Valley, sections of Cocolalla Valley, and in the district between Samuels and Elmira. The terraces in these sections, however, have better air drainage than the lower lying valleys and, therefore, are less affected by frost.

AGRICULTURAL HISTORY AND STATISTICS

Most of the early settlers were squatters who settled on the desirable meadowlands where pasture and hay could be obtained for their livestock. Such lands were comparatively free of timber and brush, easily cultivated, fertile, and well supplied with moisture. These were the subsistence ranches of the early period of settlement before lumbering became important.

Lumbering became very active about 1900, when some of the timberlands became available for homesteading, and the rest of the land could be acquired by lumber companies from railroads and other sources. This industry created a large demand for hay and grain for horses and also for farm produce. Most of the better bottom lands and even some of the poorer soils were farmed because of the high prices paid for farm products. Agriculture reached its peak with lumbering and also declined with it, leaving the less desirable land abandoned.

Since a part of Bonner County was taken to form Boundary County in 1915, the earliest data applicable to its present area are those from the United States census of 1920. In that year, only 14.7 percent of the county was in farms, and only 21.5 percent of the farm land was cropland or plowable pasture. The corresponding proportions in 1935 were 17.9 percent and 22.5 percent, respectively.

Table 3 gives the acreages of the principal crops in 1919, 1929, and 1934.

TABLE 3.—*Acreages of principal crops in Bonner County, Idaho, in stated years*

Crop	1919	1929	1934	Crop	1919	1929	1934
	Acres	*Acres*	*Acres*		*Acres*	*Acres*	*Acres*
All hay	22,157	22,088	26,877	All hay—Continued.			
Timothy and clover, alone or mixed	15,380	14,044	14,100	Wild hay	3,179	2,745	....
Alfalfa	198	2,786	4,272	Oats	1,245	1,884	1,971
Grains cut green	2,658	1,774	3,698	Wheat	866	1,372	1,304
Other tame hay	742	739	[1] 4,807	Barley	154	119	201
				Potatoes	791	447	801

[1] Includes wild hay.

It will be seen from table 3 that hay is the most important crop grown. Timothy and timothy and clover mixed occupy the largest acreage. This is owing to continuation of the old practices and to the farming of a comparatively large acreage of lowlands and meadows. Wild hay and hay from grains cut green are also important. Alfalfa is the only hay crop showing any significant increase in acreage. The production of cereal crops, principally oats and wheat, has expanded slowly since 1919. A considerable acreage is devoted to potatoes and root crops.

Considering the total acreage of the county the number of livestock is small although more cattle, sheep, and chickens were reported in 1935 than in 1920. The number and value of livestock in census years are shown in table 4.

TABLE 4.—*Number and value of livestock in Bonner County, Idaho, in stated years*

Livestock	1920		1930		1935 [1]
	Number	Value	Number	Value	Number
Cattle	7,736	$436,494	9,466	$464,596	11,853
Horses	2,101	219,401	1,602	89,873	1,831
Sheep	997	14,025	2,979	21,527	2,322
Swine	1,572	38,210	1,450	17,705	1,131
Poultry	27,544	30,299	[2] 42,686	[2] 31,588	[2] 36,930

[1] Value not reported.
[2] Chickens only

Commercial fertilizers are seldom used. An expenditure of only $1,802 on 33 farms was reported in 1919, and $2,855 was spent for this purpose on 128 farms in 1929. Most of the fertilizer is applied, in the form of gypsum, to alfalfa which otherwise cannot be produced successfully. The reclamation of peat land is also a factor in the increased demand for fertilizers.

The expenditure for labor on farms is not large. In 1929, $80,590 was paid in wages on 410 farms, or $196.56 per farm reporting.

The size of the average farm has decreased slightly from 156.4 acres in 1920 to 137.9 acres in 1935. There were 1,451 farms in 1935, of which only 7 included 1,000 acres or more. Considerable variation in the size of farms occurs throughout the county. The smallest units are near Sandpoint. According to the 1935 census, owners operated 85.9 percent of the farms, tenants 13.8 percent, and managers 0.3 percent. The value of land and buildings averaged $33.09 per acre in 1930 and $20.48 in 1935.

Near the large towns and community centers the farm buildings compare favorably with the average throughout the county, but in more remote sections the pioneer type of log buildings predominates. Farm machinery varies correspondingly. In most sections lack of equipment seriously retards full development of the land and curtails the production of crops.

Most of the horses are large, as many have been or still are used in connection with logging. Many of the sheep, dairy cattle, and beef cattle are well bred, and a few herds are purebred. Improved breeding is essential and demands considerable attention in a livestock country.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures such as those in road or railroad cuts are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [4] and its content of lime and salts are determined by simple tests.[5] Drainage, both internal and external, and other external features such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, especial emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. Areas of land such as coastal beach or bare rocky mountainsides that have no true soil are called (4) miscellaneous land types.

The most important group is the series which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Mission, Springdale, Pend Oreille, Bonner, and St. Joe are names of important soil series in this county and in adjacent parts of northern Idaho and eastern Washington.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Bonner silt loam and Bonner fine sandy loam are soil types within the Bonner series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, there may be areas that are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important difference in the soil itself or in its capability for the

[4] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity and lower values indicate acidity.

[5] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction.

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growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance, the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

The great diversity in the soils of Bonner County is due mainly to the heterogeneous character of the underlying glacial deposits which largely determine both the physical make-up of the soils and the relief of the land. In most places, the agencies of soil development have not been sufficiently strong to modify the parent soil materials greatly, and these materials have retained their inherent textural differences. The extreme variation in both surface and internal drainage conditions also has been an important factor in producing wide differences in the characteristics of the soils.

On the basis of their characteristics these soils may be divided into three natural groups: (1) Light-colored soils, representing the large areas of well-drained forested upland; (2) dark-colored soils, representing the comparatively small and scattered areas of poorly drained or excessively wet lowland; and (3) miscellaneous land types. There are three natural subgroups of the light-colored soils—those with clay subsoils, those with sandy subsoils, and those with gravelly and stony subsoils.

The light-colored soils of the forested uplands are by far the most extensive soils in the county, although they are less important agriculturally than the dark-colored soils of the bottoms, which occur chiefly in a limited area along streams. The light-colored soils are low in organic matter and nitrogen because very little organic matter has been incorporated from the coniferous forest growth. Although these soils are not leached appreciably, owing to the comparatively light rainfall and to the continuous deposition of wind-borne silt during their development, they are benefited by fertilization with gypsum to supply sulphur which apparently is deficient and is needed for the growth of legumes. Despite the slightly acid reaction of these soils, crops respond but little to applications of lime. The response to applications of potash and phosphorus likewise is not significant. When the land is first cut over, it is claimed that the soils have a toxicity caused by resins, and clearing and cultivation often are not attempted for a few years after the land is cut over.

The loessial silt deposit largely explains the uniformly silty texture of most of these soils, although in some areas where this deposit is very thin or lacking, the texture is coarse and gravelly or stony because of the underlying glacial materials. This generally silty character favors ease of cultivation and retention of moisture in the surface soil over large areas, but extreme variation in moisture-holding capacity occurs in the subsoils. Owing to the low organic-matter content and to the single-grain structure of the surface soils, wind erosion is appreciable when the soil is put into cultivation and is not protected by vegetation. Water erosion is less severe but becomes destructive if the land is not properly protected. Due to the fine silty loose character of the soil, a properly compact seedbed is difficult to obtain without heavy rolling. After a long period of cultivation the relative proportion of gravel and coarse materials increases in places where erosion removes the finer surface materials.

Owing to the deficiency of rainfall during the summer, only the soils that have subsoils and substrata with good moisture-holding capacities can be cropped continuously and successfully. Because the supply of moisture is so important a limiting factor in the production of crops, the subsoil characteristics are the important consideration in the classification of the light-colored forested soils. Those with clay subsoils are most important agriculturally but are inextensive. Those with sandy subsoils are less valuable because of poorer moisture-retaining properties. Those with gravelly and stony subsoils have widest distribution and account for the greatest acreage, as they cover a long continuous area from south to north and extend into the high mountains. Owing to the porousness of the subsoils, especially of the outwash plains, the general rolling or hilly character of the morainic areas, and to the extremely rough relief of the mountainous areas, this land has poor agricultural possibilities and should be utilized principally for forestry.

The dark-colored soils are inherently fertile, and, because of their position, they have a plentiful supply of moisture. During their development they have benefited from the incorporation of large quantities of organic matter derived from a dense growth of deciduous trees, shrubs, and grass. For this reason the content of nitrogen is high, and the mineral elements of fertility are plentiful due to the absence of leaching and to the addition of plant nutrients carried in from higher lying areas by drainage waters.

The miscellaneous land types, including coastal beach, riverwash, and a number of classes of rough land, have no agricultural value except for forestry and pasture.

The value and importance of the fertility and moisture supply of the dark-colored soils of the bottoms, together with their value as hay meadows and ease of clearing, was recognized by the first settlers who established their ranches on these lands. Very little demand existed at this time for the forested soils of the uplands with their valuable timber. The early settlers practiced a subsistence type of agriculture on these dark soils which has persisted until very recently.

With the extension of lumbering, the demand for hay, grain, and other farm products increased in logging camps and mill towns. This stimulated an expansion of agriculture, and crops were planted on the less desirable soils of the river bottoms and on logged land of the uplands. Some of these lands, which had been denuded of their trees and which were sold to persons inexperienced in farming, were practically valueless for agriculture, although they were easily cleared. With the aid of part-time employment and the sale of forest products, the farmers on the poorer lands were able to make a satisfactory living for a while, but many farms were abandoned when lumbering declined. Even the farmers on the better types of cut-over land had little success, because the essential differences between these light-colored forest soils and the dark meadow soils were not understood at first.

The present-day agriculture owes much of its success to sound experiments on cropping methods, fertilization, introduction of plants, and variety tests, conducted at the substation of the State Agricultural Experiment Station near Sandpoint. Seed of the best varieties has been distributed to the farmers. Agriculture is progressing because the crops grown are adapted to the natural climatic and soil environment. The deficiencies of the soils have been determined and means introduced to correct them. Likewise, cultural practices for the various types of soils are being worked out and generally accepted.

In the early agricultural development of this section, hay and grain were the dominant crops, and they are still the best suited crops for the climate and soils. Hay occupies first place among the crops grown because of the large areas of natural meadows throughout the county—the wild hay meadows of the overflow land—and because the cool short summers are favorable for the growth of introduced hay crops. The old practice of growing timothy or timothy and clover continues on the wet soils of the lowlands. Both red and alsike clover are used in these mixtures, but alsike is especially suitable for the wetter areas. Red clover is grown on both dark- and light-colored soils, but it frequently suffers from drought on the latter. Continuous cropping to timothy has seriously depleted the fertility of both the dark- and the light-colored soils.

Alfalfa, which has been introduced more recently and is now an important crop, does not grow successfully on the dark-colored soils because of excess moisture. The higher lying, well-drained light-colored soils are best suited to this crop. Owing to the deficiency of rainfall in summer, the best land for successful crop production consists of the well-drained soils that have sufficient moisture-storage capacity, such as those with a compact fine-textured or clay subsoil. Alfalfa is becoming more popular as its requirements are better understood. Such practices as inoculation of seed, careful preparation of the seedbed, and fertilization with gypsum, now are adhered to rather closely. Until introduction of alfalfa, the problem of winter feeding was acute, especially in the more droughty years when other legume crops failed to produce normal crops. Because alfalfa is a deep-rooted crop it produces fair yields during dry years and therefore stabilizes the supply of hay. This factor allows the expansion of the livestock industries which are essential for a well-balanced agriculture. Furthermore, alfalfa yields more heavily and has a higher value for feeding than other hays, and it is more easily cured than clover. It also helps to increase the content of organic matter and nitrogen, both of which are deficient in the light-colored soils. Alfalfa grows well on the soils in which the moisture-storage capacity is sufficient, as in most of the soils the content of essential mineral elements is comparatively high.

Sweetclover also is a good crop for increasing the organic-matter and nitrogen content of the soils, but in this county most of it is used as a pasture crop. It is not so well suited to wet soils as is alfalfa because it often is injured by heaving of the soil during cold wet winters. It probably could be grown to advantage on the more gravelly droughty soils, because of its rapid growth when abundant moisture is available in the spring. Winter vetch also makes rapid growth during the period of plentiful moisture and could be grown more generally on these droughty soils.

The valuable experiments carried on by the substation have been on the important soils of higher moisture-holding capacity. A good moisture-holding capacity is a fundamental requirement of a good agricultural soil and is necessary for a stabilized agriculture. If the very extensive gravelly droughty soils are to be utilized to a greater extent, the introduction or development of drought-resistant crops is essential. Considerable work already has been done on the logged and burned-over lands of the county (*3*) with introduced grasses, principally for pasture. The grasses that do well are orchard grass, bromegrass, slender wheatgrass, tall oatgrass, meadow fescue, redtop, and Kentucky bluegrass. White and alsike clover are often seeded with the grasses which make a stand more successful where sown with legumes.

Of the grains grown, wheat, oats, and barley have proved to be the best suited for this section. Winter wheat produces larger yields than does spring wheat. Oats yield best on the dark-colored soils, although they are grown with success on the light-colored soils. Wheat and barley seldom are grown on the dark-colored soils of the lowlands, owing to the wetter colder conditions and the shorter growing season, compared with the uplands. The wetness of these soils in winter is not favorable for the production of winter wheat. Corn is not grown extensively, because of the short season, the wet cold spring weather, and the cool nights during the growing season. Grains are sometimes cut green for hay, especially in the early development of the farm before better hay crops have become established.

Peas often are used in hay mixtures with excellent results. They have also been grown very successfully for seed on the lowlands. Potatoes are adapted to this section and do well on the more fertile soils having good moisture-holding capacity. Frost is detrimental to this crop in certain localities, especially on the dark-colored soils of the lowlands. Root crops, especially carrots and turnips for livestock feed, return large yields on both types of land.

Garden vegetables and fruits are grown on most farms but are most successful on the dark-colored moist soils and on the light-colored soils having fine-textured subsoils. Dark-colored soils are more often chosen for gardens and orchards, where irrigation water usually is available if needed, but vegetables and fruits can be grown on either type of soil. Orchards are maintained only in areas where the soils have sufficient moisture or are irrigated and where the danger of frost is least. The climate of the area skirting Pend Oreille Lake is especially moderated, and, if other conditions are suitable, excellent fruit is produced. The more hardy tree fruits, such as apples, pears, plums, prunes, and sour cherries, are grown. The small fruits are mostly raspberries, currants, gooseberries, white-bark raspberries (blackcaps), dewberries, and strawberries.

The large area of pasture land available on the bottoms and cut-over land and the large quantity of hay and grain grown make the raising of livestock a profitable enterprise. The sale of animal products is the most remunerative method of marketing crops in this section, owing to the long distance to large markets, and it is the main source of cash income. Enough hay for winter feeding nearly always can be grown on the dark-colored soils of the lowlands, but lack of hay for winter feeding is a problem on the light-colored cut-over lands, in contrast to the abundance of summer pasture. The production of alfalfa hay tends to overcome this deficiency. Therefore, livestock enterprises are increasing in importance and are receiving the encouragement they need in this area where such enterprises are essential for successful farming.

In the following pages the characteristics of the individual soils are discussed in detail, their location and distribution are shown on the accompanying soil map, and their acreage and proportionate extent are given in table 5.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in Bonner County, Idaho*

Type of soil	Acres	Percent
Mission silt loam	13,184	2.4
Mission silt loam, friable-subsoil phase	7,360	1.3
Mission silt loam, sandy-substratum phase	1,984	.4
Mission silt loam, rolling phase	448	.1
Mission silt loam, imperfectly drained phase	1,280	.2
Mission silty clay loam	1,728	.3
Mission loam	384	.1
Mission fine sandy loam	2,240	.4
Clayton silt loam	1,472	.3
Clayton silt loam, flat phase	576	.1
Clayton silt loam, hilly phase	448	.1
Cabinet silt loam	2,432	.4
Cabinet silt loam, hilly phase	384	.1
Selle fine sandy loam	4,736	.9
Selle fine sandy loam, flat phase	448	.1
Elmira fine sand	4,096	.7
Elmira fine sandy loam	1,024	.2
Colburn very fine sandy loam	8,640	1.6
Bonner silt loam, sandy-substratum phase	2,240	.4
Bonner fine sandy loam, sandy-substratum phase	1,728	.3
Springdale gravelly silt loam	5,440	1.0
Springdale gravelly silt loam, stony phase	1,024	.2
Springdale gravelly loam	3,200	.6
Springdale gravelly fine sandy loam	11,072	2.0
Springdale gravelly fine sandy loam, rolling phase	1,664	.3
Springdale gravelly fine sandy loam, deep phase	3,008	.5
Springdale coarse sandy loam	3,136	.6
Bonner silt loam	9,472	1.7
Bonner silt loam, stony phase	192	(1)
Bonner loam	4,160	.7
Bonner loam, rolling phase	1,536	.3
Bonner gravelly loam	6,848	1.2
Bonner fine sandy loam	3,840	.7
Bonner fine sandy loam, imperfectly drained phase	640	.1
Bonner fine sandy loam, stony phase	64	(1)
Bonner gravelly fine sandy loam	960	.2
Bonner sandy loam, sandy-substratum phase	512	.1
Bonner coarse sandy loam	2,112	.4
Kootenai gravelly silt loam	7,808	1.4
Kootenai gravelly silt loam, rolling phase	1,600	.3
Kootenai gravelly silt loam, steep phase	768	0.1
Pend Oreille silt loam	13,312	2.4
Pend Oreille loam	5,120	.9
Pend Oreille loam, hilly phase	30,912	5.6
Pend Oreille loam, stony phase	2,304	.4
Pend Oreille fine sandy loam	1,088	.2
Loon loam	7,616	1.4
Waits silt loam	4,416	.8
Waits silt loam, hilly phase	4,992	.9
Garrison gravelly loam	256	(1)
Colville silty clay loam	4,928	.9
Peone silty clay	1,536	.3
Peone silty clay, low-bottom phase	1,984	.4
Peone silty clay loam	3,008	.5
Peone loam	1,792	.3
Peone fine sandy loam	4,032	.7
Chamokane gravelly loam	5,120	.9
Narcisse loam	4,608	.8
Cocolalla silty clay loam	6,848	1.2
Cocolalla silty clay loam, deep phase	256	(1)
Cocolalla silty clay loam, light-colored phase	1,344	.2
Peat	4,864	.9
St Joe loam	2,624	.5
St. Joe silty clay loam	1,216	.2
Coastal beach	256	(1)
Riverwash	256	(1)
Rough mountainous land (Loon soil material)	245,184	44.0
Rough mountainous land (Waits soil material)	58,112	10.4
Rough mountainous land (Moscow soil material)	896	.2
Rough stony land (Loon soil material)	1,280	.2
Rough stony land (Waits soil material)	448	.1
Steep broken land (Bonner soil material)	4,736	.9
Steep broken land (Springdale soil material)	1,216	.2
Steep broken land (Elmira soil material)	320	.1
Steep broken land (Selle soil material)	1,024	.2
Steep broken land (Mission soil material)	3,008	.5
Total	556,800	

[1] Less than 0.1 percent.

LIGHT-COLORED SOILS WITH CLAY SUBSOILS

The group of light-colored soils with clay subsoils includes soils of the Mission, Clayton, and Cabinet series. Agriculturally, these are the best light-colored soils of the uplands. They are the ones on which agriculture has survived in this section of low summer rainfall. They are, therefore, the soils on which future agricultural settlement should be encouraged. The location of most of them near large bodies of water minimizes the danger from frost and lengthens the growing season as compared with the general region. These soils represent a small proportion of the area surveyed, but, together with the dark-colored soils of the bottom lands, they are the main soils on which agriculture can be carried on from year to year without failure. The farm unit that contains areas of them is more or less insured against total failure.

Although a larger proportion of these soils is farmed than of the other groups of light-colored soils, the proportion cultivated is small. This is explained by the fact that much of the land is held in large units with small cleared acreages, by the sparse settlement of the county, and by the absence of an urgent demand for land, even the better types of soil.

These soils are developed from a wide variety of rock materials laid down as glacial delta, outwash, and till deposits. Those from glacial outwash generally are flat or gently sloping, and those from till have rolling or hilly relief.

Of this group the Mission soils have the most favorable relief, most continuous extent, and most desirable location as regards freedom from frost and accessibility to markets and transportation, and it is for these reasons that they are the most important agricultural soils of the group. They have developed on flat delta plains and lake terraces and are derived from fine-textured materials that in most places are stratified to great depths. The largest continuous area is in the vicinity of Sandpoint, the center of population in the county. Other bodies occupy similar favorable locations near the towns along Pend Oreille River.

