IDAHO AGRICULTURAL EXPERIMENT STATION

Chemical and Mechanical Analyses of Characteristic

IDAHO SOILS

BY

J SHIRLEY JONES

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DIGEST

Inquiry by farmers and others interested in soil management is continually being made of this department relative to the chemical and physical properties of the soils in different sections of this state. Particularly is this true of those sections that are still in the first stages of development and whose agricultural possibilitiea are therefore as yet somewhat problematical. In order to secure the information necessary to answer properly the inquiries which have thus far been received, detailed analyses have been made of samples representative of districts in the semi-arid and in the humid sections of the state. For the most part the samples represent extensive areas, and, therefore, the information sought, althought it has already by correspondence been given the parties directly interested should be as widely spread as possible.

On page 5 may be found a brief discussion of those compounds which experience teaches are of first importance in soil fertility. Following this may be found a statement of what in a soil should be considered adequate and inadequate percentage of potash, phosphoric acid, and nitrogen. Comment on the analysis of the individual samples is made in the light of all the data that could be secured by correspondence and personal visits to the various districts.

As a rule the soils of the state are rich in all of the mineral elements required in plant growth. Certain districts in the south however are apparently deficient in phosphoric acid. .04 per cent is the lowest and .70 per cent the highest amount of phosphoric acid found in samples from the south. The average is .19 per cent, which is far above the lower limits of adequacy. In the north this compound is more evenly distributed; the lowest amount found is .09 per cent, the highest .56 per cent, average .25 per cent. The timber soils of the north appear to be exceptionally well supplied with phosphoric acid. In potash the soils from the south are somewhat, in lime they are decidedly richer than those from the north. Discarding samples which are known to represent abnormal soils, the average potash and lime content of samples from the south is .61 per cent and 1.90 per cent respectively; that of samples from the north, .50 per cent and .72 per cent respectively. Certain districts in the north contain too little lime in the form of a carbonate and as a result the soils are slightly acid. This condition should be improved by the application of finely crushed limestone. In humus and nitrogen large areas in the south and much of the burned over timber soils of the north are deficient. The growth of one or more of the legumes—alfalfa, clover, peas, should be resorted to as the first step in their improvement.

Chemical and Mechanical Analyses of Characteristic Idaho Soils.

The chemical and mechanical examination of the soils of this state was commenced early in the history of this experiment station; the results of the first work were published as Bulletin No. 28. Previous to the time that the writer assumed charge of the chemical work of the station, soil analysis had been given a prominent place in the work of the department. For various reasons it seemed desirable that this work should not only be continued but that its scope should be so enlarged that eventually every type of agricultural land within the state would be given an aggressive, systematic laboratory study; for it is now very generally recognized that the best practices in the management of soils rest fundamentally upon an intimate knowledge of their chemical and physical properties.

Since within the state there are many types of soil and each is more or less distinctly characteristic of comparatively large areas, it becomes necessary in order to answer many inquiries relative to the agricultural possibilities of the different sections, to ascertain by analysis their predominant chemical and mechanical properties. The analyses given on subsequent pages of this bulletin were made particularly with this end in view. From a careful study of these analyses together with those recorded in Bulletin No. 28, a very good idea may be gained of the general character of the lands of the state that are now or will in the immediate future be put under cultivation.

Owing to the conditions under which this work was prosecuted, an absolutely uniform method of procedure in securing samples was not found practicable. Many of the samples reported upon in the following pages were sent to the department by the owners of farms or small tracts of land, who desired information relative to the chemical and mechanical characteristics of the soil in their immediate locality. Many requests fcr soil analyses have been received, but no samples taken without specific directions from this department, or by men known to be capable of properly sampling soil areas, arc included in this report. A large number of the samples were collected by myself when visiting certain sections of the State at the solicitation of the owners or persons interested in large tracts of land, or when visiting those sections in connection with other lines of investigation. All samples are believed to be fairly representative of the sections from which they came.

In many instances the information deducible from the results of laboratory examination has already by correspondence been given the parties directly interested. But the keen interest usually displayed by farmers and others interested in soil management, whenever the soil is a subject for discussion, teaches the importance of securing and publishing all data possible relative to the chemical composition and physical properties of all soil types found within the state. In the immediate future this work will be broadened sufficiently to permit of a more detailed study of the different soil types, which, up to this time, have been studied in a general way only.

THE COMPOSITION OF SOILS

In order that those interested may better understand the purposes of soil analysis and may properly interpret the analyses which follow, some consideration must here be given to the nature and composition of soils in general.

For practical purposes soils may be considered as mechanical mixtures of mineral and organic matter in which highly organized plants may find physical support and from which they may secure adequate amounts of the chemical elements necessary for their proper development. The mineral matter, sometimes spoken of as rock powder, results from the weathering of rock structures and the minerals of which rocks are composed. The organic matter consists of the remains of plant and animal bodies which have been by natural or artificial agencies incorporated with the disintegrated rock particles. Considered individually, the mineral and organic matter is each a mechanical mixture of a very large number of more or less complex chemical compounds. The more complex forms of either class of soil constituents are totally or partially unavailable as plant food. The fertility of the soil depends upon the ultimate re-arrangement of the elementary constituents of these complex compounds into such simple ones as are soluble in the medium through which plant food is taken into the plant.

Although the natural agencies at work in the dissolution of the rock particles and the remains of plant and animal life incorporated with them are constantly at work, they never accomplish the complete liberation of the chemical elements which constitute this mineral and organic matter. This is not necessary, since plants do not require their food in an elementary form. They do, however, require it in the form of compounds readily soluble in the secretions of their root systems or in the solutions of the soil. To provide the necessary food for growing plants these readily soluble compounds should contain calcium, iron, magnesium, nitrogen, potassium, phosphorus, and sulphur. As a matter of fact they always contain in addition to these, aluminum, chlorine, and silicon, and occasionally other elements, which, although not essential to the elaboration of the compounds of which the plants ultimately consist, are taken up by them along with the essential elements and may be found in the ashes when the plants are burned. Nitrogen is derived from the organic portion of the soil, the other elements principally from the mineral portion.

Seldom do any of the chemical elements mentioned above occur in the soil entirely in a single compound. For example, calcium is present as a carbonate, a phosphate, and as a silicate; potassium occurs as a sulphate, a carbonate, a silicate, etc. These compounds are not equally soluble in the secretions of the plant roots or the solutions of the soil, and from this fact has arisen the expression, *available,* and *non-available* plant food. The degree of solubility of the compounds in which calcium, potassium, nitrogen, sulphur, etc. occur, is of great importance in arriving at just conclusions regarding a soil's fertility. The more insoluble forms are known to be wholly unavailable as plant food until by chemical transformation induced by cultivation and other agencies, the elements of which they are composed secure places in compounds that are soluble in the solutions of the soil and become therefore available as plant food.

For practical purposes, Agricultural Chemists have classified the compounds containing the elements mentioned above, as: first, those soluble in water and dilute organic and mineral acids; second, those soluble in strong mineral acids; and third, insoluble compounds which require for their decomposition a combination of high heat and fluxes.

The first class represents the compounds whose elements are immediately available as plant food. The second class constitutes that part of the soil whose elements are not immediately available but which are gradually becoming so as the result of certain chemical transformations induced by natural agencies and hastened by intelligent soil management. The third class, so far as plant food is concerned, is practically inert material, although it will eventually become a part of the second and then of the first class.

In this work we have had in mind principallv the determination of the potential fertility of the soils of the different localities as represented by the samples which reached the laboratory. The soils were digested for ten hours at the temperature of boiling water with hydrochloric acid of specific gravity 1.115. The percentages therefore may be taken as indicative of the amounts of both the immediately available plant food and that which may be gradually made available under proper methods of soil management.

Percentage Adequacy of Soil Ingredients.

Two systems of recording soil analyses are in vogue. In one the mineral elements are reported in the form of their oxides; in the other they are reported as elements. For purposes of comparison it seems to us the better plan to adhere to the former system. Therefore potassium is reported and referred to as potash, K_2O; sodium, as soda, Na_2O; calcium, as lime, CaO; magnesium, as magnesia, MgO; iron, as iron oxide, Fe_2O_3; aluminum, as alumina, Al_2O ; phosphorus, as phosphoric acid, P_2O_5; and sulphur, as sulphur trioxide, SO_3.