In undisturbed virgin areas the soils of the Mission series are covered with a thin organic layer of forest litter which is dark and for the most part undecomposed. This layer is underlain by a thin ½- to ¾-inch layer of light-gray leached material that grades into a layer of light yellowish-brown mildly acid floury fluffy silty textured material, about 10 inches thick. In many places this layer contains round iron or manganese shotlike concretions. It is underlain by a light grayish-yellow subsoil that gradually changes with depth to light gray. Both the subsoil and substratum are massive, friable, and stratified, with a high proportion of silty clay, clay, and silty clay loam layers and a few layers of fine sand. Owing to their flat relief and favorable subsoil texture, the Mission soils absorb and hold in reserve a large amount of moisture. In a section of higher rainfall, poor drainage probably would develop on such flat relief. In this area of limited summer rainfall, however, moisture saturation is a valuable asset, even though it tends to make the soil cold in the spring. The heavier textured members of the series in many of the depressions are gray, indicating poor oxidation caused by the slowness with which water drains from the subsoil.

The agricultural experiment substation at Sandpoint is located on Mission silt loam, and the results of experiments carried on there are applicable to all the important light-colored soils having clay subsoils and good moisture-holding capacity.

Because all the Mission soils are such favorable soils, little discrimination in the choice of crops is made on the basis of texture of the surface soil. Therefore the hay crops—alfalfa and red clover—are grown extensively on these soils, regardless of the texture of the surface soil or subsoil. Given an equal moisture-holding capacity, however, the lighter textured members with more friable subsoils are conducive to larger yields, especially of alfalfa. All the grain crops are grown, yields of which, except oats, are not exceeded, even on the dark-colored soils. Wheat yields most on the silt loam with a heavy subsoil. Potatoes do not do so well on the typical members with heavy subsoils as on those with lighter textured and friable subsoils. This is also true of vegetables, berries, and fruits. In all these comparisons it must be remembered that the limiting factor is moisture, and if these lighter textured soils approach droughtiness, preference should be given soils with heavier textured surface soils and subsoils.

The Clayton soils resemble the Mission soils, but the parent materials are derived mainly from glacial till in which compact and heavy-textured materials predominate. In many places subdrainage is more restricted than in the Mission soils. The relief is morainic, rolling, or hilly.

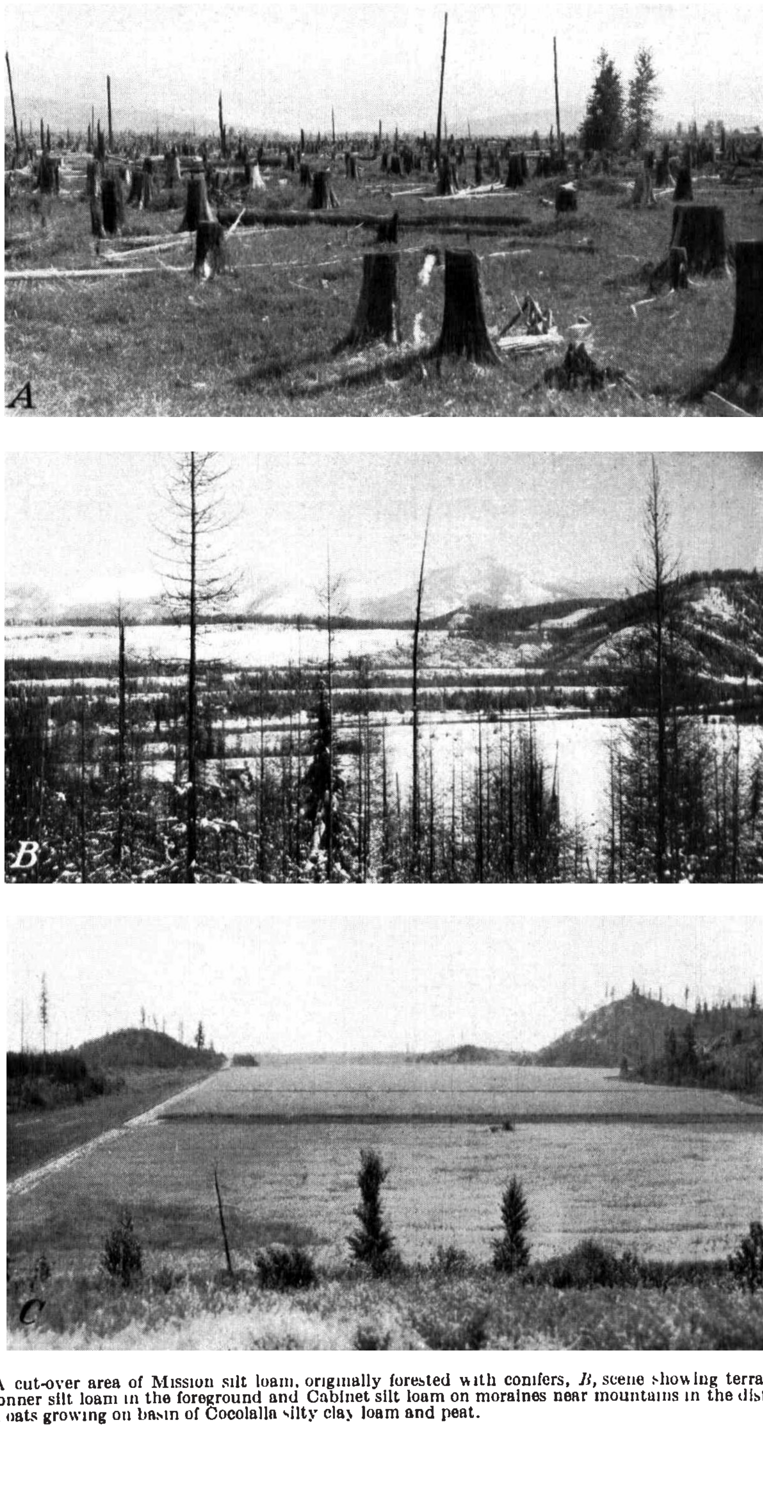
The Cabinet soils differ from the Mission soils in that they have a lighter colored more compact subsoil of prismatic structure and a reddish-brown heavy plastic clay substratum. These soils are developed under moderately heavy rainfall and under coniferous forest on morainic boulder clay materials. The relief is undulating or strongly rolling, with numerous pot holes. Subdrainage is greatly retarded.

Mission silt loam.—Mission silt loam, which occupies about 20 square miles is the most extensive Mission soil and the most important light-colored agricultural soil in the county.

A cultivated field of Mission silt loam is characterized by a 10- or 12-inch surface soil of light yellowish-brown friable slightly acid silt loam underlain by a light yellowish-gray cloddy compact nearly neutral silty clay subsoil that continues to a depth ranging from 30 to 45 inches. The substratum consists of stratified layers of gray rust-stained medium-friable silty clay loam, silt loam, very fine sandy loam, and fine sandy loam to a depth below 75 inches. The material generally is calcareous below a depth of 40 inches.

The land generally is flat, and drainage channels are few. Run-off, therefore, is slow, and much of the moisture penetrates the soil. This is especially true of the lower flat terrace at Sandpoint. On the higher terrace near Selle and elsewhere at comparable elevations, the drainage system is older and more complete, and there are fewer gray areas of ponded drainage than in the area at Sandpoint. Mission silt loam seems to be deficient in organic matter, nitrogen, and sulphur, as are all the light-colored forested soils in this county. These deficiencies are overcome by the use of barnyard manure, the growing of legumes in the rotation, and the application of gypsum.

Sandpoint, county seat, situated on Mission silt loam. Across Pend Oreille Lake the glacier-scoured mountains may be seen



A, A cut-over area of Mission silt loam, originally forested with conifers, *B*, scene showing terraces of Bonner silt loam in the foreground and Cabinet silt loam on moraines near mountains in the distance, *C*, oats growing on basin of Cocolalla silty clay loam and peat.

The largest continuous body of this soil is around Sandpoint (pl. 1), but important areas are widely scattered to the north and northeast of that city and along Pend Oreille River.

Yields of most of the crops commonly grown average higher on this soil than on most light-colored soils because of the excellent moisture-storing capacity and the loose floury texture of the surface soil, which inhibits excessive evaporation. The surface soil is easily cultivated, but, because it is so fluffy, it is difficult to work into a good seedbed. Rolling is needed for this purpose. The fluffy condition of the surface soil also makes it especially susceptible to wind erosion when unprotected by vegetation, and, in many fields that have been farmed for many years without provision for protection against this hazard, a considerable proportion of the surface soil has been lost.

The kinds of crops and yields obtained at the experiment station are indicative of what may be expected from this soil under the best practices. The average acre yields of legume hay at this station for the 4-year period, 1923–26 (*2*), are as follows: Alfalfa, 3.5 tons; white sweetclover, 3.8 tons; yellow sweetclover, 2.8 tons; medium red clover, 2.5 tons; mammoth red clover, 3.2 tons; alsike clover, 2.4 tons; and hairy vetch, 1.5 tons. Timothy, especially with clover, has been sown extensively in the past, but the yields obtained have been discouraging.

In variety tests over a 5-year period, 1923–27, the yields of fall-sown wheat ranged from 29.9 bushels an acre for the best adapted variety to 14.3 bushels for the least adapted; and the yields of spring wheat ranged from 25.5 to 16.5 bushels. Over a 4-year period, oats returned from 52.5 bushels for the best adapted variety to 42.6 bushels for the least adapted; barley, 33.7 to 28.3 bushels; and peas, 20 to 15.1 bushels. Potatoes yielded from 6,294 to 5,049 pounds an acre over a 5-year period. Average acre yields of root crops from 1922 to 1926 are: Carrots, 17,240 pounds; turnips, 10,898 pounds; mangels, 9,279 pounds; rutabagas, 8,578 pounds; and sugar beets, 8,107 pounds.

Plate 2, *A*, shows an area of Mission silt loam which has been cutover but not cleared. It originally was forested with conifers, principally Douglas-fir, spruce, tamarack, and cedar.

Mission silt loam, friable-subsoil phase.—The texture of the surface soil of Mission silt loam, friable-subsoil phase, is similar to that of the typical soil, but the subsoil is more friable and consists of less dense clay interstratified with considerable silt and sand. These features promote greater warmth and better drainage but reduce the water-holding capacity in some areas having the sandier subsoils. In areas where sufficient moisture is retained for the growth of crops, however, crop adaptations are wider and crops, especially alfalfa and potatoes, should do better than on the typical soil. The deeper substratum is similar to that of the typical soil, except that the lime content is much more variable.

This soil occupies scattered bodies in association with sandier soils in the valley north of Pend Oreille Lake. It is much less uniform than the typical soil. It probably is a little better drained than the typical soil due, not only to the character of the subsoil and relief, but also to its association with porous soils. Except for the

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preference that might be given to alfalfa, potatoes, or vegetables on this soil, the productivity is similar to that of typical Mission silt loam and generally the same crops are grown.

Mission silt loam, sandy-substratum phase.—The sandy-substratum phase of Mission silt loam resembles the typical soil in relief and in the physical characteristics of the surface soil and subsoil, but the deeper substratum is a loose porous sand with a sprinkling of gravel. This soil is, therefore, intermediate between those soils having clay subsoils and those having gravelly subsoils. Moisture tends to become depleted in late summer because of lack of storage capacity in the substratum, and in the more droughty years crop yields are lowered seriously. Alfalfa should produce fairly well in normal years. Cropping is more uncertain, however, than on typical Mission silt loam. The lack of water-holding strata in the substratum also makes it difficult to obtain water for domestic purposes except at great depths.

This soil is not extensive. Most of it lies on the high terraces north of Pack River and east of Elmira.

Mission silt loam, rolling phase.—Areas of Mission silt loam with rather rolling and slightly broken relief are differentiated on the soil map as a rolling phase. Such areas have a less stable silty surface soil than does the typical soil and are subject to erosion which has exposed the clay and silty strata in many places. The rolling or sloping relief does not prohibit cultivation, although it is less favorable than the relief of the typical soil. Less than 1 square mile of this soil is mapped, principally along Priest River.

Mission silt loam, imperfectly drained phase.—The imperfectly drained phase of Mission silt loam occupies areas of rather poor, slow, or ponded drainage, in which aeration and oxidation are restricted. In places, the poor drainage is caused by an accumulation of excess drainage waters from surrounding higher lying upland soils or mountainous areas. The subsoil is more compact than that of the normal soil, which further contributes to slow internal drainage. This soil warms very slowly in the spring and tends to heave in winter, causing much winter-killing of alfalfa. The removal of spring floodwaters through an adequate system of surface drains is essential, as this enables the soil to warm sooner in the spring and thus lengthens the growing period. The areas in the very shallow depressions have produced good crops of alfalfa when properly drained.

This soil is less acid than the typical soil. Some imperfectly drained areas of the friable-subsoil phase of Mission silt loam are included in mapping.

Mission silty clay loam.—The surface soil of Mission silty clay loam is light yellowish-brown silty clay loam to a depth of 8 or 10 inches. It is underlain by a gray compact subsoil that contains many red iron stains. The substratum, which begins at a depth of about 40 inches, is stratified with lighter textured materials and is slightly less compact than the subsoil. This soil occurs in the overflow areas around Pend Oreille Lake and along Pend Oreille River. Moisture is poorly retained, as the organic-matter content is low. The soil compacts and cracks badly throughout as soon as the water drains off, and cultivation is difficult. Only a few areas are cultivated, and they produce low yields. The land is used principally for the production of wild hay. The total area is small.

Mission loam.—Mission loam contains more sand but scarcely more clay than does Mission silt loam. The surface soil is light fluffy fine-textured silty loam which is similar in thickness and color to the silt loam soil. The sequence of horizons in the subsoil also is the same as in that soil. In a few places sand occurs in the lower part of the subsoil and in the substratum, and the upper subsoil layer is reddish brown, indicative of a high degree of oxidation. Most of the few small areas of this soil border Pend Oreille River southeast of the town of Priest River.

Internal drainage generally is not so slow as in Mission silt loam, although the relief and surface drainage of the two soils are similar. The same crops are grown and similar yields are obtained on both soils.

Mission fine sandy loam.—Mission fine sandy loam is not extensive, but it is important for all crops commonly grown in this county. The surface soil, which continues to a depth of about 18 inches, is fluffy light yellowish-brown or buff fine sandy loam containing considerable silt. The upper subsoil layer is gray compact but gritty fine sandy loam or sandy loam. Rusty iron stains are present about 3 feet below the surface, or just above the compact clay substratum. The substratum consists of gray or greenish-brown stratified clay material similar to that underlying all the Mission soils. Internal drainage is less retarded than in the heavier textured Mission soils, but the soil is not droughty. The lighter texture makes it preferable for alfalfa, potatoes, gardens, and fruit crops.

Small bodies of this soil are widely scattered along Pend Oreille Lake from Oden westward and along Pend Oreille River to Priest River. A few areas are poorly drained and have a gray surface soil, indicating poor oxidation.

Clayton silt loam.—Where typically developed, the surface soil of Clayton silt loam consists of a 14- to 18-inch layer of light yellowish-brown or buff loose floury silt loam, which has a rather high content of very fine sand. The upper part of the subsoil is compact gritty and gravelly clay loam or silty clay loam of mottled gray and dark yellowish-brown color. The lower part of the subsoil, at a depth of about 50 inches, is dull yellowish-brown and greenish-gray tough clay which is slightly gritty and contains some gravel and stone. Below this material, stratification may or may not be pronounced. In most places stones are scattered over the surface and large boulders are exposed and embedded in the soil in some areas.

Clayton silt loam, an inextensive soil, is developed mainly in Priest River Valley. The typical relief is morainic, ranging from rather undulating to strongly rolling and hilly. The parent soil material consists of massive clay till and stratified clays, overlain by morainic material. The stratified clays probably were overridden by glaciers from main or tributary mountain valleys. The depth of morainic material is variable, and the underlying clay is exposed in many places. Internal drainage is slow; but, owing to the strongly rolling relief, surface run-off is rapid, except in trapped basins. The chief variation in this soil is in the thickness of the lighter textured materials over the clay subsoil and substratum.

Only a very small part of this land is cultivated. Farms situated on the better areas, where the clay subsoil retains enough moisture for crops during the drought period, are successfully used in the production of the crops commonly grown. The same deficiencies in organic matter, nitrogen, and sulphur exist in this soil as in other light-colored forest soils.

The unfavorable relief prevents uniform fields, and crop yields are slightly below those obtained on the Mission soils. Many seepage spots containing darker soils occur within areas of this soil, especially at lower elevations. Such areas are considered slightly better, especially near Priest River, than areas comprising Clayton silt loam exclusively.

Clayton silt loam, flat phase.—The flat phase has more favorable relief than typical Clayton silt loam, but it shows greater variation in depth to the clay than does that soil. Some of the upper soil materials are thick and light textured, and throughout a large area of this soil clay occurs at such a depth that only deep-rooted plants, as alfalfa and trees, can reach the moisture stored in this layer. This soil should not be put into cultivation unless indications of a favorable moisture supply are observed from the growth of vegetation, in deep exposures in the soil, and in the occurrence of somewhat gray areas, indicating moisture near the surface. This soil is associated with typical Clayton silt loam in Priest River Valley.

Clayton silt loam, hilly phase.—Areas of Clayton silt loam that are very strongly rolling or hilly and are unsuited for cultivation are separated as a hilly phase. The surface soil generally is thin and, in many places, is stony. This soil occurs on prominent elevations and ridges. Areas of steep escarpments also are included. The land is used principally for grazing and forestry.

Cabinet silt loam.—The surface soil of Cabinet silt loam, to a depth of 14 inches, consists of light yellowish-brown heavy silt loam underlain by a 6-inch layer of more compact light-gray or grayish-white heavy silt loam or silty clay loam that is brittle when dry and very plastic when wet. This layer rests on tough waxy clay which has some grayish-brown material along fractures. Below a depth of 2 feet the clay is massive, tough, and uniformly colored grayish yellow tinged with pink. It gives way to the deeper substratum of porous lighter textured materials containing variable quantities of gravel and stones. The deeper parent soil material consists of glacial till, together with some surface outwash deposits. The upper part of the till material is reddish-brown tough waxy clay very thinly sprinkled with gravel and stones. The lower part is a porous mass of gravel and stones.

Cabinet silt loam is not extensive, but a rather large proportion of the land is devoted to successful farms. This soil is mapped only in the vicinity of Cabinet, where fairly large continuous areas occur.

The relief is rather flat or undulating in some places, and steeply sloping and hilly in others (pl. 2, *B*). The surface of some areas is pitted with numerous little basins or kettle holes, in which water is trapped and held for long periods, owing to the imperviousness of the clay subsoil and substratum. Most of these basins contain peat or dark-colored and gray mineral soils. The areas occupied by Cabinet silt loam between the basins, however, are well drained.

With such a broken relief the farm practices must be modified, in order to meet the diversity of soils in the farm units. In districts of higher rainfall, such a soil probably would not be so favorable for the growth of crops as those with more friable subsoils, but, where storage of moisture for use during summer droughts is essential, the heavy-textured subsoil is an asset.

This soil is devoted chiefly to the production of alfalfa, clover, and wheat. The legumes, especially alfalfa, may be winter-killed because of saturation by moisture above the clay subsoil. The clay subsoil also resists penetration by deep-rooted crops, but sufficient moisture is present near the surface for the growth of crops in normal years. The subsoil is not so friable and favorable for the penetration of roots and therefore is not so good for alfalfa as that of the Mission soils. In addition, this soil warms more slowly in spring than do those soils. Two crops of alfalfa, yielding about 3 tons an acre, usually can be obtained, and clover yields one crop of about 2 tons. The higher better drained intermediate areas are preferred for alfalfa and the lower areas and basins for clover. Wheat produces from 20 to 25 bushels to the acre. Dairying and livestock raising are practiced extensively, and considerable quantities of hay and feed crops are consumed. Other crops for subsistence are grown also.

Cabinet silt loam, hilly phase.—Areas of Cabinet silt loam that are not suited to cultivation because of their steep and hilly relief are classified as a hilly phase. Less than 1 square mile is mapped, and the only use made of this land is grazing and forestry.

LIGHT-COLORED SOILS WITH SANDY SUBSOILS

The Selle, Elmira, and Colburn soils and the sandy-substratum phases of the silt loam and fine sandy loam members of the Bonner soils represent the light-colored soils having sandy subsoils. Agriculturally, these soils occupy an intermediate position between the fairly productive light-colored soils with clay subsoils and the comparatively unproductive light-colored soils with gravelly and stony subsoils. In many places, areas of these soils intergrade with areas of the poorer soil types; therefore, extreme caution should be exercised in the selection of areas for permanent farms.

Where typically developed, the surface soils of members of the Selle series are light yellowish brown, silty, friable, and moderately acid. The subsoils are light grayish brown, porous, sandy, and acid. They are underlain by a light-gray incoherent sandy substratum which is neutral or only slightly acid. Lime occurs in some places at a great depth, and in many places it is segregated. The sandy substratum is underlain by fine-textured old glacial lake sediments similar to those beneath the subsoils of the Mission soils. The Selle soils are developed on sandy wind-blown or wind-modified glacial lake or outwash terrace materials. They have a hummocky, rolling, or dunelike relief, and the uncultivated areas support a coniferous forest or are covered with brush. Both surface and internal drainage are excessive. In places where the Selle soils are intimately associated with the Mission soils they are used fairly successfully for most crops, especially alfalfa. During favorable years, when the rainfall is above normal, potatoes do well. Most of the areas, however, are of minor agricultural importance.