In interpreting the results of soil analyses particular attention is usually directed to the percentages of lime, potash, phosphoric acid, and nitrogen. No soil is absolutely lacking in any one of the compounds mentioned, but experience teaches that the percentage of one or more may be so low as to become the limiting factor in crop production. It is not possible to fix rigidly for all soils a percentage below which any one of the necessary elements contained in the compounds mentioned may be deemed inadequate to meet the demands of cultivated plants for normal growth and development. Generally speaking the richer the soil is in lime in the form of a carbonate, the lower may go the percentage of the potash, phosphoric acid, and nitrogen, because limestone is recognized as an exceedingly active factor in influencing the availability of the other compounds named.

Without entering into an extended discussion of the points involved in this important question, this may be said: soils whose potash content is less than twenty-five one hundredths per cent (.25 per cent) are likely to prove weak in potassium; if they contain less than eight one hundredths per cent (.08 per cent) phosphoric acid, they will be found weak in their phosphorus content. If weak in either potash or phosphoric acid the application of expensive mineral fertilizers will soon be necessary. Soils whose potash content lies between twenty-five and thirty-five one hundredths per cent (.25 per cent.—35 per cent) may as a rule be considered well supplied with potassium. If they contain from eight to fifteen one hundredths per cent (.08 per cent—.15 per cent) of phosphoric acid, cultivated crops will usually secure all of the phosphorus they require without the addition of a phosphate fertilizer. Soils which contain more than the last named percentages of potash and phosphoric acid, are, unless unusual conditions prevail, to be considered rich in the elements potassium and phosphorus.

With regard to adequate percentages of nitrogen, no very definite statement should be made without first ascertaining the extent to which the soil's organic matter has undergone humification. Organic matter must be converted into humus before its nitrogen becomes of any value as plant food. In other words, in the interpretation of soil analyses, the percentage of humus nitrogen may be of more importance than the percentage of total nitrogen. Experience indicates however that one tenth of one per cent (.10 per cent) of total nitrogen ordinarily insures a fair suppy of this element in forms suitable to meet the requirements of cultivated crops.

In the interpretation of soil analyses, in so far as the writer is aware, sulphur is seldom given any comment whatever. In the analyses which follow it will be noted that the percentage of sulphur trioxide is not always stated. As a rule this omission means that sulphur was not found by the analyst, or was present in such small amounts as to render its quantitative determination impractical. All farm crops, and particularly the legumes, require appreciable quantities of sulphur for their complete development. It is possible that some of our soils are deficient in this element and that benefit to certain crops might result from the addition of fertilizers containing sulphur in an available form.

This is a point we hope to investigate later. The comparatively large amounts of magnesia and iron in all soils insures a sufficient amount in the available condition to meet the rather light demands of all crops in this respect.

The percentages of sand, silt, and clay, of which the various soil types are composed, are indicative of their water holding capacity and the ease with which they may be cultivated and their plant food rendered available. The mechanical analyses are therefore of importance in connection with the various problems of soil management that may arise in connection with each type of soil. Mechanical analyses of the various soil types were made and appear with the chemical analyses. For the mechanical analysis only that portion of the soil (usually all of it) which passed through a sieve whose meshes are 2 millimeters (.08 inches) in diameter was used. The several portions are designated as sands, silt, and clay. The clay includes all particles whose diameters are less than .005 millimeters (.0002 inches). Silt includes those particles whose diameters range between .005 and. .05 millimeters (.0002-.002 inches.) The sands include all particles whose diameters are greater than .05 millimeters (.002 inches).

The chemical analyses were made on what is called "fine" soil—that portion which passed through a seive whose meshes are .5 millimeters. It is generally believed that those particles of soil whose diameters are greater than .5 millimeters are too coarse to be considered of any value as sources of plant food. In the majority of samples 90 per cent or more of the soil consisted of "fine" soil. But in a few instances the amount was much less. These points should be borne in mind when interpreting the following analyses.

In the main the chemical analyses were made by Mr. H. P. Fishburn, and Mr. C. W. Colver, assistants in the department. The latter also made the mechanical analyses.

All samples of soil examined have been classed under one of two general headings. viz: Soils from the semi-arid sections, and soils from the humid sections. All samples representing the south and south eastern part of the state, will be found under the former. All representing the northern part, under the latter heading.

Percentages in both chemical and mechanical analyses have been calculated on the soils dried at 103°—105° C. When humus nitrogen was determined in the course of chemical analysis, its percentage has been calculated to percentage in the soil as well.

Percentage Composition of Soils from the Semi-Arid Sections by Counties.

LABORATORY NUMBER	ADA	CANYON			
	136 Surface Soil	82a Surface Soil	82b Sub-Soil	83 Hard Pan	84 Clay
Coarse soil	......	6.00	25.00	......	......
Fine "	100.00	94.00	75.00	......	......
CHEMICAL ANALYSIS OF FINE SOIL.					
Insoluble matter	73.09	87.40 (insoluble matter and soluble silica together)	70.74	39.12	76.42
Soluble silica	11.42				
Potash (K_2O)	.52	.82	.64	.51	.90
Soda (Na_2O)	.46	.37	.44	.42	1.04
Lime (CaO)	1.09	.83	8.75	21.28	.93
Magnesia (MgO)	.74	.61	1.28	2.97	1.42
Manganese oxide (Mn_3O_4)	......	.06	.04	.08	.07
Iron oxide (Fe_2O_3)	2.89	3.24	3.29	1.75	4.89
Alumina (Al_2O_3)	4.65	4.08	4.92	2.62	8.27
Phosphoric acid (P_2O_5)	.04	.05	.06	.11	.08
Sulphur trioxide (SO_3)	......	trace	trace	.18	trace
Carbon dioxide (CO_2)	......	.07	4.78	15.01	1.28
Volatile matter	5.46	2.76	4.98	14.99	5.08
Total	100.36	100.29	99.92	99.04	100.38
Total nitrogen	.19	.05	.08	.17	.07
Humus	1.94	1.88	.55	1.50	.52
Humus nitrogen, per cent in humus	4.88	......	......	......	......
Humus nitrogen, per cent in soil	.09	......	......	......	......

The sample from Ada County, No. 136, was sent in by Mr. T. V. Dedwith, who writes that it is typical of the soil in Boise Valley near Star and bordering the Boise River. The soil represented by this sample varies from two to five feet in thickness and is underlaid by sand and gravel. It produces garden truck successfully without surface irrigation, but being low and close to the river, is doubtless sub-irrigated. It is weak in phosphoric acid, but as it is a sandy soil, fairly rich in lime and in a good state of cultivation, it probably does not need immediate fertilization. The humus content is also rather low, but of a fairly good quality as indicated by the percentage of nitrogen it contains. About one-half of the total nitrogen contained in the soil is combined with the humus. This is good, for nitrogen so combined is readily available. As a rule soils from semi-arid regions are alkaline in reaction, but this one is distinctly acid; a condition accounted for only by the fact that it is sub-irrigated heavily. If this condition is normal and general the application of lime will prove beneficial.

The samples from Canyon county, Nos. 82a, 82b, 83 and 84, were sent to the laboratory by Professor Elias Nelson, formerly in charge of the sub-station farm located four miles Southwest of Caldwell under the Boise-Payette U. S. Reclamation Project. No. 82a is characteristic of a major portion of the surface soils of the farm. It is a light colored soil varying in thickness from eight to twelve inches. In its raw condition, Professor Nelson describes it as "stubborn and impermeable to moisture." As a rule it is underlaid by a sub soil (82b) described as a dark brown clay from four to eight inches in thickness which changes more or less abruptly into a stratum of light colored sand.