The Elmira soils occur in the valley north of Pend Oreille Lake at lower elevations than do the Selle soils. They also differ from these soils in having slightly more reddish brown surface soils and in the presence of lime in the subsoils. For the most part, the lime is segregated in root channels, and it originated possibly from floodwaters highly saturated with lime. Owing to extreme droughtiness and generally unfavorable rolling or hummocky relief, these soils have little value for agriculture. In the vicinities of Elmira and Samuels, the land is pitted with trapped drainage basins in which peat and dark-colored soils have developed. In this section where the relief is nearly level, the subsoil is compact. Some of these areas might be made to produce some crops, but, in general, cultivation of these soils is not recommended.

The Colburn soil, formed on low terraces along Pack River Valley and elsewhere, differs from the Selle soils, in that it has a higher clay concentration and compaction in the subsoil. These features make it somewhat more favorable for agriculture and place it in an intermediate position in agricultural value between the Selle and the Mission soils. Although the heavy clay subsoil characteristic of the Mission soils is lacking in the Colburn soil, the low-lying flat position of the Colburn favors the accumulation of moisture during periods of high water, and this moisture is retained for an extended period. Some areas lie in an advantageous position for irrigation, and the irrigated areas are very productive. Practically all the crops of this general region are grown.

Most of the Bonner soils are included in the group of light-colored soils with gravelly and stony subsoils, and the series description of the Bonner soils is given in the section that discusses that group.

Selle fine sandy loam.—Selle fine sandy loam is associated with the Mission soils on the higher delta terrace along the valley north of Pend Oreille Lake and along Priest River Valley. It is not an extensive soil, but is important owing to its close association with the Mission soils, from which it is distinguished by a more friable subsoil and, in most places, by a steeper relief.

The 8- or 10-inch surface soil consists of yellowish-brown very friable porous fine sandy loam containing a large quantity of silt. The subsoil, to a depth ranging from 14 to 20 inches, is light grayish-brown or yellowish-gray friable loamy sand. This material is underlain by structureless incoherent loose gray sand, except for bands of dull grayish-brown or salt-and-pepper-colored sands containing reddish-brown iron stains. Lake-laid clay layers underlie this soil at a variable depth, but in most places they lie at too great a depth to aid in the retention of moisture for cultivated crops.

Only the more favorably located areas have much agricultural value. They are good for the production of deep-rooted crops like alfalfa, and good yields generally are obtained. Most crops that grow well on Mission fine sandy loam also grow well on the associated areas of Selle fine sandy loam. The larger areas do not yield so well as do the Mission soils, owing to the thickness of the sandy soil materials.

In a few areas the soil is lighter colored throughout than the typical soil, owing to poor oxidation and aeration, caused by intermittent floodwaters. Such areas generally have slightly heavier textured subsoils, which increase the water-holding capacity and therefore make a more desirable soil. A few areas, that consist of wind-blown ridges or dunes, are used only for the growing of grass and trees.

Selle fine sandy loam, flat phase.—The flat phase of Selle fine sandy loam consists of the more level areas of Selle fine sandy loam, principally in Priest River Valley. Most of it occurs in one continuous body, in which the clay substratum lies at too great a depth to be of benefit to any vegetation except trees. Unless this soil is irrigated, it should be used for forestry and grazing. The total area is less than 1 square mile.

Elmira fine sand.—The 14-inch surface soil of Elmira fine sand consists of light loose incoherent fine sand. It is slightly more reddish yellow than the corresponding layers of the Selle soils which it resembles in physical features. The red tint is more pronounced when the soil is wet. Below the surface soil the sand continues but has a yellowish-gray color, is slightly firm, and lacks the light floury character of the surface soil. Gray becomes the dominant color, and iron stains appear below a depth of 22 inches. Below a depth of 4 feet the sand is dull brownish gray and contains root cavities which have become filled with lime and decaying organic matter.

Elmira fine sand is developed west of Elmira, in the vicinity of Samuels, and south of Samuels. Its droughtiness and hummocky relief make it poorly adapted to cultivated crops.

The surface is dotted with small basins or areas of trapped drainage, in which peat and dark-colored soil are developed. In such areas, trees benefit from seepage moisture. The only use for this land should be forestry and pasture. Snowbush (sticky laurel) is the principal ground cover at present.

Elmira fine sandy loam.—The color of the 12-inch surface soil of Elmira fine sandy loam is similar to that of Elmira fine sand. This layer is underlain by yellowish-brown slightly compact loamy sand. Below a depth of 18 inches and continuing to a depth ranging from 5 to 6 feet is dull grayish-brown iron-stained compact sand showing the effect of poor internal drainage. This material rests on calcareous loose incoherent sand. This soil supports a good growth of the better types of conifers, also some alder and birch.

The relief, the texture of the surface soil, and, in places, the position in relation to moisture render Elmira fine sandy loam more favorable for agriculture than Elmira fine sand. Areas in which moisture conditions are most favorable possibly could be farmed with a fair degree of success. The flatter areas lie adjacent to the numerous poorly drained areas throughout the Elmira soils. A few areas included with this soil, adjacent to poorly drained areas, are gray. If proper drainage could be established, such areas could be used successfully for the production of crops, especially hay and grain. This is not an extensive soil.

Colburn very fine sandy loam.—The 10-inch surface soil of Colburn very fine sandy loam is light yellowish-brown friable floury very fine sandy loam, in which mica is prominent. It is underlain to a depth of 30 inches by light grayish-brown somewhat cloddy highly micaceous loam with a greenish-yellow tinge. Below a depth of 30 inches, the material is light grayish-brown uniformly fine subangular granitic gravel or very coarse sand or sandy loam, interstratified with fine-textured iron-stained silt, fine sand, and some clay materials. Owing to the relatively low position and to the seasonal high water table, the subsoil is saturated. The generally favorable relief is broken in many places by drainage channels of present and abandoned streams. This soil is developed on stream terraces which adjoin the flood plains occupied by the Peone soils along Pack and Priest Rivers and Grouse and Lightning Creeks.

The crops best adapted to Colburn very fine sandy loam are similar to those grown on the sandy-substratum phase of Mission silt loam. In general, this soil is more droughty than the Mission soil, and correspondingly lower yields may be expected except where the land is situated where there is a good supply of moisture in the subsoil.

Stones are scattered over the surface and throughout the soil in a few areas which are shown on the soil map by stone symbols. Such land is used only for grazing.

Bonner silt loam, sandy-substratum phase.—Areas of Bonner silt loam with a sandy instead of a gravelly substratum are differentiated as a sandy-substratum phase. This is a less droughty and a better agricultural soil than is typical Bonner silt loam. It is developed on glacial outwash materials and has smooth or comparatively flat relief. Owing to the friability of both surface soil and subsoil, internal drainage is good.

This soil is characterized by an 8- or 10-inch surface soil of light-brown or light yellowish-brown acid friable floury silt loam. The subsoil is pale yellowish-gray acid firm heavy silt loam or silty clay loam, resting at a depth of about 25 inches on porous fine sand or fine sandy loam. Gravel occurs at a very great depth.

The largest areas are those south of Newport in the southwestern part of the county.

This is one of the best agricultural soils of the Bonner series, and it produces good yields of crops when the supply of moisture is sufficient to mature them.

Bonner fine sandy loam, sandy-substratum phase.—The surface soil of the sandy-substratum phase of Bonner fine sandy loam is thicker than that of the corresponding phase of Bonner silt loam. The subsoils of the two phases are similar, except for the somewhat coarser and less compact material in the fine sandy loam soil. The potential agricultural value of this soil probably is less compared with the other soil, owing to its light texture and lower moisture-holding capacity. In areas where the fine-textured soil material is comparatively thick, however, the moisture capacity is more favorable, and crops that are able to take advantage of early moisture do fairly well. The lighter texture has contributed to a more undulating relief, but, in general, this is not adverse to agriculture. Soils of these two phases are associated along the western boundary of the county.

LIGHT-COLORED SOILS WITH GRAVELLY AND STONY SUBSOILS

This group comprises the Springdale and Bonner soils developed on glacial outwash and the Kootenai, Pend Oreille, Loon, and Waits soils developed on glacial drift. These soils cover about 25 percent of the area surveyed.

Only a very small proportion of these soils is used for cultivated crops. In the southern and drier part of the county, where the growth of conifers is more open and a grass and deciduous-bush ground cover obtains, the predominating soils are those of the Springdale and Kootenai series, which are slightly darker than the soils in the more humid northern part where conifers dominate the vegetation. The grass and bush vegetation on the Springdale and Kootenai soils has increased the organic-matter and nitrogen content of the soils, and therefore they are darker than the more densely forest covered soils. The increase of organic matter and nitrogen is comparatively small, however, and, owing to the greater deficiency of summer rainfall, the productivity of these soils is no higher than that of the lighter colored soils. The Springdale and Kootenai soils occur in areas where the mean annual rainfall is about 25 inches, and their lighter colored counterparts, the Bonner and Pend Oreille soils, respectively, occur in areas where the mean annual rainfall is at least 30 inches. Only a small percentage of the precipitation occurs during the growing season, and crops suffer from lack of moisture in both locations, especially in the drier one.

In the lighter colored or more heavily forest covered soils, leaching and translocation of clay has taken place; therefore, the soils are more acid, distinctly pale yellowish brown in their virgin condition, and slightly more compact in the subsoil than the soils having a less dense forest cover. The greatest contrast exists between the soils at high elevations in the northern part of the county and those at low elevations in the southern part. Owing to the low agricultural value of all the soils in this group, the chemical differences are not important, in respect to cultivated crops. These differences do affect, however, the choice of trees for reforestation and the grazing capacities of the two areas.

The Springdale soils are developed on glacial outwash plains under a mixed grass, bush, and thin forest cover. They have light-brown or dull-brown friable surface soils underlain by sandy subsoils and substrata.

The Bonner soils differ from the Springdale soils in that they are lighter colored, more acid, and occur in areas of greater rainfall. Therefore, they are slightly better for cultivated crops.

The Kootenai soils are developed on glacial drift and morainic materials which are predominantly stony and gravelly. They are extensively developed to the south of Bonner County and are fairly extensive in the southern part of the county in areas of low rainfall. The relief ranges from undulating to semimountainous. Where typically developed, these soils lack the thin gray layer immediately below the forest litter, which is evident in the Bonner, Mission, Cabinet, and other soils in the more humid forest-covered soils to the north. The Kootenai soils are characterized by pale-brown or light-brown friable surface soils underlain by firmer lighter colored subsoils which may contain some water-worn gravel. The substratum is loose, porous, and very gravelly. The reaction is slightly acid throughout.

The Pend Oreille soils differ from the Kootenai soils in that they are more acid, lighter colored, especially in the surface soil, and have a rather distinct, very thin ash-gray layer under the forest litter. The relief and parent materials of the two soils are similar.

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The Loon soils, which resemble the Pend Oreille soils in profile, are formed from glacial drift materials having their source mainly in granitic rocks and in gneiss and mica schists. The relief ranges from undulating to hilly. The surface soils are light brown or pale yellowish brown and are friable. They are underlain by gray or grayish-brown subsoils which contain considerable slightly disintegrated granitic materials. The substratum is loose, porous, and very gravelly. These soils are droughty and are used mostly for forestry and grazing.

The Waits soils are similar in color, development, and relief to the Loon soils, but they are developed from shale, sandstone, and quartzite.

Springdale gravelly silt loam.—The 14-inch surface soil of Springdale gravelly silt loam is light-brown friable floury silt loam, with a slight red tinge when wet. It contains some gravel. Below this and continuing to a depth of about 40 inches is the yellowish-brown gravelly loam upper subsoil layer, in which the quantity of gravel increases with depth. The material in this layer is more compact and contrasts sharply with the light fluffy surface soil. The texture is gravelly fine sandy loam at a depth of about 40 inches. The lower subsoil layer consists of coarse stratified sand and gravel, in many places containing a large quantity of stones, especially in the lower part. Yellowish-brown clay, brown iron, and white silica coat the gravel and stones, being more pronounced on the under sides. In the gravelly and stony sandy substratum, the materials are grayer than those above. Lime-carbonate-coated gravel is present in places at greater depths.

The largest areas of this soil are near Clagstone, Edgemere, and Careywood.

The porous character of the subsoil and its low moisture-holding capacity make farming hazardous. Only very small areas, in which the depth of soil and supply of moisture are most favorable, now are cultivated, as most of the areas once farmed have been abandoned. The insufficient supply of moisture limits the agricultural possibilities, and, for the most part, the land should be used for the growth of forest trees, especially yellow pine, and for the grazing it affords. The coarse pinegrass which grows on this, as well as on other Springdale soils, however, is poor forage. The introduction of drought-resistant hay and pasture crops might offer some inducement for the raising of livestock.

Springdale gravelly silt loam, stony phase.—The stony phase of Springdale gravelly silt loam consists of areas, similar to typical Springdale gravelly silt loam, in which large quantities of stones and boulders are scattered over the surface and throughout the soil materials. It is an inextensive soil and has even less agricultural possibilities than the typical soil.

Springdale gravelly loam.—Springdale gravelly loam is less extensive than Springdale gravelly silt loam, with which it is associated. The two soils have similar relief, except that a few areas of the gravelly loam are extremely hummocky. They are equally droughty and have essentially the same characteristics in the lower part of the profile. The surface soil of Springdale gravelly loam is more gravelly and, in many places, thinner than that of Springdale gravelly silt loam. Both surface soil and subsoil are slightly heavier textured than the corresponding layers of the silt loam. The utilization of both soils is limited to forestry and grazing.

Springdale gravelly fine sandy loam.—The surface soil of Springdale gravelly fine sandy loam is light-brown or dull light-brown light fluffy gravelly fine sandy loam. The principal textural difference between this soil and the gravelly silt loam is that this soil has a larger proportion of fine sand in the surface soil and upper subsoil layer. The lower subsoil layers and substratum are practically the same in the two soils.

A few areas in depressions or other places where excess moisture accumulates are grayer throughout, and such areas are slightly better adapted for crops than is the typical soil. In some places in the depressions the surface soil is exceptionally thick, gravel is scanty, and no excess moisture accumulates. Such areas are decidedly better than the typical soil for the production of most crops.

Springdale gravelly fine sandy loam is the most extensive Springdale soil. It is associated with the gravelly silt loam and gravelly loam members in the southwestern part of the county. The relief and agricultural limitations of all three soils are similar.

Springdale gravelly fine sandy loam, rolling phase.—Areas of Springdale gravelly fine sandy loam that have a rolling or hilly relief are classified as a rolling phase. This soil is closely associated with the typical soil, but it is not extensive.

Owing to its unfavorable relief and the porosity of the subsoil and substratum, the land is used principally for forestry and grazing. It is considered a less desirable soil than Bonner loam, rolling phase, a soil that has similar characteristics but occurs in an area of greater precipitation.

Springdale gravelly fine sandy loam, deep phase.—The deep phase of Springdale gravelly fine sandy loam is comparatively free of gravel, and the surface soil is much thicker than in the typical soil, the average depth being about 20 inches. The surface soil is light brown, friable, and about neutral in reaction. The subsoil is less compact than the corresponding layer in the heavier-textured soils of the Springdale series. The substratum is gravelly and porous. In places the Springdale soils merge with the Moscow soils. Areas of this deep soil join with areas of Moscow loam of the earlier soil survey of Spokane County, Wash., on the west.

Both internal and external drainage are good. This soil is not so droughty as either the typical soil or its rolling phase. A larger proportion of the light rains are absorbed by plant roots in this sandy soil than in heavier textured soils.

Springdale coarse sandy loam.—Springdale coarse sandy loam is characterized by a light-brown porous incoherent coarse sandy loam surface soil about 14 inches thick. This layer is underlain by gray firmer coarse sandy loam that grades, at a depth of about 2 feet, into coarse sand and gravel. The relief ranges from undulating to hilly, and internal and external drainage are excessive. The land is used only for forestry and grazing. A few small areas are in the southwestern part of the county.

Bonner silt loam.—Bonner silt loam is developed from glacial outwash materials on smooth or comparatively flat relief (pl. 2, *B*). It differs from Springdale gravelly silt loam in that it occurs in areas of higher precipitation and, therefore, is more leached, more acid, and lighter colored. It also contains less gravel in the surface soil than does the Springdale soil. Owing to the heavier rainfall, it is more valuable for the production of cultivated crops than are the Springdale soils, and agriculture is less speculative, although in many years it is hazardous.

The surface soil of light yellowish-brown floury silt loam is about 16 or 18 inches in thickness. Areas that have occupied favorable positions for the deposition of loessial silt have thicker surface soils and are more valuable. The upper subsoil layer consists of light grayish-brown gravelly fine sandy loam or gritty loam, with considerable compaction. The material, however, is comparatively porous and brittle and has a somewhat vesicular appearance. Iron stains in the form of bands or mottles are present in many places. Below a depth of about 3 feet is the lower subsoil layer of dull yellowish-brown or dull brownish-gray, slightly stained with red, loose porous coarse sand and gravel. This material is stratified. The porosity increases and the yellow color diminishes with depth.

Bonner silt loam is one of the better agricultural soils in the group of light-colored soils with gravelly and stony subsoils. In places where this soil is situated favorably with regard to a supply of moisture, such as adjacent to or in depressions, or in flat areas below terrace fronts, where the surface soil is thick, crops are produced with a fair degree of success. Such areas are associated in many places with the dark-colored soils and comprise a part of the farm unit. Under such conditions, it is supplementary to the dark soils for various crops not suited to the wet dark-colored soils. In average years, crops that are able to take advantage of the early moisture, especially hay crops, which do not need late moisture for maturity, can be depended on for fair yields. The dark-colored soils, however, are almost essential in the farm unit, to stabilize crop yields during dry years. This accounts for the large number of abandoned farms which include only Bonner silt loam.

On the more favorable areas, alfalfa is grown to some extent. Because of its deep rooting system it can take advantage of the moisture at the greater depths. The moisture supply generally is limited, and because of this alfalfa stands come to maturity very slowly and do not develop a healthy thick cover very readily. Unlike alfalfa grown on the soils underlain by clay subsoils, which produce two and three cuttings annually, only one cutting can be expected. At best, all crop yields, even on the most productive areas of this soil, are less than one-half as high as those obtained on soils with clay subsoils, and the productive capacity on farm units of soils with clay subsoils having good moisture-holding capacity is not sufficiently high to warrant the inclusion of soils with gravelly subsoils into the farm unit. The investment in land and the cost of clearing, which is high, put the initial investment above the productive value of the land.

A few areas of this soil are decidedly gray throughout the surface soil and subsoil, owing to temporarily ponded or slightly excessive moisture. The excess moisture is an asset, and in most places surface drainage for spring run-off is established readily.

Other included areas occupy slightly depressed relief or positions below terrace fronts which also accumulate and retain moisture to a greater extent than does typical Bonner silt loam. The surface soil is thicker than in the typical soil, ranging from 20 to 24 inches in thickness. In the lower lying positions, the surface soil assumes a grayer or darker color and contains more organic matter, and the subsoil materials are more mottled with iron stains than elsewhere in this inclusion. These areas are associated with the darker soils in many places. Frost is a more frequent hazard than in areas of typical Bonner silt loam.

Very small bodies mapped as this soil join with transitional areas of the Kootenai and the Springdale soils of Kootenai County on the south.

This is the most extensive Bonner soil. The largest areas are between Newport and Priest River, near Edgemere and Vay, and northwest of Sandpoint.

Bonner silt loam, stony phase.—Areas of Bonner silt loam that have stones or boulders on the surface are classified as a stony phase. In most places removal of the stones is impracticable. This soil is used only for forestry and grazing. Less than one-half square mile is mapped, mainly in an area northwest of Sandpoint.

Bonner loam.—Bonner loam has profile characteristics similar to those of Bonner silt loam, from which it differs chiefly in its slightly thinner and, in places, slightly gritty surface soil of light floury loam. It is much less extensive than the silt loam. The limitations of selection and production of crops are similar for the two soils.

Bonner loam, rolling phase.—Bonner loam, rolling phase, is not adapted to cultivated crops, owing to its strongly rolling relief. It is used for forestry and to some extent for grazing. The surface soil is thinner than that of the typical soil and in most places is gravelly. The total area is small.

Bonner gravelly loam.—Bonner gravelly loam differs from Bonner loam in that its surface soil is not so thick and contains more gravel and in that the gravelly subsoil materials occur at a slighter depth. In this respect it resembles the Springdale soils. The profile generally is less gray than the typical Bonner soil, and fewer iron stains appear in the subsoil. This soil is less favorable for agriculture than is Bonner loam. The largest areas are along the northern side of Pend Oreille River between Newport and Priest River and along the southern side southwest of Laclede.