The poor physical condition of both surface and sub-soil in the natural state is partly attributable to the very low percentage of organic matter each contains, augmented in the case of the sub-soil by its high percentage of lime carbonate which imparts to it certain cement-like properties. In them alfalfa starts slowly, but nevertheless its growth seems to be the most feasable method of loosening the soil particles and getting more organic matter incorporated with them. Both surface and sub-soil are rich in potash and lime, but decidedly weak in phosphoric acid. While their phosphorus content is possibly sufficient to meet present demands, some addition to it will be necessary in the future. Particularly is this true if the soils are to produce small grains.*

No. 83 is described as a "white lime formation generally called hard-pan in this district." It underlies a considerable portion of the surface soil and occasionally comes very close to the surface itself. The chemical analysis shows it to be a lime-stone formation of the same character which often appears in irrigated districts and because of its cement like properties causes considerable distress to horticulturists because the roots of fruit trees have difficulty in penetrating it. If by mechanical means it can be loosened up and kept loose, it will add materially to the value of the surface-soil because it is richer both in phosphoric acid and nitrogen.

No. 84 is said to be characteristic of a certain type of surface soil in this district, never large in area, but always particularly difficult to work and get into a satisfactory state of cultivation. The areas characterized by this type of soil are known locally as "slick spots." The

* A fusion analysis of the "insoluble" matter gave large quantities of potash and lime, but only traces of phosphoric acid. Practically all had been extracted by the hydrochloric acid treatment. Since there is no "reserve" phosphoric acid, the soils are unquestionably weak in this respect.

analysis of this sample indicates that the soil is weak in phosphoric acid, and low in organic matter and nitrogen. Mechanical loosening of the soil particles together with the incorporation of more organic matter is obviously the only course to pursue with it.

Nos. 82b, 83 and 84 with the usual mechanical manipulation previous to chemical analysis, yielded very low percentages of "fine" soil, a fact which simply emphasizes their undesirable physical characteristics.

A mechanical analysis of Nos. 136, 82a, 82b, and 84 gave results as indicated below.

Laboratory Number	Loss on Ignition per cent.	Sands* per cent	Silt per cent	Clay per cent
136	4.68	73.75	21.65	5.04
82a	2.64	79.73	15.13	5.02
82b	10.72	75.29	15.82	8.79
84	4.88	53.23	23.30	24.46

* In these and subsequent analyses made by the centrifugal method, no grading was made of the sands into, "very fine sand," "fine sand," "coarse sand," and "gravel."

The first three samples therefore represent sandy loam soils, and the fourth a sandy clay.

ELMORE COUNTY

LABORATORY NUMBER	RIVER BOTTOM AND BENCH LAND				HIGH LAND
	169a Surface Soil	169b Surface Soil	169c Sub-Surface Soil	169d Sub-Surface Soil	218 Surface Soil
Coarse soil	6.00	5.00	5.00	6.50	16.70
Fine "	94.00	95.00	95.00	93.50	83.30
CHEMICAL ANALYSIS OF FINE SOIL					
Insoluble matter	45.95	50.44	57.16	55.17	70.10
Soluble silica	18.05	19.39	15.32	13.80	12.08
Potash (K_2O)	1.38	1.60	1.25	.94	.46
Soda (Na_2O)	.77	.91	1.50	.73	.36
Lime (Ca O)	8.12	5.24	5.84	7.75	2.44
Magnesia (Mg O)	2.53	2.49	2.37	2.27	1.78
Manganese oxide (Mn_3O_4)	.15	.03	.03	.02	none
Phosphoric acid (P_2O_5)	.21	.15	.28	.15	.13
Iron oxide (Fe_2O_3)	2.90	3.53	7.64	1.18	4.38
Alumina (Al_2O_3)	6.25	7.97	2.08	6:40	3.79
Sulphur trioxide (SO_3)	trace	trace	trace	trace	.07
Undetermined, volatile matter, CO_2, etc. (CO_2 large)	13.69	8.25	6.53	11.59	4.27
	100.00	100.00	100.00	100.00	99.86
Total nitrogen	.20	.04	.04	.07	.057
Humus	1.71	very low	very low	very low	.34
Humus nitrogen, per cent in humus	5.15	......	......	......	16.50
Humus nitrogen, per cent in soil	.08	......	......	......	.055

Nos. 169a, 169b, 169c, and 169d are from low lands bordering the Snake River in sections 32 and 33 of T. 5, R. 6 E, B. M. in Elmore County. They were sent to the laboratory by Mr. Monroe G. Haight of Boise, who made particular inquiry regarding their alkali content, and the possibility of reclaiming them should they be found badly impregnated with alkali salts. No. 169a represents the land close to and twelve feet above the river. The soil is dark in color and six to eight feet in depth. Gravel underlies it. No. 169b represents the surface foot of the bench land one thousand feet back from the river and eight feet higher than that represented by No. 169a.

Nos. 169c, and 169d are representative of two types of soil which underlie the surface foot of the bench land. Adjoining the tract represented by these four samples is an area of approximately eighteen square miles the soils of which possess the same general characteristics shown by these samples. The entire tract is about three hundred feet lower than the surrounding country.

The chemical analyses show all four soils to be strongly calcareous, and well supplied with all the mineral elements necessary for crop production. The low land is fairly well supplied with humus and nitrogen in an available form, but the bench lands are lacking in organic material.

Mr. Haight's observations of the natural vegetation and surface characteristics inclined him to the belief that these soils are impregnated with alkali salts. The analysis of a water solution of the soils gives .8 per cent sodium carbonate in the surface foot of both the low and the bench land, and .3 per cent sodium carbonate in the sub-surface soils of the bench land. The surface soils are already too highly charged with black alkali to permit the successful growth of any cultivated crop adapted to that section. Mr. Haight was advised that the soils, although unusually rich in the mineral elements of plant nutrition, would doubtless prove unproductive until the excess of alkali salts is leached out. This he proposes to do by means of a pumping plant established on the banks of the river.

Sample No. 218 is characteristic of the high land of the southern part of Elmore County: The sample was taken and sent to the laboratory by Mr. Alex. McPherson of Twin Falls. The location of the tract from which this sample was taken is thought to render it especially desirable for orchard purposes. The sample itself was taken from sec. 22, T. 5 S., R. 8, E. B. M.

The alkalinity of this soil calculated as sodium bi-carbonate is .117 per cent; a percentage which should be taken as a warning against the careless use of irrigation water. Aside from this, the analysis indicates a splendid soil in every particular. Practically all of its nitrogen content is in the form of humus, which is unusual even in semi-arid sections. If properly handled this soil will doubtless prove to be wonderfully productive in the crops suitable for an irrigated section.

From their mechanical composition, Nos. 169a and 169c represent sandy clay soils. Nos. 169b and 169d represent sandy loams, and No. 218 a fine sandy soil. The mechanical analyses are given below.

Laboratory Number	Loss on Ignition per cent	Sands per cent	Silt per cent	Clay per cent
169a	12.38	53.19	23.82	23.28
169b	6.80	62.38	19.55	18.56
169c	7.33	54.76	23.05	22.40
169d	10.13	70.21	13.52	16.50
218	3.94	85.60	7.64	6.98

FREMONT COUNTY. – UPPER SNAKE RIVER VALLEY SOILS.

The soils whose analyses are given on page 14 are representative of several large areas in the upper valley of the Snake River, in the south eastern part of Fremont County. Judged from the standpoint of either chemical or mechanical composition, the soils of this part of the state are far from uniform. The valley here has an elevation of nearly 5000 feet. A great deal of the land sub-irrigates readily. The small grains, potatoes, sugar beets, alfalfa, clover, and timothy, grow exceptionally well with irrigation. Large areas above the canals are being developed into "dry land farms."

Samples No. 210a and 210b were taken close to the dividing line between Fremont and Bingham counties, seven miles S. E. of Rigby, and fairly represent the soils of the "dry farms" in that section. Both are raw soils. The first was taken from the bench land, and the second farther down in the valley of a small creek. The first therefore represents by far the larger area in that section of the state. The chemical analysis indicates that both are strong soils, well supplied with all the elements necessary for plant growth. The percentage of humus appears low, but the percentage of nitrogen in the form of humus is high; this indicates that these soils are well supplied with this important

FREMONT COUNTY.—UPPER SNAKE RIVER VALLEY SOILS

LABORATORY NUMBER	210a	210b	211a	211b	212	213	214a	214b
Coarse Soil	......	......	76.77	71.35	24.65	60.45	......	......
Fine “	100..00	100.00	23.23	28.65	75.35	39.55	100.00	100.00
CHEMICAL ANALYSIS OF FINE SOIL								
Insoluble matter	68..85	68.95	78.13	84.53	69.42	78.84	76.00	74.83
Soluble silica	10..00	10.43	8.06	......	......	7.53	8.82	8.40
Potash (K2 O)	..43	.67	.43	.57	.79	.51	.75	.78
S da (Na2 O)	..35	.21	.23	.30	.46	.47	.24	.44
Lime (CaO)	4..61	4.10	.83	.66	3.73	.70	.85	.82
Magnesia (MgO)	1..32	1.51	.64	.81	.92	.76	.62	.66
Iron oxide (Fe2 O3)	2..26	2.42	3.69	4.19	3.09	3.07	3.16	2.88
Alumina (Al2 O3)	4..29	4.49	4.60	4.62	5.50	4.91	4.10	5.32
Phosphoric acid (P2 O5)	..11	.21	.04	.33	.25	.17	.35	.32
Sulpher trioxide (SO3)	..05	.05	.05	.03	.02	.03	.02	none
Carbon dioxide (CO2)	......	......	none	none	high	......	none	none
Volatile matter	7.10	6.40	3.54	3.91	7.28	3.49	4.43	4.62
Total	99..37	99.44	100.24	69.95		100.48	99.41	99.07
Total nitrogen	..11	.11	.09	.12	.14	.07	.14	.14
Humus	..79	.28	.93	1.05	1.08	1.19	1.56	1.52
Humus nitrogen, per cent in humus	10.28	20.30	9.60	11.36	6.15	4.73	6.52	6.64
Humus nitrogen, per cent in soil	..08	.07	.08	.12	1.05	.06	.11	.10

element in available forms. "Dry farming" up there, however, means wheat farming. Wheat growing alone will in a short time reduce the humus content of these soils to such an extent that the crop will not be as profitable as it is at present. Alfalfa and peas should be experimented with in the endeavor to get a crop that may be used to maintain the humus content at somewhere near its present amount. This done, and soils of this type may always be designated as strong.

In the vicinity of St. Anthony the surface soil is very gravelly in nature. It varies in depth from eighteen inches to four feet, and overlies strata of practically pure gravel. The soils here have been built up by the action of the river. A particularly gravelly soil is that of the Egin Bench, represented by samples No. 211a and 211b. Both samples were taken from the State Industrial School farm. The first was taken to a depth of twelve inches in a wheat field, the second to the same depth in an adjoining alfalfa field. With a single exception the ordinary interpretation of the analysis of the fine soil from each of these samples, would lead one to consider the soils represented by them as well supplied with all the elements necessary for plant growth. The exception noted is the phosphoric acid content of No. 211a which would be considered low in any case. The ordinary interpretation, however, is likely to prove misleading here for the simple reason that the ratio of fine to coarse soil is very low. If plants, as a rule can get no appreciable nourishment from the particles designated as coarse, then the amounts of available plant food in both soils is necessarily low. To illustrate this point: The fine soils of No. 210a and 211a contain the same percentage of potash soluble in hydrochloric acid. No. 210a is all fine soil, No. 211a contains but twenty-three per cent of fine soil. Wheat sown in soil represented by No. 210a has a supply of potash equivalent to 17,200 pounds per acre foot, while wheat sown in soil represented by 211a has a total of less than 4000 pounds per acre foot to draw upon. In order to be strictly comparable with Nos. 210a and 210b the percentage of the various ingredients in Nos. 211a and 211b should be divided by 4.

The beneficial effects of alfalfa are plainly indicated in No. 211b for the percentages of total nitrogen, humus, and humus nitrogen present in it, are substantially higher than those of No. 211a.

South of St. Anthony the soil is apparently less gravelly. As represented by sample No. 212, seventy-five per cent of it will pass as fine soil. It is of a calcareous nature as indicated by the high percentage of lime stone present. It is exceptionally strong in potash, and phosphoric acid, but only fairly well supplied with nitrogen in available form. This particular sample was taken to a depth of one foot, six miles south of the city.

Farther west, towards Sugar City, high percentages of gravel are again noticeable. Sample No. 213 was taken to a depth of one foot from raw land two miles west from the place of boring for No. 212. The analysis of this sample indicates that the soil here is somewhat similar to that across the river on Egin Bench and represented by samples No. 211a and 211b. Its percentage of available nitrogen is low. When brought into cultivation, attention will soon have to be given to its humus, and humus nitrogen content.

North east of St. Anthony, and south and east of Ashton, a different type of soil is met with. The land here is really bench land, a hundred feet or so higher in elevation than that surrounding St. Anthony. The soil as a rule is only two or three years removed trom the raw state. It is "dry farmed" and the immense crops of small grain harvested indicate a soil of high fertility. The indication is substantiated from the results of the chemical analysis of the two samples taken to represent the section. The soil is a deep sandy loam. No. 214a was taken to a depth of 15 inches in a wheat field just south of Ashton. No. 214b was taken to the same depth on the farm of H. G. Fuller seven miles south east of Ashton. Both analyses indicate exceptionally strong soils. They are particularly high in their content of phosphoric acid, and potash, and well supplied with nitrogen in available form. Alfalfa and clover are already being grown in this section, a fact which means that the supply of soil humus and nitrogen can readily be maintained.

The mechanical composition of each of the soils found in this part of the upper Snake River Valley is fairly represented in the subjoined table of mechanical analyses:

Laboratory Number	Loss on Ignition per cent	Sands per cent	Silt per cent	Clay per cent
211a	4.92	64.96	25.31	8.90
211b	3.03	81.61	9.25	9.61
212	7.53	64.74	23.47	12.43
213	2.26	79.42	11.26	9.35
214a	4.42	80.11	14.64	6.64
214b	4.48	77.04	15.38	8.01

Laboratory Number	215a	215b	215c
Coarse Soil	10.00	15.00	65.00
Fine "	90.00	85.00	35.00
CHEMICAL ANALYSIS OF FINE SOIL			
Insoluble matter	74.80	74.09	68.00
Soluble silica	9.13	8.78	9.32
Potash (K_2O)	.87	.75	.89
Soda (Na_2O)	.45	.61	.64
Lime (CaO)	.90	1.01	1.66
Magnesia (MgO)	.45	.46	.76
Iron oxide (Fe_2O_3)	3.64	3.74	3.10
Alumina (Al_2O_3)	4.18	4.35	6.76
Phosphoric acid (P_2O_5)	.23	.28	.49
Sulphur trioxide (SO_3)	.02	.02	.02
Carbon dioxide (CO_2)	----	----	small
Volatile matter	5.42	6.20	8.09
Total	100.09	100.29	99.73
Total nitrogen	.16	.17	.22
Humus	2.12	2.45	2.76
Humus nitrogen, per ct. in humus	4.97	4,66	4.33
Humus nitrogen, per ct. in soil	.11	.12	.13

The Teton basin, at an elevation of 6000 feet, lies in the extreme south eastern part of the State. The basin extends from north to south and comprises about 100,000 acres of agricultural and grazing land. Through the middle of the basin flows the Teton River which finally reaches the Snake River in the vicinity of Sugar City. The soil is of a very gravelly nature and has not yet been extensively broken up. The three samples whose analyses are given above were taken at the request of Mr. J. D. Kilpac, of St. Anthony, who wished to ascertain their chemical and mechanical composition that he might compare it with that of the soils of the upper Snake River Valley near St. Anthony and Ashton.