Bonner fine sandy loam.—The light texture of Bonner fine sandy loam makes it a little more droughty than the other Bonner soils except in places where the surface soil is thick. The 18-inch surface soil, in most places, is light yellowish-brown or light-buff fine sandy loam containing considerable silt. The upper subsoil layer is slightly compact light grayish-brown sandy loam and may or may not contain a sprinkling of gravel. Below a depth of about 3 feet the subsoil lacks compaction and has similar stratification and color as do the other Bonner soils. This soil is developed mainly in the central part of the county along Cocolalla Creek and near Algoma and to less extent in Priest River Valley.

Bonner fine sandy loam, imperfectly drained phase.—The imperfectly drained phase of Bonner fine sandy loam occurs in small areas most of which are in the vicinity of Algoma. It is formed in a low-lying basin, and much of the surface soil is gray. The subsoil consists of well-compacted material in which reddish-brown iron stains are common, owing to poor drainage and a high water table. The coloration from poor drainage in the lower part of the subsoil is more green and gray than in the material above. The increased moisture in this soil and the capacity to retain it makes this a more valuable soil than the typical soil.

Bonner fine sandy loam, stony phase.—The stony phase of Bonner fine sandy loam is a very inextensive nonagricultural soil which differs from the typical soil only in its high stone content throughout the soil profile. It is used mostly for forestry.

Bonner gravelly fine sandy loam.—Bonner gravelly fine sandy loam is inextensive and unimportant. It includes areas having shallower and more gravelly surface soils than typical. The droughtiness is increased by these features, especially where the quantity of gravel is excessive. The two principal areas are northwest of Edgemere and east of the town of Priest River.

Bonner sandy loam, sandy-substratum phase.—Bonner sandy loam, sandy-substratum phase, is rather too coarse to retain moisture well, and, in general, it is unsuited for agriculture. In a few areas where excess moisture is drained from higher elevations, crops are grown with fair success. Most areas are used for forestry. Less than 1 square mile is mapped. It occurs mostly along Pend Oreille River in the central part of the county north of Morton.

Bonner coarse sandy loam.—Bonner coarse sandy loam has profile characteristics similar to those of Bonner gravelly fine sandy loam. The coarseness of the materials, especially at the surface, makes this soil very droughty, in which respect it resembles Springdale coarse sandy loam. It should be used only for forestry and grazing. Some areas have a hummocky relief. This soil is developed mainly south and southeast of Newport.

Kootenai gravelly silt loam.—The 12-inch surface soil of Kootenai gravelly silt loam is light-brown or dull light-brown, with a slight red tinge, friable floury silt loam. Gravel is sprinkled through this layer. A rather definite line of demarcation occurs between the surface soil and the upper subsoil layer which is somewhat compact and consists of somewhat more reddish brown gritty fine sandy loam or loam. Gravel is very pronounced in this layer which, in most places, is also stony. Both these horizons become more pronounced reddish brown when wet. The content of gravel and stone in the lower subsoil and substratum increases with depth. These layers are not stratified as are the corresponding layers of the Springdale soils, and they contain but small quantities of sand and fine gravel. The gravel and soil materials are derived from a variety of rocks and have a variegated color, in which yellowish brown predominates. Some of the gravel pieces are brown from iron stains; others are coated white with silica on their under sides. A few areas of this soil have considerable stone on the surface. Such areas are nonagricultural and are shown on the soil map by stone symbols.

Fairly large areas of Kootenai gravelly silt loam are in the southern part of the county and extend into Kootenai County, where they are even more extensively developed. The agricultural value of this soil is low, as is that of the Springdale soils, because it lies in the section of low rainfall and has a droughty porous subsoil. In places it has a great variety of heterogeneous materials in the subsoil and substratum, owing to its development from glacial drift. In places where the material is heavier textured, the moisture storage capacity is increased. This asset, however, probably is offset by the generally less favorable relief compared with that of the Springdale soils. Stones and boulders are scattered over the surface and throughout the soil in most places.

The agricultural limitations of this soil are about the same as those of Springdale silt loam. The deficiencies of moisture, organic matter, and nitrogen make successful farming over an extended period extremely uncertain.

Kootenai gravelly silt loam, rolling phase.—Areas of the rolling phase of Kootenai gravelly silt loam have a broken relief and are extremely stony. The surface is broken by innumerable small knolls, knobs, and pot holes in highly complicated arrangement. These features alone preclude any agricultural development. This soil is less extensive than typical Kootenai gravelly silt loam. It occurs in one fairly large body on the Kootenai County boundary southwest of Clagstone.

Kootenai gravelly silt loam, steep phase.—Kootenai gravelly silt loam, steep phase, consists of long narrow strips of Kootenai gravelly silt loam, having hilly and steep relief. There is an increased stoniness, especially on the steeper slopes, and large boulders are prominent in many places. This is essentially a nonagricultural soil used only for forestry and grazing. The total area is small.

Pend Oreille silt loam.—The surface soil of Pend Oreille silt loam is light yellowish-brown or light-buff silt loam of light floury consistence and lacking compaction. In most places, at a depth of about 16 or 18 inches, a few gravel and stones are present. The surface soil is abruptly underlain by a more compact upper subsoil layer of light yellowish-gray gravelly gritty loam or sandy loam, which is brittle and highly vesicular. Both gray and iron stains occur, and boulders are numerous. At a depth of about 4 feet the material becomes loose and more porous, and the porosity increases with depth. The color is light yellowish brown or grayish yellow with a green tinge. Large quantities of gravel and boulders are present, and iron stains and mottles appear in most places. Great variability characterizes the substratum which ranges from heterogeneous massive till to materials in which segregation by water action and massive stratification are evident.

Pend Oreille silt loam is extensively developed throughout the county on glacial drift deposits having their source in a variety of rocks. In the origin of its parent materials, it is similar to the Kootenai soils, but it differs from those soils in having a lighter yellowish-brown surface soil and subsoil, greater compaction in the subsoil, and, in many places, heavier textured materials in the substratum. Especially is this true where this soil is adjacent to the mountainous areas. The Pend Oreille and Kootenai soils are also similar in profile development and moisture-holding capacity. In general, the Pend Oreille soils are more rolling or hilly than the Bonner soils, and this results in greater variability in the thickness of the surface soil and in less favorable conditions for cultivation. This disadvantage is offset in places where the subsoil and substratum consist of heterogeneous heavier textured materials.

The slight compaction of the subsoil makes Pend Oreille silt loam a more valuable soil than the Kootenai soils, although the difference is not sufficient, even with the increased rainfall, to make farming successful on this soil over a period of years. Areas favorably situated with respect to moisture or having an exceptionally thick surface soil may be farmed with fair success, especially if associated with better types of soils, but the development of farm units entirely on this soil is not recommended.

The average crop production on this and similar gravelly soils over a period of years probably is only about one-half of that obtained on Mission silt loam. Most of the areas of generally droughty soils that are farmed occur in positions favorable for domestic water supply and, for the most part, are associated with the dark-colored soils along stream bottoms, basins, or seepage areas. It is difficult or impossible to get an adequate supply of water on many of these soils on higher land, owing to the porous gravelly substratum which does not hold water.

Pend Oreille loam.—Pend Oreille loam is not so extensive or so widely distributed as Pend Oreille silt loam. It is similar to the silt loam in profile characteristics, with the exception of the surface soil which generally is not so thick, is of coarser rather gritty loam texture, and, in many places, contains a slightly greater quantity of stones and gravel. The relief ranges from undulating to steep.

In general, because of its thinner surface soil and more rolling or steeper relief, this soil is less well suited for agriculture than is the silt loam.

Pend Oreille loam, hilly phase.—The hilly phase of Pend Oreille loam is extensively developed in association with typical Pend Oreille loam and Pend Oreille silt loam. A very large area is east of Samuels. The relief of the land makes it unsuitable for cultivation. Included areas range from strongly rolling to semimountainous. Much of the land is eroded and extremely gravelly and stony. The thickness of the surface soil varies much more than in the typical soil. Moisture conditions in the more mountainous areas are favorable for the growth of trees. In places this hilly soil merges with the Moscow soils of the mountainous areas. A small body joins with the Moscow soils of Spokane County, Wash., in which the soils of rougher relief were mapped in less detail. A very small area joins with rough mountainous land of Kootenai County on the south.

Pend Oreille loam, stony phase.—The stony phase of Pend Oreille loam is separated from the typical soil on account of its large content of stones and boulders. The total area is not large. The land is used mainly for forestry and to a small extent for grazing.

Pend Oreille fine sandy loam.—Pend Oreille fine sandy loam is inextensive and is agriculturally unimportant. In most places the surface soil consists of yellowish-brown friable rather thick fine sandy loam. The relief is hummocky, owing to the light texture of the soil which subjects it to wind drifting. The subsoil generally is lighter textured and more porous than the corresponding layer in the heavier textured soils of this series. The soil is more droughty than the other Pend Oreille soils mapped.

Loon loam.—Loon loam has a surface soil of light yellowish-brown or light-buff loam which contains gritty fragments of granitic materials. The material is friable, loose, floury, and light in weight. Beginning at a depth of 16 or 18 inches is the upper subsoil layer of dull brownish-gray compact yet porous brittle gritty loam or sandy loam, containing angular granitic rock fragments, rounded gravel, stones, and boulders. Considerable iron mottling and a vesicular structure are apparent. The loose lower subsoil layer begins at a depth of about 4 feet and consists of highly angular granitic very coarse sand and gravel. The light-gray color gives the appearance of loose freshly ground granitic rock material. There is some iron staining. Boulders and stones are numerous throughout the surface soil and subsoil.

Loon loam is mapped in many scattered areas, mainly adjacent to the granitic Selkirk Mountains. The glacial drift material, on which it is developed, is derived principally from granodiorite, gneiss, and mica schist rocks. The relief ranges from sloping to strongly rolling.

The subsoil and substratum materials are variable in composition and are rather porous and droughty. The moisture-retaining capacity varies greatly. In places where granitic rock fragments are coarse, less compaction takes place in the subsoil and substratum; where these granitic materials have been weathered by seepage waters. however, the subsoil assumes a much heavier texture and has an increased water-holding capacity. Most of the farmed areas lie in such favorable positions up in the mountains, that a supply of water for domestic use is available. In such positions, the soil is farmed in association with the darker soils.

The crops grown on this soil are those commonly grown in this section, but, as on other soils with permeable gravelly and stony subsoils, the deficiency of rainfall in summer limits production and often results in failure of crops that require a long time for maturity. The crops grown and yields obtained are similar to those on Pend Oreille silt loam and Pend Oreille loam.

In places, the glacial materials giving rise to the Loon soils thin out, and the soils merge with the soils of the Moscow series, which are developed in place from similar rocks. In such localities, differentiation of the soils of the two series is difficult, and as mapped a very small area of Loon loam joins with Moscow loam of the earlier Spokane County, Wash., survey.

Waits silt loam.—The 14-inch surface soil of Waits silt loam is light yellowish-brown or light-buff floury silt loam, with a scattering of gravel and, in places, a few boulders. The upper subsoil layer is yellowish-gray or grayish-brown slightly compact iron-stained gritty gravelly loam or sandy loam. It has a vesicular appearance. The lower subsoil layer, below a depth ranging from 40 to 48 inches, is more gray, more porous, and more gravelly or stony than is the material above that depth. Some of the gravel have a coating of silt or clay. At greater depths, white silica coats the under sides of the

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gravel and stones. Gray and blue argillites and quartzites impart a similar color to the lower part of the subsoil and substratum.

The topographic position is similar to that of Loon loam. Waits silt loam is less extensive than either Pend Oreille loam or Loon loam, which it resembles. It is associated with the Cabinet and Coeur d'Alene Mountains which are made up of rocks of the Belt series, including shales, sandstones, and metamorphosed equivalents of argillites and quartzites. Such materials, transported and deposited as till, compose the greater mass of the material on which this soil is developed. For the most part, the soil materials are finer than those of the Loon soils, which are formed from granite. Several members of the Belt rocks are calcareous, and therefore these soils are likely to have more lime in the deeper substratum than the other soils developed on glacial drift. Most of the areas that receive moisture from seepage have more compact and finer textured subsoils, compared with other areas, and this results in a larger moisture-storage capacity.

Areas adjacent to Pend Oreille Lake undergo the moderating influence of that body of water and are adapted to a wide variety of crops, including fruits and vegetables. Elsewhere the kind and yields of crops are the same as on the Pend Oreille and Loon soils. As with those soils and others having gravelly subsoils, the insufficient moisture-holding capacity is the principal limiting factor in crop production.

A few areas, which have an excessive quantity of boulders on the surface, are used only for forestry and grazing.

Waits silt loam, hilly phase.—The hilly phase of Waits silt loam has a steep, strongly rolling, or hilly relief, and the land, in general, is unsuited for cultivated crops. In most places the surface soil is comparatively shallow and gravelly. Much of it contains stones and boulders. The high position of this soil renders it favorable for forest growth.

DARK-COLORED SOILS

Most of the dark-colored soils occur on the river flood plains, depressions, and low terraces. They are the most important and most productive farming soils of the county and are the soils on which there is least danger of crop failure. They form the nuclei of most of the more important farms of this general region. The pioneer agriculture was established on these soils, and the present agriculture is dominated by them even though the deficiencies of the light-colored soils have been more thoroughly investigated and understood. These soils have high natural inherent fertility, high content of organic matter, and a plentiful supply of moisture. There are few limitations to the production of crops except the establishment of proper drainage. The supply of water is not only ample for domestic purposes, but often water is available for the irrigation of home gardens, a feature that adds greater security to the subsistence type of agriculture practiced in the county.

The abundance of native hay cut from the meadows, bottoms, and overflow lands has also been a basic factor in the development and security of livestock enterprises, which also are important in the agriculture. The introduction of grass and legume crops has increased the importance of these lands by producing higher yields of hay.

These fundamental factors show why the dark-colored soils have been so important in the agricultural development of the county. Owing to their occurrence in small scattered bodies or narrow winding areas along streams, these soils, in most places, form the smaller although the most important and stable part of the farm unit. On some farms the light-colored soils are used only for pasture and a supply of wood; on others, they are used for supplementary crops, such as alfalfa and grains, or other crops which are not grown on the dark-colored soils because of excessive moisture or conditions these crops do not tolerate.

The aggregate area of these dark-colored soils is very small as compared with the great extent of the light-colored soils. They are widely distributed, however, in practically all parts of the county, especially in the valleys along stream courses.

For the successful utilization of these soils, other than for native hay, some kind of artificial drainage or flood control system must be provided in most places, in order to drain excessive water from the land and stabilize seasonal fluctuations of the water. This can be accomplished nearly everywhere, except in areas that are inundated annually by Pend Oreille Lake and tributary streams.

The crops of first importance are the hay and pasture crops. The native hay and pasture consist principally of water-loving grasses and rushes, which produce an abundance of hay but have coarse stems and a lower feeding value than do the introduced hay crops. In these native meadows, yields are said to diminish under continuous cropping. At present, yields range from ½ to 1½ tons an acre. Of the introduced crops, timothy and timothy and clover mixed (usually alsike) are grown extensively. Timothy is said to deplete the fertility of soils more rapidly than the other crops. Early yields of this crop are said to have been about 2½ tons an acre, but now they range from ½ to 1 ton. Timothy and alsike (together) at one time produced as high as 4 tons an acre but now average about 2 tons. Yields of red clover (alone or in a similar mixture) are a little higher than this. Red clover is grown on the better drained soils. The principal grain crop is oats, which produce much higher yields than they do on the light-colored soils. This crop returns from 70 to 80 bushels an acre. Peas also have been grown with success, and they yield much higher than on the light-colored soils. When the production of wheat is attempted, the spring varieties are chosen. Root crops yield well on most of these soils, and home gardens are excellent.

All the soils appear dark on the surface when wet and in a virgin condition, but only those with a high organic-matter content remain dark when dry or after the surface soil is disturbed. The color ranges from dull gray to nearly black at the extremes in moisture content.

Included within this dark-colored group of soils are the Garrison, Colville, Peone, Chamokane, Narcisse, Cocolalla, and St. Joe soils, as well as peat.

The Garrison soils, represented in this county by less than one-half square mile of Garrison gravelly loam, are formed from gravelly glacial outwash deposits. They are not so productive as most of the other soils in this group. Their much darker colored surface soil and rather dense grass cover in virgin areas distinguish them from the Springdale soils.

The Colville soils are developed from glacial-lake deposits and are characterized by very dark grayish-brown or nearly black granular friable acid surface soils underlain by gray or light-gray heavy-textured plastic neutral materials. These soils occupy level or gently sloping areas in glacial lake basins or on flat poorly drained terrace positions.

The Peone soils occupy alluvial flood plains and low terraces and are associated with the dark-colored soils. Cultivation has nearly destroyed the dark color which the thin surface soil had in the virgin condition, and the cultivated areas are as light or lighter in color than many of the soils in the group of light-colored soils. Agriculturally, however, they are more productive than the light-colored soils and, for this reason, are grouped with the dark-colored soils. Owing to their proximity to Pend Oreille Lake, the seasons are long, and the frost hazards are minimized. Practically all of the crops commonly grown are produced with fair success on these soils. Their light color is explained by the light color of the parent material rather than by the processes of soil development. The Peone soils are characterized by a rather uniform gray or light-gray silty material continuing from the surface to great depths. This material is fairly friable and permeable, but, owing to inundation for several months during the year, the growing period is short and hay is the principal crop.

The Chamokane soils are developed on alluvial flood plains or low fans from glacial outwash materials. These soils are characterized by brown or dark-brown friable slightly granular surface soils that gradually change to the yellowish brown of the lower subsoil layer. All layers are slightly acid and friable. Some areas are flooded occasionally, but the land is easily drained. Deciduous trees and water-loving grass are common on noncultivated areas. Hay is the principal commercial crop.

The Narcisse soils occupy positions similar to those of the Chamokane soils, but they have darker surface soils and grayish-brown slightly compact subsoils. Gravel is present at a depth of about 30 inches. These soils are formed from granitic highly micaceous material. Agriculturally they are comparable to the Chamokane soils.

The Cocolalla soils are easily distinguished by their black color and high content of organic matter, due principally to the decomposition of a water-loving vegetation, such as reeds and sedges. The subsoils are composed of gray fine-textured ashy material with an alkaline reaction. These soils occupy poorly drained glacial lake basins and pockets in areas of ponded drainage in stream valleys. Properly drained areas produce good yields of hay.

The St. Joe soils differ from the Cocolalla soils in their better drainage, lighter color, lower organic-matter content, and development from granitic material high in mica. These soils are used successfully for the production of general farm crops.

Garrison gravelly loam.—Garrison gravelly loam occupies only 256 acres in this county, although it covers more than 30,000 acres in

Kootenai County on the south. It differs from Springdale gravelly loam in that it has a much darker surface soil, due largely to the large quantity of organic matter incorporated in the soil from the dense native-grass vegetation. The 10-inch surface soil is dark-brown or nearly black granular friable gravelly loam. It is underlain by a light-brown friable permeable gravelly loam subsoil, about 10 inches thick. The substratum consists of stratified gravel and sand.

This soil occurs on undulating or gently rolling terraces or outwash plains. An area lies southwest of Hoodoo Lake.

When properly managed, Garrison gravelly loam is considered a productive soil for grains and grasses.

Colville silty clay loam.—The thickness of the dark organic surface soil of Colville silty clay loam varies considerably. It is greatest in the more excessively wet areas where vegetation, especially grass, is more dense. The surface soil in typically developed areas ranges from dark grayish-brown to nearly black silty clay loam, from 5 to 8 inches thick. In the more grassy areas there is considerable granulation, and organic matter has been incorporated from the decay of grass roots. The upper subsoil layer consists of light grayish-brown or brownish-gray silty clay loam or silty clay and continues to a depth of about 2 feet. The lower subsoil layer consists of light-gray, mottled with iron stains, thickly bedded clay strata, with minor silt and sand stratification. In general, the surface soil is about neutral in reaction; the subsoil, alkaline.

Colville silty clay loam is developed on low flat terracelike positions or glacial lake basins. This soil occurs in many small widely scattered areas or depressions along Pend Oreille River. One of the largest continuous bodies lies north of Sagle. Artificial drainage is established readily in most places, even though water moves slowly through the subsoil. The provision of open drains for spring floodwaters adds several weeks to the growing season by allowing earlier cultivation and causing a warmer soil. Some areas along Pend Oreille Lake and Pend Oreille River are totally or partly inundated in early spring and therefore cannot be cultivated early.

Some of the bordering areas of this soil contain outwash materials of fine sandy material, and a small body joins with an area classified as Colville fine sandy loam, dark-subsoil phase, in Spokane County, Wash.

Colville silty clay loam is suited to most of the crops commonly grown, except alfalfa and winter wheat, which suffer from excess moisture and winter heaving of the soil.