No. 215a was taken to a depth of 15 inches on the farm of Carl Johnson, three miles south east of Driggs. Gravel occurs here at a depth of three feet. No. 215b was taken to the same depth on the farm of C. Christenson, four miles south east of Driggs. As the farm lies opposite a canyon from which a small creek finds its way into the river, this soil has been in part built up by the deposit of alluvium carried down from the mountain sides. No. 215c was taken to a depth of 12 inches at the extreme south end of the basin near the town of Victor. These three samples are said to be fairly representative of the soil of the greater part of the basin. With the exception of No. 215c the percentage of coarse material is not unduly high. The analysis of the fine soil in each instance shows a high percentage of potash and phosphoric acid. The phosphoric acid content of No. 215c is exceptionally high, due possibly to the proximity of phosphate deposits in the adjacent mountains. The nitrogen content is high and the humus of fair quality. All three samples represent practically virgin soils. The mechanical analysis of Nos. 215a and 215b is stated below:

Laboratory Number	Loss on Ignition per cent	Sands per cent	Silt per cent	Clay per cent
215a	5.09	71.50	19.05	9.78
215b	7.85	72.78	19.49	8.35

LINCOLN COUNTY

LABORATORY NUMBER	192a	192b	192c	192d	194	219
Coarse soil	......	......	......	......	4.00	......
Fine "	100.00	100.00	100.00	100.00	96.00	100.00
CHEMICAL ANALYSIS OF FINE SOIL						
Insoluble matter	75.43	69.25	81.44	59.43	73.82	70.98
Soluble silica	9.88	13.00	8.21	23.11	9.45	8.85
Potash (K_2O)	.68	.76	.72	.49	.45	.47
Soda (Na_2O)	.41	.32	.04	.96	.64	.30
Lime (Ca O)	.73	.90	.53	.95	4.88	4.50
Magnesia (Mg O)	.84	1.15	.50	1.09	.64	1.31
Iron oxide (Fe_2O_3)	5.74	3.85	5.17	5.45	3.93	3.01
Alumina (Al_2O_3)	2.21	6.26	1.06	4.74	.61	3.64
Phosphoric acid (P_2O_5)	.16	.16	.06	.16	.47	.11
Sulphur trioxide (SO_3)	......	......	......	......	trace	.06
Carbon dioxide (CO_2)	none	none	none	none	1.50	1.57
Volatile matter	3.88	4.28	2.32	3.52	4.06	5.00
Total	99.96	99.93	100.05	99.90	100.45	99.80
Total nitrogen	.04	.05	.03	.04	.03	.06
Humus	poor	poor	poor	poor	poor	.40
Humus nitrogen, per cent in humus	......	......	......	......	......	14.00
Humus nitrogen, per cent in soil	......	......	......	......	......	.06

The first four samples whose analyses are given in the preceding table were sent to the laboratory by Mr. Alexander McPherson of Twin Falls. The particular sections represented by the samples are indicated below:

192a Section 13, Township 4 S, Range 19 E., B. M.
192b Section 11, Township 5 S, Range 17 E., B. M.
192c Section 23, Township 6 S, Range 18 E., B. M.
192d Section 21, Township 5 S, Range 15 E., B. M.

They fairly represent the soils in the vicinity of Shoshone, a little north and west of the center of the county.

Aside from the rather low percentage of phosphoric acid in No. 192c these analyses indicate soils rich in mineral plant food. The percentage of water held at saturation is remarkable. Their one serious defect is the lack of adequate percentages of nitrogen and humus. The amounts present will doubtless be sufficient for one or possibly two crops; but in bringing them into a thrifty state of cultivation, alfalfa as a crop should be given first consideration.

No. 194 is said by Mr. Frank S. Reid to be representative of the soil of his farm in the south western part of Lincoln County near Wendell. A high percentage of lime carbonate characterizes this soil and distinguishes it from those found in the vicinity of Shoshone. Rich in mineral plant food, being far above the normal in phosphoric acid, its nitrogen and humus content must be improved before it can become highly productive.

No. 219 was taken on the demonstration farm of the North Side Twin Falls Land and Water Company located just outside of the town of Jerome. This soil like that near Wendell is highly calcareous. It is rich in potash and fairly so in phosphoric acid. In nitrogen and humus it is decidedly richer than those represented by the samples just mentioned. Practically all of the soil nitrogen is in the humus form, which fact means that it may readily be made available to meet the demands of growing crops. The amount of nitrogen and humus present probably warrants the custom adopted there of growing a crop of potatoes and one of wheat and oats before seeding to alfalfa. The soil is alkaline in reaction but not excessively so. Its water holding capacity at saturation is good.

These soils are all sandy in character. The mechanical analyses of the first four, those from the vicinity of Shoshone, are stated below:

Laboratory Number	Loss on Ignition per cent.	Sands per cent	Silt per cent	Clay per cent
192a	3.19	81.68	9.93	8.40
192b	3.62	68.46	18.39	12.78
192c	2.24	82.10	6.34	11.57
192d	3.40	69.98	12.88	17.14

OWYHEE AND TWIN FALLS COUNTIES

LABORATORY NUMBER	193	149	217a	217b
Coarse soil	......	13.00	......	......
Fine "	100.00	87.00	100.00	100.00
CHEMICAL ANALYSIS OF FINE SOIL				
Insoluble matter	60.39	84.61	57.55	63.66
Soluble silica	16.06	4.48	13.36	14.16
Potash (K_2O)	.97	.44	.48	.62
Soda (Na_2O)	1.16	.33	.16	.16
Lime (CaO)	3.14	1.25	5.05	3.61
Magnesia (MgO)	.87	.21	4.07	2.70
Iron oxide (Fe_2O_3)	5.82	5.38	2.45	2.65
Alumina (Al_2O_3)	5.41	......	6.01	6.05
Phosphoric acid (P_2O_5)	.70	.29	.20	.15
Sulphur trioxide (SO_3)	......	.03	.13	.11
Carbon dioxide (CO_2)	1.25	.75	2.25	1.09
Volatile matter	4.70	1.41	7.63	5.50
Total	100.47	99.18	99.34	100.46
Total nitrogen	.04	.03	.09	.11
Humus	very low	.53	1.16	1.08
Humus nitrogen, per cent in humus	......	5.00	3.92	4.53
Humus nitrogen, per cent in soil	......	.03	.05	.05

Owyhee County.

Owyhee County is thus far represented by one sample only. No. 193 was sent to the laboratory by Mr. A. E. Bailey of Grandview. This particular sample represents the soil of the east end of Grandview Valley, of which about 8500 acres is under irrigation. Bruneau River is the source of water supply for the district. Mr. Bailey took the sample to a depth of 20 inches. He states that it is fairly representative of the whole valley. Sand and gravel underlie the soil at a depth of 4—5 feet. The valley lies 20—50 feet above the Snake River, towards which the land gently slopes. Alfalfa yields exceptionally well, but the people of the valley are planning to plant fruit trees extensively.

The chemical analysis of this sample indicates a soil exceptionally rich in mineral plant food. The high percentages of potash and soda suggested the probability of there being appreciable quantities of the alkali salts present. Such was found to be the case, and Mr. Bailey was advised to that effect. The heavy yields of alfalfa would indicate that there is no trouble at present from this source. The abundance of water, and perfect drainage too, will enable the farmer to wash these salts out should they ever become troublesome. As is the case with most soils in this part of the State, the nitrogen and humus content is low. For horticultural purposes it should be improved in this respect.

Twin Falls County.

Sample No. 149 represents to a depth of ten inches a soil in the vicinity of Twin Falls, and characteristic of that found on the farm of Mr. M. Somischen of that city. The percentage of insoluble matter is unusually high for soils of that section. The mineral matter apparently has not undergone decomposition to the same extent as is usually the case in soils of semi-arid sections. Nevertheless this sample is well supplied with potash, lime, and phosphoric acid. Its weakness lies in its very low nitrogen content. Mr. Somischen was advised that grain growing on this land would probably prove unprofitable until it had been in clover or alfalfa for several years.

Sample No. 217a and 217b are typical of the soil found south and west of Twin Falls. No. 217a was taken to a depth of twelve inches from raw land three miles south west of Twin Falls, just across the road from Mr. Farris' farm. No. 217b was taken to the same depth in an alfalfa field on his farm; the field had been in alfalfa for three years.

The chemical analysis of the samples indicates that each is representative of a strongly calcareous soil and one that will remain productive just so long as its nitrogen and humus content is properly maintained. The fairly high percentage of nitrogen in the raw soil as represented by sample No. 217a explains the two or three heavy yields of wheat and oats from this land before it becomes necessary to seed it to alfalfa or clover. The success of the grain grower, however, even here, will be limited by his ability to maintain the supply of nitrogen by the growth of alfalfa and clover.

The general physical characteristics of the soils whose chemical analyses have preceded, are indicated by the results of the mechanical analyses stated below:

Laboratory Number	Loss on Ignition per cent	Sands per cent	Silt per cent	Clay per cent
193	5.76	62.38	25.05	12.75
217a	5.10	74.35	17.30	8.35
217b	1.61	75.81	15.46	8.42

WASHINGTON COUNTY

LABORATORY NUMBER	206a	206b	206c	206d
Coarse soil	32.00	26.00	13.00	49.00
Fine "	68.00	74.00	87.00	51.00
CHEMICAL ANALYSIS OF FINE SOIL.				
Insoluble matter	43.53	43.24	45.30	44.31
Soluble silica	20.69	20.50	19.71	25.04
Potash (K_2O)	.28	.28	.41	.36
Soda (Na_2O)	.27	.27	.21	.20
Lime (CaO)	1.04	1.18	.82	.77
Magnesia (MgO)	.80	.73	.90	.64
Iron oxide (Fe_2O_3)	12.29	12.36	11.38	13.67
Alumina (Al_2O_3)	11.54	11.49	9.60	6.67
Phosphoric acid (P_2O_5)	.12	.08	.10	.09
Sulphur trioxide (SO_3)	.07	.06	.08	.06
Carbon dioxide (CO_2)	......	......	......	......
Volatile matter	9.36	10.02	10.60	7.49
Total	99.99	100.21	99.11	99.30
Total nitrogen	.15	.18	.21	.14
Humus	3.72	3.87	5.04	2.84
Humus nitrogen, per cent in humus	3.90	4.12	3.79	4.53
Humus nitrogen, per cent in soil	.13	.16	.18	.12

These samples were all taken in the valley of the Weiser River, near Council. They fairly represent the soils of the district known as the J. J. Allison Irrigation tract. No. 206a was taken in a barley field on Middle Fork Hill. It represents to a depth of 8 inches the reddish loam soil of that immediate locality. No. 206b represents to the same depth a very similar soil from raw sage brush land on the School Section. No. 206c was taken to a depth of eight inches from a cultivated field on the Farrill place, and No. 206d to the same depth on the raw land of the Woods farm. These last two samples are very similar in appearance and are typical of the light colored sandy loams of that locality.

Since all of the land represented by these four samples is to be converted into orchard tracts, the samples taken to represent it might very properly have been taken to a greater depth, because the tree roots will soon go below this depth to secure the elements of plant food.

The percentage of potash in Nos. 206a and 206b is a little low for the soils represented by them to be considered more than fairly well supplied with this ingredient. It should be noted however, that the percentage of lime in each case is fairly high, a fact which means that the low percentage of potash will probably prove entirely adequate for the present at any rate. No. 206b is only fairly well supplied with phosphoric acid, but there is sufficient lime present to render this readily available. No. 206c and 206d are very well supplied with all the mineral elements necessary for plant growth, although neither should be regarded as strong in their phosphoric acid content. In humus content these soils resemble the soils from humid more closely than those from semi-arid regions. The percentage of nitrogen present indicates an adequate supply of this element and it is practically all in the readily available form as indicated by the amounts of humus nitrogen calculated to percentage of the soil.

The soils represented by the samples whose analyses have been given and commented on in the preceding pages are all known from my own observations to be characteristic of large areas in the semi-arid portion of the state. Practically all the land represented by these samples is either already in the process of agricultural development or soon will be. None of it is many years removed from the raw condition. In some sections certain undesirable physical characteristics such as, lime stone hard pan, "slick spots," high percentages of coarse gravel, and outcroppings of lava rock, are known to be prevalent, and wherever they are so, they should certainly be given careful attention by the settlers or prospective settlers. As a rule the comparatively low percentages of insoluble matter indicate soils whose minerals have undergone decomposition to an unusual degree. The soluble compounds resulting from the weathering or partial decomposition of the parent minerals have not been leached out and carried by water to the ocean but remain in the soil to render it potentially rich in all the mineral elements necessary for plant growth. With but very few exceptions, the natural agencies at work in the formation of these soils have built up the mineral, or inorganic, at the expense of the organic portion. Where no serious difficulty is experienced with such bad physical conditions as those mentioned above the one thing required to render these soils highly and permanently productive is the incorporation of more nitrogenous organic material with the mineral matter. Fortunate will be the farmer of that section who clearly and early comprehends this fact and provides in his system of rotation a prominent place for alfalfa and clover.

Percentage Composition of Soils of the Humid Sections by Counties

BONNER COUNTY

Laboratory Number	145a	145b	145c	145d	145e	204	209	331
Coarse soil	......	......	35.00	8.00	30.00	30.00	......	......
Fine "	100.00	100.00	65.00	92.00	70.00	70.00	......	100.00
CHEMICAL ANALYSIS OF FINE SOIL								
Insoluble matter	74.36	43.40	70.05	67.26	64.09	74.86	75.32	67.75
Soluble silica	12.15	26.28	11.96	12.14	15.60	7.93		
Potash (K2 O)	.66	.44	.25	.35	.39	.30	.36	.37
Soda (Na2 O)	.45	.34	.57	.39	,53	.24	......	......
Lime (CaO)	.90	.10	.63	.61	.58	.81	.78	1.03
Magnesia (MgO)	trace	trace	trace	trace	.74	.42	......	.31
Iron oxide (Fe2 O3)	3.04	4.44	3.27	3.70	4.35	2.26	......	12.38
Alumina (Al2 O3)	5.86	10.13	6.45	7.53	5.32	7.46	......	
Phosphoric acid (P2 O5)	.09	.15	.56	.28	.28	.43	.41	.19
Sulphur trioxide (SO3)	none	none	none	none	none	.04	......	......
Carbon dioxide (CO2)	......	......	......	......	......	......	......	......
Volatile matter	3.09	14.37	6.09	6.23	7.81	5.70	......	16.55
Total	100..60	99.65	99.83	98.49	99.69	100.43	......	......
Total nitrogen	none	.16	.08	.11	.17	.10	.11	......
Humus	none	good	fair	good	good	1.36	......	......
Humus nitrogen, per cent in humus	......	......	......	......	......	6.62	......	......
Humus nitrogen, per cent in soil	......	......	......	......	......	.08	......	......

Samples No. 145a to 145e inclusive were sent to the laboratory by Mr D. Mihills of Spokane, Washington. He states that they are representative of soils in the Pend d'Oreille River Valley near the boundary line between Idaho and Washington. (These samples were taken in sections 4 and 5 in township 55 N. R. 4 West B. M. on the south side of the river.) A few years ago these sections were heavily timbered. At the time these samples were taken the heavy timber had been cut, and the light growth together with most of the stumps from the heavy growth had been grubbed out. Mr. Mihills made particular inquiry regarding the suitability of the soils represented by these samples for orchard purposes. He has recently planted them largely to winter apples.

No. 145a represents a very light colored surface soil close to the river. Away from the river it becomes a sub-soil to the soils represented by the remaining samples. The chemical analysis shows it to be practically devoid of nitrogen and humus, rich in potash and lime, and fairly well supplied with phosphoric acid. It should be heavily manured before attempting to grow anything upon it. No. 145c represents a soil of a very similar character farther back from the river. It is probably the result of the first type coming close to the surface as a subsoil and becoming more or less incorporated with the alluvium carried down from the near-by hills. It is fairly well supplied with nitrogen and humus, rather poorly with potash, but exceptionally well with phosphoric acid. Nos. 145b, 145d, and 145e, are apparently representative of alluvial and colluvial soils carried down from the adjacent hillsides. With one exception, No. 145b, the samples are representative of soils fairly well supplied with lime. Of nitrogen and humus all three samples give evidence of an abundant supply. Nos. 145d and 145e indicate soils particularly rich in phosphoric acid.