Peone silty clay.—Peone silty clay differs from Colville silty clay loam in that it has a thinner and lighter colored surface soil and a lighter colored, less organic stained, and less developed subsoil. In most places there have been comparatively recent deposits of lake sediments upon the surface. In representative areas the surface soil is about 2½ inches thick and consists of light grayish-brown plastic silty clay. A bluish-gray cast is noticeable, especially when the soil is wet, and red iron staining is pronounced. In most places, the material in this layer is heavily matted with grass roots and shows some lamination or thin banding of sediments. The surface soil appears decidedly gray when dry or cultivated, and this is one of the lightest colored soils of the group of dark-colored soils. Between depths of 2½ and 40 inches, the material is dull bluish-gray very plastic and sticky silty clay or clay, in which iron mottles and some organic stains appear. Below this layer, the material continues as very light gray or yellowish-gray green-tinted strata of clays, silts, and sands. Red iron staining is pronounced, especially in the more sandy strata. This soil is neutral or very slightly acid throughout the profile.

Peone silty clay generally is not cultivated, owing to the annual flooding from Pend Oreille Lake and Clark Fork. Where associated with Colville silty clay loam, it lies lower than that soil and is submerged for a much longer time. Generally the water subsides in the early summer, and the native hay which it supports can be harvested in August and September. This soil is used more than any other soil in the county for the production of native hay, and it occurs in continuous areas ideal for haying operations. The hay, which is made from coarse grasses and rushes, is of average quality. Yields range from ½ to 1 ton an acre.

Peone silty clay, low-bottom phase.—The low-bottom phase of Peone silty clay lacks the dark organic horizon or root matting of the typical soil, and it is decidedly light gray. As it is marshy or flooded most of the year, it is almost devoid of vegetation, except coarse rushes and reeds. Much of it is a channel for water during a large part of the year. It has little value for the production of agricultural crops.

Peone silty clay loam.—Peone silty clay loam occurs mainly on the deltas where Pack River and Clark Fork enter Pend Oreille Lake. As typically developed, the surface soil is light grayish-yellow or yellowish-brown silty clay loam about 20 inches thick. It is somewhat compact when dry and is plastic when wet. The upper subsoil layer consists of fine sandy loam which is similar in color to the surface soil or slightly more yellowish gray. It is somewhat compact but is more friable than the material above. The lower subsoil layer becomes more brownish yellow, owing to the brown and reddish-brown iron staining. This material lacks the compaction of the overlying layers and is rather loose. The micaceous character of the materials is somewhat obscured in the surface soil but is pronounced in the subsoil. The soil is slightly acid throughout.

Although heavy textured, the land is easily tilled, and both roots and water penetrate freely, owing in part to the large content of fine micaceous materials. Excessive moisture drains readily through the friable subsoil. Though not so well suited to all crops as Peone fine sandy loam, most crops do well, and the relatively frost-free location aids in crop production. This is one of the important agricultural soils in the section near Clark Fork.

Areas of this soil near the mouths of both Pack River and Clark Fork, that are shown on the soil map with swamp symbols, are flooded for a long period during the spring. This inhibits the growth of trees, and only grass, rush, and sedge vegetation survives. This type of vegetation has caused the incorporation of larger amounts of organic matter in the surface soil, and extended periodic inundation has also caused a lighter gray and more highly iron-stained subsoil. Native hay is cut on these areas when Pend Oreille

Lake subsides, generally in August or September. An average of about 1 ton an acre is obtained.

Peone loam.—Peone loam occupies only a few areas, principally near Clark Fork. It differs from Peone silty clay loam in that it has a slightly darker and less heavy textured surface soil. The 8-inch surface soil of light grayish-brown friable slightly acid loam is underlain by a gray friable permeable loam or silt loam subsoil that becomes more friable and sandier with depth. Drainage is good, and fair success is obtained in the production of nearly all the crops commonly grown. The relief is favorable for the use of modern machinery. This soil is regarded highly by most farmers, although its fertility appears low and the land is benefited by the use of manure.

Peone fine sandy loam.—The 10-inch surface soil of Peone fine sandy loam consists of light grayish-brown or slightly yellowish gray slightly acid friable mellow fine sandy loam. The upper subsoil layer, to a depth of nearly 40 inches, is light yellowish-brown permeable friable loose loamy fine sand or fine sandy loam. The lower subsoil layer and substratum are loose incoherent gray sand. The material throughout the entire profile is slightly acid and highly micaceous.

This is the best drained Peone soil, and, where recent deposition of sandy material has not been detrimental, the land is productive. This soil is used for all the crops commonly grown, but it is especially well adapted for truck crops.

Chamokane gravelly loam.—Chamokane gravelly loam occupies narrow alluvial bottoms and small fans along the minor streams throughout the county. It is derived from glacial materials of widely different origin and composition. The surface soil, to a depth of 12 inches, is dark-brown or grayish-brown granular friable gravelly loam which is fairly high in organic matter. The content of gravel varies considerably in the different areas. The subsoil is brown or light-brown porous very gravelly loam or gravelly sandy loam to a depth of 2 feet. The substratum, to a depth below 6 feet, is gravelly, sandy, and, in places, stony. The finer textured materials are brown and, in places, are cemented slightly to larger gravel or stones by precipitated iron. Many iron splotches and stains occur in this material. In general, the reaction of this soil is slightly acid at all depths.

The uncultivated areas support a dense growth of deciduous brush and trees, mostly alder, and, in the wet areas, water-loving grasses. The land can be cleared easily, and artificial drainage, where necessary, can be provided readily. The fertility of the soil is high, and the supply of domestic water is adequate. This is a valuable soil for grazing.

The cultivated areas are used for home gardens, hay, and pasture, which comprise the basic units of subsistence farms. Timothy, timothy with clover, or clover alone, are the principal hay crops. Yields are similar to those obtained on the other dark-colored soils. This soil generally is unsuited for alfalfa, owing to excessive moistrue. In some areas, the production of crops is limited by the very large content of gravel.

Areas of this soil shown on the soil map with stone symbols have a large content of stone on the surface. Such areas are used only for forestry and grazing.

Narcisse loam.—Narcisse loam occupies positions similar to those occupied by Chamokane gravelly loam.

The color of the surface soil of Narcisse loam varies considerably, owing to the different moisture conditions under which the soil has developed. In general, it is darker, more granular, and more friable than Chamokane gravelly loam, but some areas are decidedly gray. The gray color is associated with inclusions of a lighter textured soil. In representative areas, the surface soil is very dark grayish-brown granular highly micaceous loam, about 14 inches thick. A sprinkling of fine gravel occurs in places. The upper subsoil layer is grayish-brown somewhat compact loam or sandy loam, in which reddish-brown iron mottling generally is evident in soil pores and crevices. The lower subsoil layer, beginning about 3 feet below the surface, is more loose and porous than the overlying material, owing to a high content of fine gravel and sand of highly micaceous granitic character. It has a brownish-gray or pepper-and-salt color, in which gray becomes more dominant with depth. Under moisture saturation, the color is mottled gray and rust brown. The surface soil is slightly acid and the subsoil very slightly acid. This soil is developed on alluvial materials of granitic origin and occurs in association with glacial granitic soils. Although its total area is slightly smaller than that of Chamokane gravelly loam, its distribution is equally as wide. The proportion of gravel is less and the porous subsoil and substratum occur at greater depths than in the Chamokane soil.

The agricultural possibilities, crop adaptations, and yields of this soil are similar to those features of Chamokane gravelly loam. The two soils occupy a similar position in the subsistence farm unit in which they are included. Yields are more uniform on Narcisse loam, probably because of the small content of gravel in the surface soil. Owing to the greater organic-matter content and thicker surface soil, fertility is not depleted so readily as in the Chamokane soil.

Cocolalla silty clay loam.—Cocolalla silty clay loam is the most extensive and widely distributed soil in this group. In areas of typical development the surface soil consists of a 10- to 16-inch layer of very dark grayish-brown or almost black highly organic silty clay loam which is very granular and friable. The transition is abrupt to an upper subsoil layer of contrastingly yellowish-white or very light yellowish-gray slightly plastic silt loam or very fine sand. When dry this material is of exceptionally light weight and of smooth but sharp powdery feel. This continues to an average depth of about 3 feet, but is much deeper in places. The lower subsoil layer is of very fine sand or sand texture and is slightly more gray than the upper subsoil layer. Red iron stains are pronounced. The gray color increases with depth, and in some places the material is of grayish gleilike character but rather porous. The deep substratum is gravelly in most areas, but it is composed of stratified clays in some. The reaction of the surface soil is slightly acid; that of the subsoil is alkaline.

Artificial drainage must be established before the full agricultural value of this soil is utilized. In many places, intercepting drains, as well as central drains, are necessary for adequate drainage.

This is an important soil for the production of native hay and pasture. Other hay and pasture crops have been introduced and do well. Timothy has been produced extensively on this soil, but apparently it has caused some depletion of the fertility. Red and alsike clovers are grown in combination with timothy, and red clover is grown alone also. This is one of the best soils for the production of oats (pl. 2, *C*), and good yields of root crops, vegetables, and other crops are obtained. Because of its low-lying position, much of the land is frosty and generally is slow to drain and warm in spring. Frost is not so great a hazard in the many areas near the lakes.

Much of this soil is developed in old glacial lake or other basins throughout the upland areas occupied by both the gravelly soils and those with clay subsoils. Other areas are in the wider stream bottoms of retarded or sluggish drainage. In general, the soil lies in a position where floodwaters are high in spring and subside in late summer, causing a downward percolation of water as the water table is lowered. The surface soil is highly organic, in many places somewhat peaty. The subsoil is leached and of a very light gray color, almost white when dry. In areas where the surface soil is shallow, plowing brings the white subsoil to the surface in places.

Cocolalla silty clay loam, deep phase.—In the deep phase of Cocolalla silty clay loam, the surface soil extends to a depth ranging from 2 to 3 feet. It is dark colored, highly organic, and in places almost mucky. The subsoil is similar to that of the typical soil. The value and fertility of the land increases according to the thickness of the surface soil, but the drainage problem is intensified in many places, necessitating the use of methods similar to those used on peat. Less than one-half square mile is mapped, mainly in an area north of Big Creek, a tributary of Priest River.

Cocolalla silty clay loam, light-colored phase.—The light-colored phase of Cocolalla silty clay loam consists of areas in which the surface soil is light gray or gray, similar in texture to the subsoil, and very thin. The light color is especially pronounced in cultivated fields. The fertility is proportionally decreased with the decrease in the thickness of the surface soil.

Peat.—Peat is widely distributed in rather small bodies. It is closely associated with the Cocolalla soils and generally occupies the lower areas. In places the Cocolalla soils and peat grade into each other almost imperceptibly.

In most places, the 14-inch surface layer of peat is dark reddish-brown well-decomposed peat. Below this, the material is less decomposed, has the appearance of matted compressed flattened sedge fibers, and is lighter reddish brown. Flattened straw-colored to almost black sedge fibers are prominent. This material continues to an undetermined depth. In most places the reaction is slightly or medium acid throughout.

The greater part of this soil consists of sedge peat developed in old lake basins, but there is considerable woody peat in small seeped areas having a heavy growth of cedar, hemlock, and alder. No differentiation is made on the basis of origin.

This soil responds well to applications of phosphate and potash, which are essential in a continued cropping system. Timothy and other grasses are grown for hay; and oats (pl. 2, *C*) and peas, for grain. Very high yields of oats and peas are obtained where adequate drainage is provided. A better quality of hay is obtained from the introduced hay crops which are more commonly grown, but native hay is still cut from some areas.

The installation of a proper drainage system and control of the water table are essential for the successful production of crops. This requires both intercepting and central, or main, drains in places.

St. Joe loam.—St. Joe loam is not so extensive or so widely distributed as Cocolalla silty clay loam, but it is equally productive and is suited to a wider range of crops, especially in the better drained areas. Most of this soil lies in the upper part of Pack River Valley, along Sandpoint Creek, and near Blanchard. It is developed on recent alluvial materials of granitic origin and is highly micaceous throughout.

As typically developed, the 10-inch surface soil is medium dark-brown or dark grayish-brown very granular and friable heavy loam. When wet it becomes much darker. It is highly micaceous. The upper subsoil layer is much lighter colored than the surface soil. It consists of light yellowish-gray or light-gray slightly compact stratified loam and very fine sandy loam, stained or mottled with dark-colored organic matter and rusty-brown iron compounds. This layer is about 20 inches thick. The lower subsoil layer is light-gray loose porous stratified fine sand. In the lower part of the subsoil, darker coloration generally appears. In most places, the entire soil is very slightly acid.

Lying mainly in the immediate flood plains of active streams, which carry considerable sediment during the spring flood period, the surface soil is frequently disturbed and therefore the texture is variable. In places it is light loam, and in other places it is fine sandy loam. Owing to its position, protection from flood and artificial drainage are essential. In most of the areas, especially in the lower part of Pack River Valley and in Pend Oreille River Valley, these are impossible, owing to the yearly inundation by Pend Oreille Lake. Adequate drainage and protection from overflow are provided at Blanchard, and water for irrigation also is available.

This soil is not so dark and highly organic as is Cocolalla silty clay loam, but it is higher in mineral plant nutrients than that soil. St. Joe loam also has greater friability throughout, drains more readily, warms earlier in the spring, and has a somewhat longer growing season than does the Cocolalla soil. The friable and light-textured surface soil allows for a wide selection of crops, but the principal crops grown are hay and oats. Yields of most crops are about the same as for the Cocolalla soil. Red clover is better adapted to the St. Joe soil, and yields are higher. This soil generally is too wet for alfalfa. Oats and peas yield more on most of the Cocolalla soils.

St. Joe silty clay loam.—St. Joe silty clay loam differs from St. Joe loam in that it is definitely heavier in the surface soil and the subsoil. The lower part of the substratum contains considerable iron-stained material, owing to poor drainage. This soil is as productive as Cocolalla silty clay loam, in places where it is protected from flooding and is successfully drained. Much of this soil, however, lies in small depressions throughout the lower part of Pack River Valley, in which water stands until late in the season. Therefore, they are used principally for the production of native hay. Several areas are southwest of the town of Clark Fork. The total area is small.

MISCELLANEOUS LAND TYPES

The miscellaneous land types include coastal beach, riverwash, rough mountainous land, rough stony land, and steep broken land. They comprise 56.8 percent of the land surveyed.

Dense growths of conifers and other valuable trees are produced on rough mountainous land. Some areas provide summer range for cattle and sheep.

Rough stony land is less rugged but more stony than rough mountainous land and is about as variable in its soil characteristics. It is nonagricultural for cultivated crops but is fairly well suited for forestry and grazing.

Five types of steep broken land are separated on the basis of parent material. All consist of steep short slopes where accelerated erosion has been and is still very active. The best practice on this land is to maintain a close cover of grass and to regulate grazing in order that extensive areas of thin or barren land may not be exposed, especially at the beginning of the rainy season.

Coastal beach.—A few small areas of shifting sand and gravel, bordering the shore of Pend Oreille Lake, are classified as coastal beach. They are nearly barren and have no agricultural value.

Riverwash.—Riverwash consists of the sandy, gravelly, and stony materials occurring in stream channels that are subject to frequent overflow. It occurs principally along Lightning Creek north of the town of Clark Fork. It is not used for crops.

Rough mountainous land (Loon soil material).—Areas of rough mountainous land (Loon soil material) include a large part of the Selkirk Mountains in the western part of the county and comprise 44 percent of the land covered by this soil survey. The soil mantle, which is largely of glacial origin, varies greatly in texture, depth, and consistence. The color ranges from light yellowish brown to dark grayish brown or nearly black along narrow mountain streams, and in places the Loon soil material grades into and merges with the Kootenai soils, as along the southern boundary of the county.

The loessial soil mantle covering the lower lying Loon soils also is spread over these rugged areas, but its thickness varies considerably. The presence of this mantle, however, tends to make the soil characteristics more uniform than they would be if it were absent. Most of the soil is very gritty with angular granitic fragments, and it is more or less gravelly and stony. Boulders are scattered throughout the surface soil and subsoil.

The precipitation, much of which comes as snow, is sufficient for the demands of the more valuable varieties of trees that thrive throughout this general region. Much of this land, however, is cut over or burned over and produces inferior trees in places. There is drastic need for systematic reforestation and careful planning of cutting to maintain the profitable production of timber.

Rough mountainous land (Waits soil material).—Areas of rough mountainous land (Waits soil material) occur in the Cabinet and Coeur d'Alene Mountains. Their total area is much less than that of rough mountainous land (Loon soil material) although it represents over 10 percent of the area surveyed. Bare rock outcrops in many places. The soil material varies in color, texture, and thickness, and it is derived from different parent rocks. These rocks consist of shale, sandstone, and metamorphosed equivalents—argillites and quartzites. In general the texture is less gritty than in areas of rough mountainous land (Loon soil material).

Rough mountainous land (Moscow soil material).—Areas of rough mountainous land (Moscow soil material) occur principally along the boundaries of Kootenai and Spokane Counties. The soil material is light colored and is developed from gneiss and mica schists. Heavy forest covers the land.

Rough stony land (Loon soil material).—Rough stony land (Loon soil material) is derived from rocks, dominantly granodiorites, and gneiss or mica schist. Intrusive masses of more basic rock also occur in places.

Rough stony land (Waits soil material).—Rough stony land (Waits soil material) is formed from sedimentary rocks. Otherwise, it does not differ essentially from rough stony land (Loon soil material).

Steep broken land (Bonner soil material).—Areas of steep broken land (Bonner soil material) consist of escarpments along stream courses and between terrace levels within areas of Bonner soils. These areas have the gravelly substratum characteristic of the Bonner soils. The surface soil is gravelly, loose, and porous. This unfavorable physical characteristic, combined with the steep relief, limits the value of the land, even for grazing. Such areas in a farm unit are very objectionable as most of them cannot be crossed with farm machinery and therefore many fields are divided into small tracts.

Steep broken land (Springdale soil material).—Areas of steep broken land (Springdale soil material) bear the same relation to the Springdale soils that steep broken land (Bonner soil material) does to the Bonner soils. This land is used only for pasture, and it has a low carrying capacity. It forms only a small proportion of the area surveyed.

Steep broken land (Elmira soil material).—Steep broken land (Elmira soil material) consists of steep droughty brush-covered narrow areas on the edge of bodies of Elmira fine sand. This land is much less valuable than Elmira fine sand. Only one-half square mile is mapped.

Steep broken land (Selle soil material).—Steep broken areas and escarpments within areas of Selle fine sandy loam are differentiated as steep broken land (Selle soil material). This land has very little agricultural value. The surface soil and, in most places, the subsoil are lacking, thereby exposing the plastic clay substratum. The unfavorable relief and poor physical characteristics reduce the value of this soil to almost nothing. Most of the small area mapped is along Priest River.

Steep broken land (Mission soil material).—Steep broken land (Mission soil material) comprises areas associated with Mission silt loam which have the characteristic stratified lake-laid clay subsoil and substratum but are so steep and broken that the surface soil has been removed and the land can be used only for grazing and forestry. This land occurs along streams and between terrace levels.

It lowers the value of the adjoining areas, as farm management is more difficult with this land type within the farm unit.

LAND USES AND AGRICULTURAL METHODS[6]

Most of the successful farm operations in this county which includes extensive areas of cut-over lands involve the use of a legume in the crop rotation. The light-colored soils especially are deficient in nitrogen and organic matter, and the most economical and efficient way to furnish and maintain these materials is by growing legumes. Alfalfa is well adapted to the light-colored soils, yields most dependably, and furnishes a high quality of hay. The following are comparative acre yields of legumes on Mission silt loam at the Sandpoint substation for an average of 7 years, 1923–29: White-blossom sweetclover 3.15 tons, yellow-blossom sweetclover 2.49 tons, Grimm alfalfa 3.22 tons, Common alfalfa 3.25 tons, medium red clover 2.35 tons, mammoth red clover 2.78 tons, and alsike clover 2.01 tons.

The Grimm variety of alfalfa is grown because of its hardiness in winter. On checking variety stands at the experiment farm, after 4 years of growth, it was found that 80 percent of the Grimm alfalfa survived and only 48 percent of the Common variety.

White sweetclover also gives high yields and is an excellent crop for the building up of nitrogen and organic matter, but is not in general favor as a hay crop. It is used for pasture and has a carrying capacity several times that of grasses. It should be suitable in this respect for the droughty, gravelly light-colored soils.

Red clover and alsike clover are excellent legume crops in the rotation on the wet dark-colored soils on which alfalfa cannot be grown.

Gypsum is used extensively for obtaining maximum yields of legumes. This is applied in order to supply sulphur which is found to be deficient for maximum growth of legumes (*7*). The best response to gypsum is made by alfalfa. During a 5-year period at the experiment farm, a treated plot yielded 3.07 tons an acre and an untreated plot, 1.45 tons. Sulphur gives about the same results as gypsum. Gypsum is applied at the rate of about 200 pounds an acre every third year. To new seedings it is applied at the time of seeding or the succeeding fall. Application of lime has not proved sufficiently beneficial to be justified.

Table 6 shows the effect of one initial application of various fertilizers on hay crops on Mission silt loam at the Sandpoint substation, for the 5-year period 1922–26 (*7*).

TABLE 6.—*Average acre yields of hay in response to one initial application of several fertilizers on Mission silt loam at the Sandpoint substation, 1922–26*

Crop	Untreated	Phosphate	Gypsum	Lime	Crop	Untreated	Phosphate	Gypsum	Lime
	Pounds	*Pounds*	*Pounds*	*Pounds*		*Pounds*	*Pounds*	*Pounds*	*Pounds*
Alfalfa	2,898	3,515	6,159	3,716	Grass mixture	2,593	2,588	3,895	2,700
Sweetclover	1,777	2,223	3,543	2,570	Peas	1,433	1,480	1,778	1,807
Red clover	2,255	2,400	3,300	3,120	Vetch	2,110	1,885	2,095	2,770
Alsike clover	1,860	2,017	2,767	2,416					

[6] For more complete detailed discussion see Idaho Experiment Station Bulletins 136, 158 (*2*), 169, and 178.

Amendments other than the growing of legumes and the applying of gypsum, to remedy deficiencies of nitrogen and sulphur, are seldom used on the light-colored soils.

The dark-colored soils of the bottom lands also need fertilization with gypsum for maximum yields of the clovers. It is also essential to apply potash and phosphate to soils very high in organic matter, such as peat, for satisfactory yields of most crops. A mixture of these fertilizers generally is applied at the rate of 150 pounds an acre. After continued cropping it probably will be necessary to add at least phosphate to the more highly organic dark-colored soils. Most soils of the bottom lands are very slightly acid in the surface soils and subsoils; a few are alkaline in the subsoils. The soils exceedingly high in organic matter are the most acid throughout the whole soil.

The grain crops are the most important crops grown in rotation with legumes in this area. They are essential in the supply of feeds to supplement hay in feeding livestock. Thus, they are marketed as animal products, which supply the largest part of the farm income. They are excellent crops for the elimination and control of undesirable grasses and weeds that appear in stands of legumes. Probably about one-third of the cleared acreage of the farms is in these crops.

Wheat is the most important cereal crop grown on the light-colored soils. Winter wheat outyields spring wheat by about 30 percent. Winter wheat is adapted to the better drained soils, and spring wheat is used on the wetter soils, where fall seeding is not feasible. Winter wheat does best when seeded in August. The grain is ready for harvest in July. The variety of winter wheat best adapted and yielding the highest is Mosida, and this is probably used on 80 percent of the farms. Other high-yielding varieties are Jones Winter Fife, Hybrid 128, and Triplet.

Spring wheat is seeded in April and harvested in August. Pacific Bluestem, Jenkin, and Defiance are the highest yielding varieties. Pacific Bluestem and Jenkin are best suited to the areas where the growing season is longer. Marquis, Supreme, and Red Bobs should be chosen for low-lying land where the growing season is shorter.

Barley, as a substitute for corn in this section in supplying a concentrated feed for livestock, is of importance but as yet has not been very generally grown. In general, it is not well adapted to conditions in this county, and yields are low in many places, but it is satisfactorily grown on the heavier textured and more fertile soils. It is sown and harvested about the same time as is spring wheat. The best yielding varieties are Trebi, Hannchen, and Charlottetown 80.

Oats are not so productive on the light-colored soils as on the dark-colored soils. Seeding and harvesting take place about the same time as for wheat and barley. Idamine, Markton, and Victory are the most popular varieties.

Peas are well adapted to this section. White Canada and Kaiser are the best adapted and highest yielding varieties grown.

Potatoes are well adapted to the soils that are not subject to frost in late spring or early fall. Idaho Rural is the best variety for the upland soils. In places where moisture is available late in the season, the Netted Gem variety does well.

The raising of livestock is the essential source of cash income in the subsistence type of diversified agriculture that is practiced here. The large areas of natural pasture available in the stump land and native-grass meadows, combined with favorable climatic and soil environment, tend to make this pursuit profitable.

Dairying is the principal form and the most promising livestock enterprise. With the introduction of pasture crops, such as sweetclover and tame grasses, the carrying capacity of the land is increased and the size of the herds can be expanded more readily. Likewise, the problem of hay for winter feeding is being solved by the general production of alfalfa. With the increased acreage devoted to grain crops, these supplementary feeds will aid dairying, as well as other livestock enterprises. The dairy products are consumed in part locally, in the towns and logging camps, and the rest is shipped to nearby cities and mining towns.

Active interest is taken in improving the dairy herds through the use of better sires and the elimination of low-producing cows. Most of the herds are well-bred, and a few are purebred. The principal breeds are Holstein-Friesian and Guernsey, with a few Brown Swiss.

The raising of beef cattle is less commonly a major livestock enterprise on the smaller farms, as this is confined principally to the larger ranches where there is an abundance of native hay and pasture. There is much range pasture available in the national forests and privately owned land in the rugged mountainous sections where dairying is impractical. With increased production of both hay and feeds for winter feeding, cattle raising has a promising future. Most of the beef cattle are marketed locally; Pacific coast and midwest markets are available for any surplus.

Most of the beef cattle are well-bred, and purebred bulls are kept in most of the larger herds. The popular breeds are Shorthorn and Aberdeen Angus.

Sheep are important as a source of cash income on many farms. The large amount of available pasture suitable for the grazing of sheep makes this a remunerative enterprise. Transient bands of sheep are brought in to graze on the national forests and on private lands. Most of the flocks on the farms are of the Hampshire and Shropshire breeds.

Hogs are kept on a number of farms, mainly for consumption in the home. Because of the limited amount of feed grains grown, this enterprise is not very extensive. Duroc-Jersey and Poland China are the preferred breeds.

Chickens and other poultry are raised on most farms, and some of the poultry farms have expanded to commercial proportions. White Leghorn and Rhode Island Red are the principal breeds. Poultry raising fits in well with dairying, and the products are marketed in a similar manner.

PRODUCTIVITY RATINGS

The soils of Bonner County are rated in table 7 according to their productivity for the more important crops. The soil types and phases are listed in the order of their general productivity under improved farming practices, the most productive soils being at the head of the table.

TABLE 7.—*Productivity rating of soils in Bonner County, Idaho*

Soil [1]	Crop-productivity index [2] for—										General productivity grade [5]	Land classification [6]
	Wheat	Oats	Barley	Mixed timothy and alsike	Red clover	Alfalfa	Potatoes	Vegetables [3]	Native hay	Permanent pasture [4]		
St Joe loam, drained	50(75)	100(125)	35(50)	50(90)	75(125)	--------	25(30)	80(100)	80 --	80 --		
Cocolalla silty clay loam, deep phase, drained	--------	125(150)	--------	60(100)	60(110)	--------	--------	70(90)	100 --	100 --	1	Excellent cropland
Cocolalla silty clay loam, drained	--------	120(150)	--------	60(100)	60(100)	--------	--------	70(90)	100 --	100 --		
Mission silt loam	70(120)	60(100)	35(60)	50(80)	60(100)	45(80)	25(40)	40(70)	--------	50(80)		
Mission loam	70(120)	60(100)	35(60)	40(70)	50(85)	55(90)	30(50)	50(80)	--------	40(70)	2	
Mission silt loam, friable-subsoil phase [7]	60(100)	60(100)	35(50)	40(70)	50(85)	55(90)	30(50)	50(80)	--------	40(70)		
Mission silt loam, imperfectly drained phase [7]	60(100)	60(100)	35(60)	50(80)	60(100)	30(55)	25(50)	30(60)	--------	50(80)		
Mission fine sandy loam [7]	50(85)	45(90)	25(50)	30(60)	50(85)	55(90)	30(80)	50(80)	--------	40(60)		
Narcisse loam, drained	--------	100(125)	--------	50(90)	60(110)	--------	--------	80(100)	80 --	80 --		
Chamokane gravelly loam, drained	--------	100(125)	--------	50(90)	60(110)	--------	--------	80(100)	80 --	80 --		
St Joe silty clay loam, drained	--------	90(120)	--------	50(90)	60(100)	--------	--------	50(70)	90 --	90 --		Good cropland
Colville silty clay loam, drained	--------	90(120)	--------	50(100)	50(85)	--------	--------	40(60)	80 --	80 --	3	
Clayton silt loam [7]	60(100)	45(90)	25(50)	40(70)	50(85)	40(60)	25(40)	40(70)	--------	40(70)		
Cabinet silt loam	60(90)	60(90)	30(50)	50(80)	60(100)	30(55)	25(50)	40(70)	--------	50(80)		
Peone loam, drained	50(85)	75(120)	25(50)	40(70)	50(85)	30(55)	25(40)	40(70)	--------	50(70)		
Peone silty clay loam, drained	50(85)	75(120)	25(50)	40(70)	50(70)	30(45)	25(50)	40(60)	--------	50(70)		
Bonner fine sandy loam, imperfectly drained phase.[7]	50(85)	45(90)	25(50)	40(70)	50(85)	30(60)	25(50)	30(60)	--------	40(70)		
Mission silt loam, rolling phase [7]	50(85)	30(75)	20(45)	30(60)	50(85)	30(60)	25(50)	30(60)	--------	35(60)		
Cocolalla silty clay loam, light-colored phase [7]	--------	45(90)	--------	40(70)	35(50)	--------	--------	40(70)	70 --	60 --		
Peat, drained	--------	45(125)	--------	--------	--------	--------	--------	20(80)	80 --	70 --	4	
Selle fine sandy loam [7]	50(85)	45(90)	25(50)	20(50)	35(70)	40(60)	25(50)	35(60)	--------	20(50)		
Peone fine sandy loam drained	50(70)	60(75)	25(45)	30(60)	50(85)	30(60)	25(40)	40(70)	--------	40(60)		
Clayton silt loam, flat phase [7]	35(70)	30(75)	20(45)	20(50)	35(80)	40(60)	25(50)	30(60)	--------	20(50)		
Mission silt loam, sandy-substratum phase	35(70)	30(75)	20(45)	20(50)	35(70)	30(60)	25(50)	30(60)	--------	20(50)		Fair cropland
Colburn very fine sandy loam [7]	35(70)	30(60)	20(45)	20(50)	35(70)	30(60)	15(30)	20(50)	--------	20(50)		
Pend Oreille silt loam	35(75)	30(60)	20(45)	20(50)	35(70)	30(55)	15(30)	20(50)	--------	20(50)		
Pend Oreille loam	35(75)	30(60)	20(45)	20(50)	35(70)	30(55)	15(30)	20(50)	--------	20(50)	5	
Loon loam	35(75)	30(60)	20(45)	20(50)	35(70)	30(55)	15(30)	20(50)	--------	20(50)		
Waits silt loam	35(75)	30(60)	20(45)	20(50)	35(70)	30(55)	15(30)	20(50)	--------	20(50)		
Bonner silt loam, sandy-substratum phase	35(75)	30(60)	20(45)	20(50)	35(70)	30(55)	15(30)	20(50)	--------	20(50)		

Cocolalla silty clay loam, undrained		60 --		40 --	25 --				50 --	80 --	6	Poor cropland; native hay, pasture, and forest land.
St. Joe loam, undrained		60 --		40 --	35 --				40 --	60 --		
Cocolalla silty clay loam, deep phase, undrained		45 --		30 --	25 --				50 --	80 --		
Narcisse loam, undrained		60 --		30 --	25 --				40 --	60 --		
Chamokane gravelly loam, undrained		60 --		30 --	25 --				40 --	60 --		
Bonner silt loam	35(60)	30(60)	20(45)	20(45)	35(70)	30(55)	15(25)	20(40)		20(40)		
Bonner loam	35(60)	30(60)	20(45)	20(45)	35(70)	30(55)	15(25)	20(40)		20(40)		
Bonner fine sandy loam, sandy-substratum phase.	25(60)	30(60)	20(46)	20(45)	35(70)	30(55)	15(25)	20(40)		20(40)		
Garrison gravelly loam	35(60)	30(60)	20(45)	20(45)	25(60)	15(45)	15(25)	20(40)		20(40)		
Bonner gravelly loam	25(60)	30(45)	20(25)	20(45)	25(60)	15(45)	15(20)	20(30)		20(40)		
Bonner fine sandy loam	25(50)	30(45)	20(25)	20(45)	25(60)	15(45)	15(20)	20(30)		20(40)		
Bonner loam, rolling phase	25(50)	30(45)	20(25)	20(45)	25(60)	15(45)	15(20)	20(30)		20(40)		
Kootenai gravelly silt loam	25(50)	30(45)	20(25)	20(45)	25(60)	15(45)	15(20)	20(30)		20(40)		
Springdale gravelly silt loam	25(50)	30(45)	20(25)	20(45)	25(60)	15(45)	15(20)	20(30)		20(40)		
Springdale gravelly loam	25(50)	30(45)	20(25)	20(45)	25(60)	15(45)	15(20)	20(30)		20(40)		
Elmira fine sandy loam	20(50)	30(45)	20(25)	20(45)	25(60)	15(45)	15(20)	20(30)		20(40)		
Colville silty clay loam, undrained		45 --		20 --	25 --				40 --	60 --	7	
St Joe silty clay loam, undrained		30 --		20 --	25 --				30 --	70 --		
Selle fine sandy loam, flat phase	20(50)	30(45)	20(25)	20(30)	25(50)	15(40)	15(20)	20(30)		20(30)		
Bonner sandy loam, sandy-substratum phase	20(50)	15(30)	10(20)	20(30)	25(50)	15(40)	10(20)	10(20)		20(30)		
Bonner gravelly fine sandy loam	20(50)	15(30)	10(20)	20(30)	25(50)	15(40)	10(15)	10(20)		20(30)		
Pend Oreille fine sandy loam	20(50)	15(30)	10(20)	20(30)	25(50)	15(40)	10(15)	10(20)		20(30)		
Springdale gravelly fine sandy loam, deep phase	20(50)	15(30)	10(20)	20(30)	25(50)	15(40)	10(15)	10(20)		20(30)		
Springdale gravelly fine sandy loam	20(50)	15(30)	10(20)	20(30)	25(50)	15(40)	10(15)	10(20)		20(30)		
Springdale gravelly fine sandy loam, rolling phase	20(50)	15(30)	10(20)	20(30)	25(50)	15(40)	10(15)	10(20)		20(30)		
Peone loam undrained	25 --	45 --		20 --	25 --					40 --	8	
Peone silty clay loam, undrained	25 --	45 --		20 --	25 --					40 --		
Peone fine sandy loam, undrained	25 --	30 --	20 --	20 --	25 --					30 --		
Cocolalla silty clay loam, light-colored phase, undrained		15 --		20 --	15 --				30 --	50 --		
Mission silty clay loam [7]		20 --		20 --					30 --	40 --		
Peat, undrained									40 --	50 --		
Bonner coarse sandy loam	15(25)	15(30)	10(20)	10(20)	15(25)	10(15)	10(20)	10(20)		10(20)		
Kootenai gravelly silt loam, rolling phase [7]	15(25)	15(30)	10(20)	10(20)	15(25)	10(15)	10(20)	10(20)		10(20)		
Elmira fine sand	15(25)	15(30)	10(20)	10(20)	15(25)	10(15)	10(20)	10(20)		10(20)		
Springdale coarse sandy loam	15(25)	15(30)	10(20)	10(20)	15(25)	10(15)	10(20)	10(20)		10(20)		
Peone silty clay, undrained [7]										70 --	9	
Cabinet silt loam, hilly phase										40 --	01	Dominantly best suited to forestry.
Steep broken land (Mission soil material)										40 --		
Clayton silt loam, hilly phase										30 --		
Waits silt loam, hilly phase										15 --		
Pend Oreille loam, hilly phase										15 --		
Steep broken land (Bonner soil material)										15 --		
Steep broken land (Selle soil material)										15 --		

Footnotes at end of table.

TABLE 7.—*Productivity rating of soils in Bonner County, Idaho*—Continued

Soil	Crop-productivity index for—										General productivity grade	Land classification
	Wheat	Oats	Barley	Mixed timothy and alsike	Red clover	Alfalfa	Potatoes	Vegetables	Native hay	Permanent pasture		
Peone silty clay, low-bottom phase										10	10	Dominantly best suited to forestry.
Steep broken land (Springdale soil material)										10		
Pend Oreille loam, stony phase										10		
Bonner silt loam, stony phase										10		
Bonner fine sandy loam, stony phase										10		
Springdale gravelly silt loam, stony phase										10		
Rough mountainous land (Loon soil material)										10		
Rough mountainous land (Waits soil material)										10		
Kootenai gravelly silt loam, steep phase										5		
Steep broken land (Elmira soil material)										5		
Rough mountainous land (Moscow soil material).										5		
Rough stony land (Loon soil material)										5		
Rough stony land (Waits soil material)												
Riverwash												
Coastal beach												

[1] The soils are listed in the approximate order of their general productivity under current improved practices, the most productive first.

[2] The productivity of each of the various soil types for each specific crop is compared to a standard—100—which stands for the inherent productivity of the most productive soil (or soils) of significant acreage in the United States for that crop. Indexes without parentheses indicate the productivity of the soils for the specified crops without the use of soil amendments or legumes, whereas indexes in parentheses indicate the productivity under the current improved practices in Bonner County. These include the use of gypsum and the growing of legumes in rotation. The practices are based on recommendations of the agricultural experiment substation at Sandpoint. It should be realized that the ratings for Bonner County are largely inductive. Yield data by soil types are yet too fragmental to be entirely adequate.

[3] The indexes are used only for local comparison of soil types and are not based on standards of reference for any particular kind of vegetable.

[4] These indexes for pasture land are largely comparative for the soil types of this county. Although not based on quantitative yield data or used strictly in reference to the standard, it is believed they are fairly comparable.

[5] The grade numbers indicate the comparative general productivity of the soils under the prevailing improved farming practices. Refer to the text for further explanation.

[6] This characterization or classification of soils is a preliminary step to the delineation of areas of land classes in any given county. The pattern of distribution of soil types is an influential factor in the delineation of areas.

[7] These indexes refer to the better areas of this soil type. In the several soils to which this footnote applies, variations of productivity exist because of certain variable characteristics that were necessarily included. Some of the soils are characterized by a range in depth to the clay subsoil, others by variable topography, and others by a range of drainage conditions. Reference to the text brings out the particular characteristic that is most likely to effect a change in productivity.

NOTE.—Leaders, according to position, indicate either that the crop is not commonly grown because of poor adaptation, or that amendments are not commonly used.

The rating compares the productivity of each of the soils for each crop to a standard—100. This standard index represents the inherent productivity of the most productive soil (or soils) of significant extent in the United States for that crop. An index of 50 indicates that the soil is about one-half as productive for the specified crop as is the soil with the standard index. Soils given amendments, such as lime, commercial fertilizers, and irrigation, or unusually productive soils of small extent, have productivity indexes of more than 100 for some crops. The following tabulation sets forth some of the acre yields that have been set up as standards of 100. They represent long-time average yields of crops of satisfactory quality on the better soils without the use of amendments.

Crop:	
	Bushels
Wheat	25
Oats	50
Barley	40
Potatoes	200
	Tons
Timothy and alsike	2
Red clover	2
Alfalfa	4
Native hay	1
	Cow-acre-days [1]
Pasture	100

[1] Cow-acre-days is a term used to express the carrying capacity of pasture land. As used here it is the product of the number of animal units carried per acre multiplied by the number of days the animals are grazed without injury to the pasture For example, the soil type able to support 1 animal unit per acre for 360 days of the year rates 360, whereas another soil able to support 1 animal unit per 2 acres for 180 days of the year rates 90. Again, if 4 acres of pasture support 1 animal unit for 100 days the rating is 25. The animal unit is a means of measuring the feed requirements of livestock It is the equivalent of a mature horse, cow, or steer, 5 hogs; 7 sheep or goats; or 100 poultry. For very young animals double the equivalent of an animal unit for mature stock of the same kind is allowed. On semiarid grazing land the ratio is more properly 3 to 5 mature sheep to each cow.

The crop indexes without parentheses in table 7 refer to the estimated productivity of the soils without the use of amendments, whereas the indexes in parentheses refer to yields under the prevailing better farming practices. These practices include principally the use of gypsum or sulphur and manure, and the growing of legumes in rotation on the light-colored soils. These indexes may differ from county to county inasmuch as practices of management and certain characteristics of soil types may vary from county to county. Lacking specific yield data, all the indexes are to be accepted only as the best approximation available at present.

In the instance of the dark-colored soils that have poor natural drainage and are subject to floods, ratings have been given for both the drained and protected and the undrained and unprotected conditions. In this way the potential productivity of poorly drained and overflow land is expressed. The cost or difficulty of providing drainage plays no part in the productivity ratings of such land. Two soils having the same productivity when drained and protected are rated the same, although adequate artificial drainage or protection may cost ten times as much on one as on the other.