In company with Mr. Mihills, I visited his farm for the purpose of becoming better acquainted with local conditions and surroundings. My personal observations, coupled with the information gained from the preceding analyses, lead me to believe that no mistake has been made in planting so largely to apple trees.

Sample No. 204 is typical of bench land on the west side of Pend d'Oreille Lake. It was sent in by Mr. S. G. Humphrey of Sagle, ten miles south east of Sandpoint. The soil represented by this sample is timber soil not yet cleared and brought into a state of cultivation. It is apparently fairly well supplied with nitrogen in available form, but its potash content will probably be found low, since the percentage given in the table is calculated on the fine soil only. In phosphoric acid, like those from farther down the river, it is exceptionally rich.

No. 209 is a sample sent to the laboratory by Mr. Edwin Smith of the Twice-a-Week Spokesman-Review, who states that it represents bench land near Bonner's Ferry, The partial analysis indicates that the soil found here possesses the same general characteristics as the bench land south of Pend d'Oreille Lake,

No. 331 represents a different type of land than any of the preceding samples. It was sent to the laboratory by Mrs. Cora Clagstone, who states that it was taken from an alder bottom on the Clagstone ranch in the southern part of Bonner county. Similar soil had been used as a top dressing for the light and shallow soil of her garden. The sample is typical of considerable areas in that part of the county which are in need only of drainage and aeration to render them highly productive, provided proper climatic conditions prevail.

There is an opinion prevalent among the farmers of this county that all of their soils are in need of heavy applications of limestone. The chemical analyses partially support this opinion. In one instance only was lime found to be actually deficient. Nevertheless all of the soils examined are decidedly acid in reaction. This fact means that there is as a rule too little of the lime in the form of a carbonate to neutralize the organic acids formed by the decomposition of the organic material present in the soils. An acid condition of the soil prevents to a greater or less degree the highest development of cultivated plants. The application of from 1500 to 2000 pounds per acre of finely powdered limestone will doubtless prove beneficial in most instances. Heavy dressings of manure are also recommended for these and similar soils. A mechanical analysis was made of Nos. 204 and 331; the results are stated below:

Laboratory Number	Loss on Ignition per cent	Sands per cent	Silt per cent	Clay per cent
204	6.00	74.17	20.41	6.00
331	16.26	39.09	39.87	21.04

KOOTENAI COUNTY

Laboratory Number	97	200	325a	325d	325f	325g	325i	325k	325l	325m
Coarse soil	55.00	......	......	......	......	......	......	......	......	......
Fine "	45.00	......	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CHEMICAL ANALYSIS OF FINE SOIL										
Insoluble matter	71.72	71,38	70.11	70.20	72.43	63.08	71.21	73.67	80.03	55.31
Soluble silica		7.89								
Potash (K2 O)	.30	.63	.40	.32	.43	.46	.51	.56	.55	.50
Soda (Na2 O)	.49	.50	.22	.24	,19	.26	.35	.41	.33	.40
Lime (CaO)	1.10	.73	.32	.23	.34	.31	.53	.35	.40	.33
Magnesia (MgO)	.75	1.00	.58	.15	.43	.29	.48	.67	.95	.39
Iron oxide (Fe2 O3)	2.88	8.09	2.86	2.71	2.66	2.82	3.37	4.19	3.59	2,74
Alumina (Al2 O3)	7.53	4.24	8.91	9.08	6.31	8.93	8.89	9.39	5.88	4.44
Phosphoric acid (P2 O5)	.28	.32	.25	.18	.24	.24	.21	.26	.23	.23
Sulphur trioxide (SO3)	......	......	.12	.15	.14	.15	.12	.20	.11	.20
Carbon dioxide (CO2)	......	......	.06	......	......	......	.04	......	......	......
Volatile matter	12.99	5.70	15.28	15.79	16.35	22.42	14.10	9.47	7.52	34.35
Total	98.04	100.48	99.11	99.05	99.52	98.96	99.81	99.17	99.59	99.94
Total nitrogen	.24	.06	.57	.53	.66	.83	.54	.32	.24	1.46
Humus	5.75	1.08	rich	rich	rich	rich	rich	good	good	rich

The samples from Kootenai County are fairly representative of three types of soil, each of which is characteristic of large areas. No. 97 was sent to the laboratory by Mr. J. W. Buchanan of the Spokane High School. Mr. Buchanan took this sample from his own forty acre tract near Hayden Lake. He states that it represents to a depth of fifteen inches the surface soil which in that locality seldom exceeds thirty inches in depth. The subsoil is a yellowish clay mixed with gravel and boulders. In color the surface soil is a dark brown. It holds water well, seldom requiring irrigation before July 1st. Before it was platted the land had been used for growing timothy and potatoes; neither crop grew thriftily. An attempt to grow sugar beets upon it proved a flat failure. At the time the sample was taken a part of the tract had been planted to winter apples.

A personal investigation showed Mr. Buchanan's tract to be typical of the open country to the west of Hayden Lake and of the upper portion of the Spokane Valley. The chemical analysis of the fine soil of this sample indicates an abundance of potash, lime, phosphoric acid and nitrogen. Unfortunately the percentage of fine soil in the sample is very low. This means that the amount of potash present may be inadequate to meet the demands of such crops as potatoes, and sugar beets, both of which are heavy potash feeders. Although the supply of nitrogen and organic matter appears adequate, the application of large quantities of manure will prove beneficial. An application of from 1500 to 2000 lbs. of limestone will be necessary to correct the acidity present.

No. 200 is representative of the timber soils found at an elevation of 2500 to 3300 feet in the south eastern part of the county. It was sent to the laboratory by Mr. C. D. Phillips of Santa. He states that garden truck of all kinds fails to make a thrifty growth in the soil represented by it. The chemical analysis shows the sample to be well supplied with the mineral elements required in plant nutrition, but weak in nitrogen. Mr. Phillips was advised to make use of lime to correct the acidity, and since the use of liberal quantities of manure is out of the question, (there being no live stock in the neighborhood as yet) he was also advised to attempt the growth of clover, cow peas, or other leguminous crop, with the intention of plowing it under, and thereby begin the improvement of his soil on its weak side—the organic.

Samples No 325a to 325m inclusive, represent the third type of soil found in this county and examined in the laboratory. These samples are characteristic of the meadow lands bordering the St. Joe River between St. Maries and Chatcolet. The valley lands have been built up in past geological times by the gradual deposit of alluvium carried by mountain streams to the low lands from the drainage basin of the St. Joe River, and by the decay of such vegetation as usually flourishes on low lands when subject to periodic inundation.

The general character of the soil of the entire valley is clearly shown from the mechanical analyses of many samples taken from each of the several meadows and examined in detail by Professor Childers of the Department of Agronomy. The soil on and near the river banks is a fine sandy loam; this blends into a fine silty loam as distance from the river and towards the foothills is gained.

The particular portion or the valley represented by each of these samples is indicated below. The designation is that applied locally:—

Laboratory Number.	Tract Represented.	Laboratory Number.	Tract Represented.
325a	Cherry Creek Meadows.	325i	Bridge Meadows.
325d	Big Meadows.	325k	Chatcolet Meadows.
325f	Meadows on Secs. 15-22.	325l	River Bank soil.
325g	Goose Heaven Meadows.	325m	Diked (cultivated) soil near St. Maries.

As would be expected from the mode of formation, the results of examinations made in the field and supplemented later by laboratory examinations indicate that to the sub-surface soil, at least to a depth of four and five feet, may be ascribed the same general characteristics as regards both mechanical and chemical composition as that possessed by the surface soil. This land, if properly drained and areated, and subjected to intelligent cultivation, without doubt will prove to be exceptionally productive, and particularly so if devoted largely to truck farming. When brought into a state of cultivation an application of lime will hasten the correction of its acidity, which at present is accentuated by the continuous flooding to which the land has been recently subjected. Its depth and mechanical composition insures an almost unlimited feeding range for plant roots, and chemical analysis reveals vast stores of humus and nitrogen, together with an abundance of all of the mineral elements required in plant nutrition.

LABORATORY NUMBER	151a	151b	201a	201b
Coarse soil	4.00	4.00	......	......
Fine "	96.00	96.00	......	......
CHEMICAL ANALYSIS OF FINE SOIL.				
Insoluble matter	68.23	69.33	70.00	72.77
Soluble silica	12.00	11.05	9.85	8.34
Potash (K_2O)	.53	.57	.57	.60
Soda (Na_2O)	.31	.19	.50	.41
Lime (CaO)	.90	1.05	.83	.86
Magnesia (MgO)	.33	.79	.82	.78
Iron oxide (Fe_2O_3)	6.12	4.51	8.27	9.65
Alumina (Al_2O_3)	3.87	6.08	4.00	2.64
Phosphoric acid (P_2O_5)	.13	.37	.24	.25
Sulphur trioxide (SO_3)	trace	trace	trace	trace
Carbon dioxide (CO_2)	......	......	......	.....
Volatile matter	7.58	5.83	5.31	4.00
Total	100.00	99.77	100.39	100.30
Total nitrogen	.16	.19	.07	......
Humus	2.61	2.45	.92	......
Humus nitrogen, per cent in humus	3.60	6.22	......	......
Humus nitrogen, per cent in soil	.09	.15	......	......

No. 151a and 151b surface and subsurface samples respectively, represent the soil of an orchard ract in the immediate vicinity of Moscow. Since they were taken from the north side of a rather steeply inclined hill, they may be regarded as typical of rather limited areas only in the Palouse Country. To a limited degree the soil represented by them is Aeolian (wind-formed) in character, a fact which accounts for its unusual depth. The chemical analysis shows both surface and sub-surface soil to be well supplied with potash and phosphoric acid. The application of a potash fertilizer and one containing iron sulphate with the object in view of intensifying color in Jonathan and Rome Beauty apples, gave negative results. The trees apparently are securing a sufficiency of all the elements they can use in the elaboration of new growth and fruit. The percentage of total nitrogen is high, and while the percentage of humus appears low, nearly 60 per cent of the total nitrogen in 151a and 80 per cent of the total nitrogen in 151b is in the form of humus; this indicates that the humus is of good quality and insures an adequate amount of nitrogen in an easily available form.

The timber soil of eastern and northern Latah County is represented by samples No. 201a and 201b. It would appear from the analysis of these and preceding samples representing timber soils, that they are all exceptionally rich in phosphoric acid. These particular samples are rather weak in their humus and total nitrogen content. Improvement in this respect will be found necessary when the soil represented by them is brought into a state of cultivation. Like samples from the timber soils of Bonner and Kootenai counties, these indicate a deficiency in the amount of lime in the form of carbonate necessary to neutralize the acidity resulting from the decay of organic matter. It is probable that with the clearing of this land, deep plowing and thorough cultivation will overcome at least a portion of the acidity, and that the application of large amounts of limestone for this purpose will not be found necessary or advisable.

A mechanical analysis of each of these four samples has been made; the results appear below:—

Laboratory Number	Loss on Ignition per cent.	Sands per cent	Silt per cent	Clay per cent
151a	7.04	60.92	30.48	8.97
151b	5.78	64.20	21.33	14.47
201a	5.06	55.33	28.06	16.55
201b	4.14	58.90	29.13	12.20

NEZ PERCE COUNTY

LABORATORY NUMBER	147a	147b	147c	147d	147e
Coarse soil	......	.....	......	......	......
Fine "	100.00	100.0	100.00	100.00	100.00
CHEMICAL ANALYSIS OF FINE SOIL					
Insoluble matter	60.50	61.06	60.79	61.38	63.08
Soluble silica	21.00	21.08	22.21	20.44	18.84
Potash (K_2O)	.53	.53	.52	.85	.81
Soda (Na_2O)	.94	.47	.56	.37	.54
Lime (CaO)	1.33	.95	.87	1.86	.72
Magnesia (MgO)	1.08	.99	.94	.36	.32
Iron oxide (Fe_2O_3)	6.24	4.50	3.44	6.23	6.86
Alumina (Al_2O_3)	3.48	4.86	5.55	3.57	3.45
Phosphoric acid (P_2O_5)	.24	.25	.18	.14	.10
Sulphur trioxide (SO_3)	trace	trace	trace	trace	trace
Carbon dioxide (CO_2)	......	......	......	......	......
Volatile matter	4.05	4 34	4.06	4.33	4.57
Total	99.39	99.03	99.12	99.53	99.29
Total nitrogen	.06	.08	.08	.08	.09
Humus	.60	,95	.80	.82	.86
Humus nitrogen, per cent in humus	8.45	5.17	6.20	7.50	8.50
Humus nitrogen, per cent in soil	.05	.04	.04	.06	.07
Available phosphoric acid (P_2O_5)	.023	.029	.037	.038	.025

At the request of the management of the Lewiston Land and Water Company I personally visited the various tracts included in the holdings of that company on the bench lands south and east of Lewiston. Samples 147a to 147e were taken at that time for laboratory examination. Since the various tracts were to be set almost entirely to fruit the samples were taken to a greater depth than is ordinarily the practice. These samples represent the soil to a depth of eighteen or twenty inches. The first three samples are representative of what is designated as the first segregation, 147d of Block 32, and 147e of a later segregation which has been set to grapes. The land represented by the first four samples has been in cultivation for a number of years; that represented by 147e is but three or four years removed from the raw or sage brush condition. The entire area is under irrigation.

The soil of the various tracts closely resembles that from the semi-arid sections of the state, a sandy loam predominating. Chemical analysis indicates an abundance of potash. In phosphoric acid the new land is weaker than the land that has been in cultivation for years, but should not be regarded as at all deficient in this particular. Like typical soils from the semi-arid sections, this one is low in total nitrogen and humus, but from fifty to seventy-five per cent of the total nitrogen is in the form of humus, as indicated by the per cent of humus nitrogen in the soil. Considering the ease with which alfalfa and clover can be grown in this section, there should be no difficulty experienced in maintaining a sufficient amount of humus to meet all of the requirements in first class orchard soil.

In connection with the work on this soil, a question was raised regarding the availability of the phosphoric acid. It is generally conceded that a two per cent solution of citric acid will dissolve from a soil all of the lime phosphate that can be considered sufficiently soluble to enable a plant's roots to secure the supply of phosphorus demanded by it in the elaboration of its different parts. A determination of the so called "available" phosphoric acid was made on each of the samples from this section. The results indicate a liberal quantity of phosphorus in "available" condition.

The sandy loam character of this soil is indicated in the table below, two analyses only being made.

Laboratory Number	Loss on Ignition per cent	Sands per cent	Silt per cent	Clay per cent
147b	4.40	75.96	20.35	3.41
147c	4.29	74.35	21.89	3.90

A number of the samples from the north part of the state, like those from the south part, are characteristic of large areas of practically undeveloped lands. Extensive tracts of river valley, of bench and high land in Bonner, Kootenai, and Latah Counties are at present awaiting agricultural development. The first step in this process must be the clearance of the stumps and underbrush left by the lumberman. Our analyses indicate that as a rule these lands are *rich* in all of the *mineral* elements necessary for plant growth. In some instances the application of limestone as a corrective for soil acidity will be found advisable, but the farmer will not be confronted by the necessity of purchasing expensive potash and phosphate fertilizers. The burned over timber lands will be found deficient in *nitrogen* and *humus,* but the ease with which the legumes can be grown on them renders their improvement in this respect, a matter easy of accomplishment. *These lands no doubt will prove to be exceedingly productive when once brought into a state of cultivation.*

The productive capacity of the greater part of the older cultivated lands in the north—those in Latah, Nez Perce, and Idaho counties—is truly remarkable. Chemical analyses of samples representative of these lands uniformly indicate soils rich in all the mineral elements of plant nutrition. In their potential richness, however, there lies a danger—that of careless treatment. *Although potentially rich their fertility is not inexhaustible.* In many districts evidence of a depletion of soil humus and nitrogen is already painfully apparent. Particularly is this true of the exclusive wheat and small grain growing districts. The one thing needful to maintain indefinitely the fertility of these lands is a system of crop rotation that permits of a restoration of soil humus and nitrogen.

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