The natural factors influencing the productivity of land are mainly climate, soil, drainage, and relief, or lay of the land. In addition to these are the factors of management and the use of amendments. Crop yields over a long period of years furnish the best available summation of those factors contributing to productivity, and they are used whenever available as the basis for the determination of indexes in the productivity tables. A low index for a particular crop may be due to some local conditions of unfavorable relief, drainage, or climate, rather than to lack of fertility in the soil. The physical characteristics of the soils, especially in relation to moisture storage, are very important in this area. Erodibility is important, especially in that it involves depth of surface soil and content of stone and gravel. Although the factors mentioned are associated within rather definite limits in each of the soil types shown on the soil map, certain variations that produce a range in productivity are more characteristic of certain of the soil types. These have been indicated by a footnote in the table.

The soils are listed in the order of their general productivity under the current improved practices as determined by the weighted average of the crop indexes in parentheses. The weighted average has been based both on the areal extent of the individual crops in the area surveyed and the comparative total value. In this way differences of productivity among areas or counties are brought out by the productivity rating.

Because of the marked differences in the suitabilities and uses of the well-drained, artificially drained, and poorly drained soils for the common crops, no uniform set of weightings of crop indexes was established to determine the general productivity grades of all the soil types. Instead, separate weightings of crop indexes were set up for each of the three general conditions of drainage as shown in table 8.

TABLE 8.—*Crop-index weightings in soils having different degrees of drainage*

Crop	Well-drained soils	Artificially drained soils	Poorly drained soils	Crop	Well-drained soils	Artificially drained soils	Poorly drained soils
Wheat	7	2		Potatoes	10	3	
Oats	10	15	15	Vegetables	5	10	
Barley	3			Native hay	5	20	30
Timothy and alsike	25	20	20	Pasture	10	15	20
Red clover	10	15	15				
Alfalfa	15			Total	100	100	100

Since the importance and suitability of certain soils for particular crops in Bonner County cannot be shown altogether satisfactorily by the above scheme of weighting, certain modifications in the general ranking of the soils were made according to personal judgment.

In addition to listing the soils in the order of their general productivity according to improved farming practices, productivity grade numbers are assigned in the column, General productivity grade. These are based also on the weighted percentage average of the crop indexes for improved practices. If the weighted average falls between 90 and 100, the soil type is assigned a grade of 1; if the weighted average falls between 80 and 90, a grade of 2 is given, etc. It will be seen from the Land classification column that soils with general productivity grades of 2 and 3 are classified as good cropland.

Productivity tables do not present the relative roles which soil types, because of their extent and the pattern of their distribution, play in the agriculture of the county. The tables give a characterization to the productivity of individual soil types. They cannot picture the total quantitative production of crops by soil areas without the additional knowledge of the acreage of the individual soil types devoted to each of the specified crops. It must be stated clearly that these productivity ratings are not to be interpreted directly into specific land values. Table 7 is not based on enough of the factors which influence land values to warrant such an interpretation. The ratings are based on the essentially permanent factors of productivity of the soils and their responsiveness to management, and little attention has been given to selling values of land.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of the environment acting on the soil materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by: (1) The physical and mineralogical composition of the parent soil material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the relief, or lay of the land, which determines the local or internal climate of the soil, its drainage, moisture content, aeration, and susceptibility to erosion; (4) the biologic forces acting upon the soil material—the plants and animals living upon and in it; and (5) the length of time the climatic and biologic forces have acted on the soil material.

The soils of Bonner County are formed from a large number of different parent materials and under a fairly wide range of environmental conditions; as a result, the soils are varied.

The county lies in the forested foothills and mountains near the edge of the treeless Columbia Plateau. The mountains rise rapidly to the north and east toward the higher ranges of the Rocky Mountains, and the pronounced and varied relief has a marked influence on climate, vegetation, and soils. The climate is of a modified continental type, influenced by winds from the Pacific Ocean. The mean annual precipitation ranges from about 25 inches in the lower southern valleys to probably about 40 inches at the higher elevations to the north. The summers are dry. Most of the precipitation occurs between the first of November and the last of March, largely in the form of snow. The predominant native vegetation consists of a dense growth of conifers, although the southern drier section supports more open stands of trees, with underbrush and some grass, and the marshy flats are covered with sedges, reeds, and other water-loving vegetation.

In this environment comparatively light-colored podzolic soils have developed throughout the uplands, and dark-colored soils that may be considered intrazonal have developed on the lower lying, poorly drained flats. For convenience in discussion, the podzolic soils are considered as belonging to two groups, the lighter colored and the darker colored podzolic soils. The latter are not dark colored except in comparison with the predominant lighter colored soils. These lighter colored soils are similar in appearance to the Brown Podzolic soils of New England but they have not yet been investigated sufficiently to justify their classification as such. The darker colored podzolic soils appear to be transitional between the lighter colored soils and the dark-colored Prairie soils, such as the Palouse (*6*), which occur on the drier Columbia Plateau to the south and west. On the Columbia Plateau the rainfall diminishes to the southwest; the grass cover becomes thinner and is finally replaced by sagebrush. The soils range from Prairie soils through Chernozem, Chestnut, and Brown soils to Sierozem or Desert soils (*5*).

Apparently, the soil-forming forces have not modified the parent materials greatly, and the latter largely determine many of the outstanding characteristics of the soils. These parent materials differ considerably, but they consist largely of glacial deposits of various lithologic compositions, mantled in most places by a layer of fine floury wind-borne material called loess. The thickness of the loess mantle varies greatly. Under dense forest and on leeward slopes or land with little slope, the mantle attains a thickness of 2 feet or more, whereas on steeper slopes, especially those facing south and west, where wind and water erosion are most active, it may be entirely lacking. Most of the soils of this county are considerably influenced by loess and therefore have a more or less silty texture.

The underlying glacial materials laid down during two glacial periods, the Spokane and the Wisconsin, are composed of till and outwash ranging from gravel and stone to clay. The texture of this material and the manner in which it was laid down largely determine the physical characteristics of the soil—its porosity, permeability, drainage, and water-holding capacity. Glaciation largely determined the present minor features of the relief and the regional drainage, as it smoothed mountain ridges, gouged out valleys in places, and in others filled them with thick layers of till, damming streams to form lakes or diverting them into new courses. Glacial moraines gave a hilly or hummocky relief to some areas, and outwash materials formed gravelly fans, or terraces, or flats of lake-laid silts and clays.

Petrographically the glacial deposits consist mostly of three types of rock materials: (1) Granitic rocks, gneiss, and mica schist high in soda-lime feldspathic minerals; (2) shales, sandstones, argillites, and quartzites; and (3) mixed materials, including those of more basic character. The sedimentary rocks are for the most part dark, indicating predominance of ferromagnesian minerals. The Selkirk Mountain range is an area in which igneous granitic, and metamorphosed granitic rocks, gneiss, and mica schist are dominant sources of the parent soil materials. Isolated igneous intrusive masses also contribute to the soils. The greater mass of materials associated with the Belt series of sedimentary and metamorphosed sedimentary rocks lies in the eastern part of the county in or near the Cabinet and Coeur d'Alene Mountains. A small area lies west of Priest River Valley. These sedimentary rocks are of fine texture, giving rise to soil materials of similarly fine texture. Some of the Belt rocks are calcareous and have contributed calcareous materials to certain soils. Although the main effect is confined to the deeper substratum, lime occurs in a few places in the subsoils of soils developed on the materials laid down during the late stage of the receding glaciers or subsequent erosional deposits.

It is apparent from examination of the profiles of the more extensive and typically developed soils of the uplands that the podzolic process has not been sufficiently strong or has not worked for a sufficiently long time to modify the parent materials greatly. These soils, developed under coniferous trees, are low in organic matter and light in color. The layer of forest litter is comparatively low in content of bases, decomposes slowly, and mixes but little with the soil. The layer of decomposed or humified organic matter is very thin. Although organic acids doubtless form, their function in leaching and soil development is limited because of the dry summers and the long winter periods during which the ground is frozen. It may be, too, that the acidity of the organic matter is neutralized by oxidation during the dry summers. An incipient podzolization is indicated by the presence in places of a light-gray ashy leached layer, less than 1 inch thick, immediately below the dark organic surface layer. Below this ashy layer the soil is typically light-brown fluffy material composed apparently of loess which has been altered but little by leaching or concentration of organic matter, sesquioxides, or other colloidal materials. It does contain some dark-brown or rusty-brown iron pellets which may be considered as an incipient concentration and which, in the true Podzols, develops into the orterde or ortstein. The deposition of this loess layer is geologically recent, if, indeed, it is not taking place at the present time. The upper part of the underlying glacial materials, where these are of coarse sandy or gravelly texture, apparently has been modified by an infiltration of silt, clay, and colloids from the fine-textured loessial material above. At any rate, the content of clay and colloids decreases and the material becomes more porous with depth, although some other explanation of this fact may exist besides the one advanced.

LIGHTER COLORED PODZOLIC SOILS

The more mature of the lighter colored podzolic soils, developed from porous loess-mantled glacial materials under good drainage and on smooth relief, include the Bonner, Pend Oreille, Loon, and Waits soils. These soils apparently have received the full impress of the regional environmental forces throughout their period of development, but only a very youthful expression of the podzolic process is evident. The inherent character of the parent materials in the individual profiles dominates texturally, mineralogically, and chemically. The soils of the various series differ in the character of parent materials, which are readily recognized in the individual profiles, but do not differ essentially in morphological characteristics. The Bonner soils are developed on loessial material over mixed granitic and Belt rocks, including shales, sandstone, quartzite, and argillite, laid down as glacial terrace. The Pend Oreille soils have similar parent material but have a morainic relief. The Loon soils are developed over glacial till from granodiorite and gneiss. The Waits soils are developed over glacial till derived from rocks of the Belt series, including shales, sandstone, argillite, and quartzite.

The following description of Bonner loam is representative of these soils. The profile described occurs in Priest River Valley in the northern part of the area surveyed, on a glacial outwash terrace derived from mixed rocks, predominantly granitic. The cover is of mixed coniferous trees, with little or no undergrowth.

1. 0 to 1¾ inches, conifer needles and decomposing dark-brown organic matter or acid humus, with some mineral material. The ignition loss is 41.1 percent.
2. 1¾ to 2½ inches, bleached white ashy podzolized material that is very light in weight.
3. 2½ to 8 inches, light yellowish-brown or light-buff floury fluffy gritty loam. Roots and some rusty-iron mottling, or organic staining, are evident. There is ascattering of rusty-iron accretionary shotlike pellets.
4. 8 to 18 inches, light yellowish-brown lightweight floury fluffy gritty loam, which is lighter, yellower, and more uniformly colored than the material in the layer above.
5. 18 to 44 inches, yellowish-gray very compact or very softly cemented brittle gritty loam or sandy loam and fine gravel. Podzolized gray-lined channels and chambers and some rusty-iron staining are evident.
6. 44 inches +, stratified mixed gravel, with angular granitic loose incoherent sand. The color ranges from yellowish gray to brown, with darker colored gravel.

The Clayton and Cabinet soils are developed on loess-mantled clay till deposits. The Clayton soils have a morainic relief and, therefore, good surface drainage. The Cabinet soils have comparatively flat relief and are pitted with numerous kettle holes, or basins, containing ponded areas in which peat and dark soils have developed. The till is of dense reddish-brown clay, through which water moves slowly, therefore drainage is imperfect.

Following is a description of a profile of Clayton silt loam, as observed in the NE¼NW¼ sec. 19, T. 56 N., R. 4 W., under a cover of mixed conifers and scattered deciduous brush. Physical data are given in table 9.

1. 0 to 1 inch, conifer needles and decomposing humified layer.
2. 1 to 1½ inches, grayish-white podzolic layer of soft amorphous material.
3. 1½ to 18 inches, light yellowish-brown or light-buff floury fluffy light-textured silt loam containing much very fine sand.
4. 18 to 50 inches, light grayish-brown and yellowish-brown material—a mixture of boulder clay, grit, and gravel. The material is compact and vesicular, with podzolized coated channels and chambers. Powdered white streaks extend downward. Some channels have rusty-iron colloid coating. Splashes of gray and yellow and reddish-brown colloid appear in the structure particles. Breakage to cloddy masses with a tendency to prismatic form takes place. The color is more gray at the top of the layer than at the bottom.
5. 50 to 70 inches, darker yellowish to somewhat reddish and greenish-gray tough boulder clay containing gravel, grit, and stone. Reddish-brown and dark-brown iron stains are present. Podzolized chambers, channels, and other gray streaks diminish or disappear in this horizon.
6. 70 to 100 inches, massive clay and thinly laminated strata of clay and sand of greenish-gray or yellowish-gray color. Fractures between the laminae have dark-brown iron stains. The proportion of rock and gravel is less than in the overlying layer.

Cabinet silt loam has a unique morphology characterized by a gray siliceous layer developed in the clay till. Mixed conifers form the principal vegetation, and there is little or no underbrush. A description of a profile of Cabinet silt loam, situated in the SE¼NW¼ sec. 34, T. 55 N., R. 3 E., follows:

1. 0 to three-fourths inch, conifer needles with decomposing organic material and a thin adhering ash-gray layer.
2. Three-fourths to 14 inches, light yellowish-brown or light-buff heavy silt loam (silty clay loam toward the bottom). The material is rather floury and loose for so heavy a texture. Round reddish-brown pellets are more numerous and larger than in any other soils of the area. The pellets show concentric rings, and some have black nuclei. Some have a gray podzolized appearance.
3. 14 to 20 inches, a light-gray or grayish-white degraded layer of silty clay loam which is rather compact and brittle when dry but crumbles to a powdery mass resembling very fine sand or silt. A cubical structure is evident in places. Iron-stained channels and root holes filled with decomposing organic matter are in evidence. The larger chambers are lined with gray.
4. 20 to 24 inches, a prismatic horizon showing strong podzolization. The tops of the prisms are grayish white, and this color carries into structure masses and down cleavage planes. The reddish-brown color of the parent material persists in the centers of the prisms, but white penetrates in streaks, channels, and chambers, some of which show reddish-brown iron stains. The texture is silty clay loam or loam.
5. 24 to 40 inches, light grayish-brown or pinkish-brown dense clay, with a 4-inch prismatic fracture. The fracture planes are lined with grayish-red colloidal material, and flattened root masses invade along the planes. There are some slight evidences of podzolization, and there are concentration areas in which reddish-brown iron staining is prominent. Drainage is restricted.
6. 40 to 60 inches, light pinkish- or reddish-brown massive dense clay, with some fracture planes lined with colloids and roots.
7. 60 inches+, somewhat stratified or laminated mottled light reddish-brown, rust-brown, gray, and olive clay. At greater depths are clays mixed with sand, gravel, stones, and boulders.

Replaceable base data for Cabinet silt loam are given in table 11.

The Clayton and Cabinet soils, developed over heavy materials, apparently have been subjected to degrading podzolization which tends to destroy or disperse the colloid, moving it to greater depths. This is indicated by the gray color of the upper part of the subsoil and the clay accumulation in the lower part. It would seem that, under imperfect drainage in Cabinet silt loam, the movement of ground water has been lateral and that a degrading podzolization process has taken place on top of the dense clay.

IMMATURE SOILS OF THE LIGHTER COLORED PODZOLIC GROUP

Within the region of the lighter colored podzolic soils are a number of youthful soils which have not received the full impress of the environment, probably because of the shorter period the parent materials have been acted on by the soil-developing forces. These include the Mission, Selle, Elmira, and Colburn soils.

Although the profiles of these soils are very immature, an incipient podzolic ash-gray layer is present in most virgin areas. In many places it occurs as a mere film over the upper part of the soil material, which is formed largely from loess. This development is promoted by the dense tree growth and consequent deep forest litter on these soils. Generally, these soils lie in flat positions, favorable for the accumulation of snow and moisture, where leaching is active. Such areas are cool and have little air movement and greater humidity.

The Mission soils are representative of youthful soils developed from stratified clay, on which podzolic characteristics are impressed because of the favorable position for development and other favorable environmental factors. The vegetation is mostly western white pine, western larch, and western red cedar.

A description of a profile of Mission silt loam, as observed in the SW¼SW¼ sec. 2, T. 57 N., R. 2W., follows:

1. 0 to 1 inch, conifer needles and raw humus which is dark brown or black when wet.
2. 1 to 1¼ inches, a podzolized layer of white or ash-gray soft amorphous material.
3. 1¼ to 12 inches, light yellowish-brown or light-buff lightweight floury fluffy silt loam. It contains a few rusty-brown shotlike pellets.
4. 12 to 30 inches, light yellowish-gray or brownish-gray fractured silty clay. Channels and chambers are coated with colloids and podzolic flour. Cloddy structure masses show brown spots and gray mottled effect of podzolization. This horizon is compact.
5. 30 to 45 inches, material which is similar to that above except that it is less colloidal and fractured. Less of the gray is evident, and yellow and brown mottlings are more pronounced. Stratification has disappeared through soil development to this depth.
6. 45 to 65 inches, dull grayish-yellow thinly stratified fine sand or very fine sand, slightly mottled with brown.
7. 65 to 75 inches, stratified clay, with very thin lamination. The color is more yellow than in the layer above, and reddish-brown mottles are present.
8. 75 inches +, a thin, slightly calcareous stratum overlying noncalcareous light yellowish-brown stratified fine sand and clayey sand.

The Selle soils occupy a similar topographic position to the Mission soils and occur in intimate association with them, as slightly more elevated dunelike and ridged areas. The Selle soils are better drained and more deeply leached of calcareous materials. The sandy materials of open porous structure allow free percolation of water, yet their unfavorable rolling surface features are not conducive to the absorption of moisture. A very slight compaction is evident in the upper part of the subsoil, and some iron stains are present throughout the lower subsoil layer. Oxidation has not proceeded to a great depth, and there is very little other development of soil.

The Elmira soils are of similar or even more rolling relief than the Selle soils and are formed on equally porous sandy materials. They occupy lower positions than the Selle and Mission soils and necessarily must have been developed after the terrace, on which the former soils occur, had been torn away and replaced by these hummocky sandy materials. Saturation by water, wind erosion, and wind deposition have contributed important features to these soils. The parent materials are mixed—but apparently mostly granitic—and are not derived from calcareous sedimentary rocks; yet they became impregnated with lime at some past time, probably through the agency of lime-charged ground water. This is evident in the lower part of the subsoil and in the substratum, where lime carbonate is present in the form of root casts. Above the calcareous materials, some iron segregation and staining appear in most places. Despite this leaching process, only a very slight horizon of compaction is developed below the loessial mantle. In favorable positions, an ash-gray layer, similar to that in the Selle soil, is present in most places.

The Colburn soils are the youngest soils showing the ash-gray podzolic development. They occupy first-terrace positions and in places are somewhat gray from occasional inundation or a periodic high water table. The materials are of granitic origin and are highly micaceous. The horizon below the loess mantle shows structural compaction and slightly developed podzolized channels and chambers, as in the older soils. There are many iron stains in the lower horizons.

DARKER COLORED PODZOLIC SOILS

The darker colored podzolic soils are developed in the southern part of the county. They include the Springdale and Kootenai soils, both of which are formed over mixed glacial materials thinly mantled by loess. These materials are predominantly from Belt rocks including shales, sandstone, quartzite, and argillite, with an intermixture of materials of granite and related rocks. They are developed under conditions of good to excessive drainage. The Springdale soils have a smooth glacial-outwash relief and the Kootenai a more rolling morainic relief.

These soils appear to be transitional between the lighter colored podzolic soils and the dark-colored Prairie soils. They have accumulated somewhat more organic matter in the upper part of the profile than have soils of the former group but much less than those of the latter. They are less leached than the former but more so than the latter.

The following description of a profile of Springdale gravelly silt loam taken in the NE¼NW¼ sec. 19, T. 54 N., R. 2 W., is representative of the darker colored podzolic soils. The forest cover is ponderosa (western yellow) pine and lodgepole pine, and the ground cover is pinegrass, bearberry (kinnikinnick), Oregon-grape, snowberry, and snowbush (sticky laurel).

1. 0 to 14 inches, light-brown floury fluffy silt loam with a slight red tinge. The uppermost part of this layer is slightly darkened by the presence of organic matter and the incorporation of grass roots. Gravel are scattered throughout. A thin layer of coniferous litter and grass mat covers the surface.
2. 14 to 40 inches, yellowish-brown very gravelly fine sandy loam. Some pieces of gravel have reddish-brown iron coatings which impart a darker appearance in places. The material is somewhat compact but loosens readily. The finer material has a slightly vesicular appearance. The gravel particles are coated with clay.
3. 40 to 80 inches +, coarsely stratified sands and gravel, with a somewhat pepper-and-salt effect caused by the variety of materials. The finer materials are predominantly light yellowish brown or light grayish brown. In the lower part of the layer, brown iron material coats the upper sides of the rocks, and white silica coats the under sides and contact edges. These silica and iron materials cement the sands and gravel into fragile clusters; otherwise, there is no compaction.

The mechanical analyses in table 9 indicate the uniformly fine texture of the loessial material and an apparent translocation of silt and clay from this horizon into the upper part of the glacial material. The higher moisture properties of the loessial material and the upper part of the glacial material over the unmodified lower glacial material are illustrated by the moisture equivalents of the Springdale and Kootenai soils, also given in table 9.

INTRAZONAL SOILS

The intrazonal soils are developed under conditions of excessive moisture, generally on low-lying land, throughout the area surveyed, but largely associated with the lighter colored podzolic soils. In these soils, excessive moisture is largely responsible for the retarded development, although, in addition, most of them are formed from very recent alluvium. The regional profile, therefore, is not impressed appreciably upon the parent materials. Unlike the light-colored soils developed under a coniferous forest on the uplands, these dark soils have developed principally under a deciduous brush, grass, and water-tolerant vegetation which has contributed a large quantity of organic residues of high base content to the soil. Those soils lying in positions where an excess of moisture exists throughout the season support a luxuriant vegetation, and conditions are not favorable for rapid oxidation; therefore, the soils are dark and highly organic.

In the vicinity of active streams, where annual transportation and deposition of soil materials take place or where annual inundation for extended periods by lake waters occurs, the growth of vegetation is retarded and the soils are gray. The gray color results from lack of oxidation and low organic content. The Peone soils are developed under these conditions.

In the darker colored soils, the surface horizon of organic accumulation is a distinct feature of the profile. The lower lying materials are of various textures, typically stratified, and have a dominantly gray or greenish-gray color, more or less stained or mottled with red, yellow, or rust brown. These colors are probably due to changes in moisture conditions and successive reduction, oxidation, and hydration.

Although of similar materials, the St. Joe soils have become darker than the Peone soils because of accumulated organic residues resulting from denser vegetation and more stable development. Saturation with water likewise has caused more pronounced mottling in the subsoil than in the Peone subsoil.

The Colville soils have developed from heavy-textured materials laid down in glacially ponded areas and lakes. These clay-sealed basins have very slow internal drainage and a permanently high water table. The subsoils are therefore of definite blue-gray glei color, with much iron staining.

The Cocolalla soils are developed in basins and drainageways somewhat similar to those occupied by the Colville soils, where materials of fine texture have accumulated and water stands on or near the surface during much of the year but apparently moves slowly downward. These soils appear to be Ground-Water Podzols. The vegetation consists of water-loving plants, principally grasses, rushes, and sedges, which produce an accumulation of peaty and mucky material on the surface. Downward movement of water apparently caused downward leaching, intensified by organic acids. In the lower lying parts of these basins, the water table in many places subsides less slowly and associated areas of peat are developed. Under the highly organic surface soil, a white siliceous layer forms. In many places this layer continues to the deeper subsoil or substratum, generally of coarser textured materials, but it may be only a few inches thick overlying more gray gleilike materials. As a rule, areas in which this white layer is thin are drainageways where the grass is not thick and deciduous brush, such as alder, is the principal vegetation. In many basins composed of heavy clays, where water subsides slowly, the layer is also thin, and here it is underlain by blue-gray glei subsoils. In places the grayish-white materials resemble diatomaceous earth, and diatoms were recognized in samples observed under the microscope. On drying, the material in the gray horizon, especially at the top, is of very light weight.

The Chamokane and Narcisse soils develop in drainageways and areas of considerable seepage, where excessive moisture predominates throughout the year. The subsoils are coarse and porous, water moves through them freely, but the continuous wet condition has given rise to iron staining brought about by alternate oxidation and reduction.

PHYSICAL AND CHEMICAL DATA

Following are a number of tables giving the results of physical and chemical analyses and tests. The data bear out much of the discussion of soil profile characteristics in the preceding text.

Table 9, containing data from the laboratories of the Idaho Agricultural Experiment Station on the mechanical analyses and moisture equivalents of a number of representative soils, indicates the general nature of the texture profiles and the resultant moisture-holding capacity of the various layers. The moisture equivalent of a soil is the amount of moisture, expressed in percentage, that the soil will hold against a force 1,000 times that of gravity. When interpreted in terms of agriculture, it is usually considered that a soil with a moisture equivalent ranging from 20 to 35 percent is a soil in which dry farming is feasible. The relatively fine silty texture and high water-holding capacity of the prevailing loessial mantle and the coarser sandy or gravelly texture and low water-holding capacity of the coarser glacial materials is demonstrated. It is shown also that the upper part of this glacial material has more silt and clay than the lower, indicating, probably, downward movement or infiltration of finer materials from above. The very high moisture equivalent of the thin surface organic layers is well illustrated, especially by Mission silt loam. The heavy texture of the underlying glacial clays in the Clayton soils, and more particularly in the Cabinet soils, is well brought out in the mechanical analyses.

TABLE 9.—*Mechanical analyses and moisture equivalents of certain soils from Bonner County, Idaho* [1]

FINE EARTH (PARTICLES LESS THAN 2 MM IN DIAMETER)

Soil type and sample no.	Depth	Gravel	Total sands	Silt	Coarse clay	Fine clay	Total clay	Moisture equivalent
Mission silt loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
541601		(2)						107.0
541602		(2)						65.3
541603	1¼- 12	(2)	15.84	64.17	7.07	12.92	19.99	43.4
541604	12 - 30	(2)	5.10	40.70	10.25	43.95	54.20	28.3
541605	30 - 45	(2)	4.55	55.85	7.10	32.50	39.60	29.8
541606	45 - 65	(2)	16.00	75.69	.92	7.39	8.31	15.7
541607	65 - 75	(2)	4.26	44.56	8.63	42.55	51.18	31.0
541608	75+	(2)	27.31	50.73	4.36	17.60	21.96	21.0
Loon loam:								
541663	0 - ¾	(2)						52.6
541664	¾- 16	(2)	34.18	55.86	3.23	6.73	9.96	31.4
541665	16 - 48	(2)	71.12	22.86	2.91	3.11	6.02	7.5
541666	48+	(2)	68.58	24.38	3.93	3.11	7.04	8.2

[1] Data furnished by R. E. Bell, soil technologist, Idaho Agricultural Experiment Station. Mechanical analyses were made by the Boyoucos hydrometer method, in the laboratories of the University of Idaho.
[2] Gravel screened out.

TABLE 9.—*Mechanical analyses and moisture equivalents of certain soils from Bonne County, Idaho*—Continued

FINE EARTH (PARTICLES LESS THAN 2 MM IN DIAMETER)

Soil type and sample no.	Depth	Gravel	Total sands	Silt	Coarse clay	Fine clay	Total clay	Moisture equivalent
Waits silt loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
541667	0 - ¾	(2)	-------	-------	-------	-------	-------	53.4
541668	¾ - 14	(2)	24.01	63.40	4.90	7.69	12.59	38.8
541669	14 - 40	(2)	49.84	41.80	4.18	4.18	8.36	13.8
541670	40 - 90	(2)	79.16	15.82	2.24	2.78	5.02	6.8
Bonner silt loam:								
541671	0 - ¾	(2)	-------	-------	-------	-------	-------	46.2
541672	¾ - 16	(2)	25.07	65.31	3.55	6.07	9.62	26.0
541673	16 - 36	(2)	44.96	44.64	3.96	6.44	10.40	15.2
541674	36 - 70+	(2)	89.36	7.10	1.78	1.76	3.54	3.3
Springdale gravelly silt loam:								
541675	0 - 14	(2)	26.58	60.72	5.29	7.41	12.70	33.7
541676	14 - 40	(2)	45.08	45.60	1.99	7.33	9.32	16.2
541677	40 - 80+	(2)	55.83	36.88	1.41	5.88	7.29	12.3
Clayton silt loam:								
5416115-6	0 - 1½	(2)	-------	-------	-------	-------	-------	51.1
5416117	1½ - 18	(2)	36.51	52.82	2.25	8.42	10.67	26.1
5416118	18 - 50	(2)	32.73	38.74	8.99	19.54	28.53	18.7
5416119	50 - 70	(2)	28.96	37.79	5.22	28.03	33.25	21.6
5416120	70 - 100	(2)	25.78	47.99	7.81	18.42	26.23	22.4
Cabinet silt loam:								
541635	0 - ¾	(2)	-------	-------	-------	-------	-------	52.0
541636	¾ - 14	(2)	24.05	50.00	10.67	15.28	25.95	34.3
541637	14 - 20	(2)	22.59	48.77	4.74	23.90	28.64	19.9
541638	20 - 24	(2)	20.96	36.37	2.93	39.74	42.67	21.4
541639	24 - 40	(2)	6.88	18.71	6.35	68.06	74.41	28.9
541640	40 - 60	(2)	6.12	14.74	7.88	71.26	79.14	40.0
541641	60+	(2)	7.62	13.57	4.55	74.26	78.81	43.0

TOTAL SOIL (INCLUDING GRAVEL LARGER THAN 2 MM IN DIAMETER)

Soil type and sample no.	Depth	Gravel	Total sands	Silt	Coarse clay	Fine clay	Total clay	Moisture equivalent
Loon loam:								
541664	¾ - 16	11.3	30.3	49.5	2.9	6.0	8.9	27.8
541665	16 - 48	28.6	50.8	16.3	2.1	2.2	4.3	5.4
541666	48+	24.4	51.8	18.4	3.0	2.4	5.4	6.2
Waits silt loam:								
541668	¾ - 14	17.3	19.8	52.4	4.1	6.4	10.5	32.1
541669	14 - 40	65.9	17.0	14.3	1.4	1.4	2.8	4.7
541670	40 - 90	68.1	25.3	5.0	.7	.9	1.6	2.2
Bonner silt loam:								
541673	16 - 36	25.5	33.5	33.2	3.0	4.8	7.8	13.8
541674	36 - 70+	73.1	24.0	1.9	.5	.5	1.0	.9
Springdale gravelly silt loam:								
541675	0 - 14	38.5	16.3	37.4	3.3	4.5	7.8	20.7
541676	14 - 40	64.1	16.2	16.4	.7	2.6	3.3	5.8
541677	40 - 80+	67.2	18.3	12.1	.5	1.9	2.4	4.0
Clayton silt loam:								
5416117	1½ - 18	1.0	36.2	52.3	2.2	8.3	10.5	26.0
5416118	18 - 50	21.9	25.6	30.3	7.0	15.2	22.2	14.6
5416119	50 - 70	48.0	15.1	19.6	2.7	14.6	17.3	11.2
5416120	70 - 100	5.3	24.4	45.4	7.4	17.5	24.9	21.2

[2] Gravel screened out.

Table 10 gives pH values for four representative soils as determined in the laboratories of the Bureau of Chemistry and Soils. The relatively high pH values throughout the profiles of the Mission and Bonner soils seems to indicate the incipient character of the podzolic development. This is especially striking in the instance of the thin ash-gray layer—the second layer in each profile—which in typical Podzols is very acid (low pH value). The comparatively high pH in this layer and the material beneath it possibly may be due to the neutralizing effect of dust or accumulation of true ash, which has a high content of bases, from frequent forest fires occurring during logging operations. The pH values for Cabinet silt loam indicate stronger acidity and greater degree of leaching, especially in the ash-gray podzolized subsoil layers.

TABLE 10.—*pH determinations of samples of several soils from Bonner County, Idaho*[1]

Soil type and sample no.	Depth	pH	Soil type and sample no.	Depth	pH
Mission loam:	*Inches*		Bonner loam:	*Inches*	
541687	0 - 1	5.8	5416131	0 - 1½	5.3
541688	1 - 1½	6.0	5416132	1½- 2	5.6
541689	1½-16	6.2	5416133	2 -22	6.0
541690	16 -40	6.2	5416134	22 -40	5.7
541691	40 -90+	5.9	5416135	40 -90+	6.0
Bonner fine sandy loam:			Cabinet silt loam:		
541692	0 - 1	5.4	541635	0 - ¾	5.0
541693	1 - 1½	5.1	541636	¾-14	5.2
541694	1½-18	5.3	541637	14 -20	5.2
541695	18 -36	5.7	541638	20 -24	4.6
541696	36 -95+	6.2	541639	24 -40	4.7
			541640	40 -60	4.9
			541641	60+	5.8

[1] pH determinations were made by E. H. Bailey, Bureau of Chemistry and Soils, using the hydrogen-electrode method.

Table 11, showing the exchangeable bases in representative samples of Bonner, Mission, and Cabinet soils, supports the pH determinations in Table 10. The relatively high concentration of exchangeable bases in the surface organic layer is striking. The same is true also of the ash-gray podzolized layer beneath it in the Bonner and Mission soils. This tendency is the opposite from what would be expected in a mature podzolic soil and again emphasizes the incipient character of leaching and the possibility of accumulation of ash from forest fires. The entire upper part of the profiles of all three soils—the mantle of floury loessial material—apparently is but little leached, whereas the underlying glacial material apparently is more strongly leached.

TABLE 11.—*Replaceable bases in some Bonner County soils*[1]

[Milliequivalents per 100 g]

Soil type and sample no.	Depth	Ca	Mg	Na	K	Base-exchange capacity[2]
	Inches					
Bonner loam[3]	0 - 1¾	39.840	5.476	0.0240	1.2900	56.06
	1¾- 2½	5.328	.662	.0170	.1650	13.78
	2½- 8	2.592	.583	.0096	.2600	12.38
	8 -18	2.026	.568	.0034	.0484	8.76
	18 -44	2.082	.488	.0065	.1340	5.06
	44+	1.457	.332	.0691	.0332	2.76
Mission silt loam:						
541601	0 - 1	45.034	8.758	2.0370	.8800	90.20
541602	1 - 1¼	20.568	3.576	.7980	.4040	51.84
541603	1¼-12	10.656	.972	.2980	.2360	20.64
541604	12 -30	9.488	1.598	.2990	.2640	14.67
541605	30 -45	6.734	1.102	.4870	.1120	8.96
541606	45 -65	5.736	.550	.2640	.0440	4.62
541607	65 -75	10.528	.852	.4800	.0740	9.71
541608	75+	22.365	.313	.2600	.0440	13.90
Cabinet silt loam:						
541635	0 - ¾	19.080	5.730	1.0620	2.0040	33.56
541636	¾-14	6.476	.171	.3382	.3088	15.78
541637	14 -20	1.932	.058	.1742	.2092	5.36
541638	20 -24	2.816	1.186	.1978	.1444	5.54
541639	24 -40	6.604	4.316	.7808	.2744	16.72
541640	40 -60	9.300	8.320	.6062	.3344	19.04
541641	60+	11.380	9.900	.5762	.3376	19.10

[1] Analyses supplied by H. P. Magnuson, associate professor of chemistry, University of Idaho.
[2] Determined by treatment with ammonium acetate.
[3] Special samples.

In Cabinet silt loam, which exhibits many of the characteristics of a Ground-Water Podzol, the strong leaching of the nearly white ashy horizon between depths of 14 and 24 inches is indicated by the low content of exchangeable bases as compared to the horizons both above and below. This is especially striking when the high clay content of this leached horizon is taken into account. The lower layers have a higher base-exchange capacity and a relatively high magnesium content, together with a much denser structure. The material is dense deflocculated clay whose physical condition may be due partly to the concentration of exchangeable magnesium.

Table 12 gives the results of chemical analyses of Bonner silt loam. These data support those in tables 10 and 11 in demonstrating the podzolic nature of a typical soil profile in this area. This is particularly true of the analysis of the colloid. The analysis of the whole soil shows the concentration of organic matter at the surface and in the third layer (2½ to 8 inches). Concentration of aluminum oxide in the latter layer is indicated also. The analysis of the colloid shows removal of sesquioxides and concentration of silica in the ash-gray layer (1¾ to 2½ inches), and the concentration of the sesquioxides in the underlying layer. That the podzolic process has not proceeded far is indicated by the thinness of the upper two layers and by the fact that, when the whole soil is analyzed, the segregation of the silica and sesquioxides is not definitely shown.

TABLE 12.—*Chemical analyses of Bonner loam, Bonner County, Idaho* [1]

ANALYSIS OF WHOLE SOIL

Depth (inches)	Organic matter	SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	CaO	MgO	MnO	$\frac{SiO_2}{R_2O_3}$
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Molecular ratio*
0–1¾	47.25	31.72	9.76	5.61	4.15	2.65	0.72	0.79	7.00
1¾–2½	6.42	61.68	19.62	7.22	12.40	3.00	1.03	.14	6.18
2½–8	8.76	65.01	20.93	6.14	14.79	1.35	1.12	.11	5.92
8–18	1.79	64.80	20.46	6.38	14.08	1.24	.63	.08	6.08
18–44	1.40	72.72	17.53	5.49	12.04	1.08	.64	.05	7.88
44+	.49	76.86	15.41	3.22	12.19	.97	.38	.03	9.22

ANALYSIS OF COLLOID

Depth (inches)	SiO_2	Fe_2O_3	Al_2O_3	R_2O_3	$\frac{SiO_2}{R_2O_3}$
	Percent	*Percent*	*Percent*	*Percent*	*Molecular ratio*
0–1¾	24.30	8.22	5.34	13.56	3.89
1¾–2½	55.73	8.02	12.00	20.02	5.48
2½–8	39.37	13.71	25.94	38.65	1.97
8–18	38.50	11.60	28.01	39.61	1.85
18–44	49.72	12.41	23.09	35.50	2.72
44+	49.51	11.91	21.09	33.00	2.82

[1] Analyses made in the laboratories of the University of Idaho.

SUMMARY

The general terrain of Bonner County is mountainous and semimountainous. An early continental glaciation overrode all but a few of the highest peaks, and a later glaciation of the valley type and subsequent erosion are responsible for the present land forms, accumulation of soil materials, and drainage of the agricultural soils which occur mainly in the valleys of the major streams. The transported parent soil materials are derived from both igneous and sedimentary rocks, and the individual materials or mixtures of both have given rise to distinct soils.

The varied relief accounts for a wide diversity of climatic, vegetative, and soil conditions. The modified continental climate is cool, somewhat rigorous, and humid. This is favorable for the support of a coniferous tree cover, and lumbering has been the important industry. The decline of lumbering was followed by increased agricultural activity on cut-over land, on which the production of crops, such as grain and hay, and the raising of livestock are of growing importance. A deficiency of rainfall during the summer restricts successful farming to soils of better moisture-retaining properties.

On the basis of their agricultural use the soils fall into three groups: (1) Light-colored soils of the large areas of well-drained forested uplands; (2) dark-colored soils of the comparatively small and scattered areas of poorly drained or excessively wet lowland; and (3) miscellaneous land types.

The light-colored soils are low in organic matter and deficient in nitrogen. With the exception of sulphur, there is no apparent deficiency of mineral elements, because these soils are youthful soils, in which leaching has not progressed to a significant state of impoverishment. Productivity can be maintained with proper rotations, which include legumes, supplemented by the addition of sulphur in some form. The expansion of livestock raising will aid materially in building up and maintaining the fertility.

The more critical problem is a sufficient supply of moisture to mature plants, as the marked deficiency of rainfall in summer causes droughtiness in those soils having open porous subsoils and substrata. Moisture is held well by the Mission, Clayton, and Cabinet soils, owing to their clay subsoils and substrata, and these are the only light-colored soils that can be farmed continuously with success. The other cut-over lands supply an extensive grazing area which can be utilized best for pasture, until economic conditions warrant the clearing of them for cultivation. Their value for summer grazing, however, is far in excess of their potential value for production of winter feeds. The introduction of alfalfa, which resists drought more successfully, returns higher yields, and produces a better quality of hay than does clover, makes the winter feeding problem less acute, and has enabled the expansion of livestock raising. Supplementary feeds of small grains, such as wheat, barley, and oats, do well on these light-colored soils, where the moisture supply is sufficient and legumes are included in the rotation.

Because of the generally wide distribution of porous glacial drift materials on rolling or sloping relief, the soils of the uplands have good internal and external drainage.

The dark-colored soils border well-defined stream channels or occupy basins and seepy spots. These soils generally require artificial drainage, protection from flood, or both, before they can be utilized properly. Their fertility is high, and their position generally insures a plentiful supply of moisture throughout the season. They are the soils on which the pioneer agriculture was established and on which the most successful farming still is carried on. Native grasses for hay and pasture grow luxuriantly on the dark-colored soils of the river bottoms. Where cultivated, these soils are used extensively for the production of subsistence crops, mostly for introduced hay crops and oats. Almost all of these soils are very dark. The group includes soils of the Cocolalla, Colville, St. Joe, Chamokane, Narcisse, and Peone series, as well as peat.

Subsistence farming, with a cash income derived from the sale of animal products, dominates the agriculture of the county, owing to the characteristics of the climate and soils and the distance from larger markets. The cool comparatively short summers are most favorable for hay and small grains.

In general, the most successful farm units are those composed at least in part of the dark-colored soils. The acreage of these soils is small and widely scattered, however, so that only a small proportion, if any, is included in the average farm. Farming is successful also on the light-colored soils with clay subsoils.

A large proportion of the land in this county, designated as miscellaneous land types, is entirely unsuited for cultivation, because of unfavorable relief, stoniness, or droughtiness. Such lands are suited to systematic reforestation or grazing. Logging operations have taxed the timber wealth seriously, and the second growth, in most places, is inferior. Large areas have been denuded almost entirely by fires.

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U S GOVERNMENT PRINTING OFFICE: 1938

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