THE RELATION OF THE PRODUCTIVITY OF CERTAIN SOIL AREAS IN THE WILLAMETTE VALLEY TO THE INTERNAL ORGANIZATION OF FARMS IN THE REGION

by

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GENERALIZED LAND PRODUCTIVITY AREAS
WILLAMETTE VALLEY, OREGON

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FOR COUNTY SOIL SURVEY MAPS
WHICH ARE THE BASIS FOR THE GROUPING SHOWN
BASE MAP BY COURTESY OF
PACIFIC NORTHWEST FOREST EXPERIMENT STATION
1936

SCALE
5 4 3 2 1 0 5 10 MILES

LEGEND

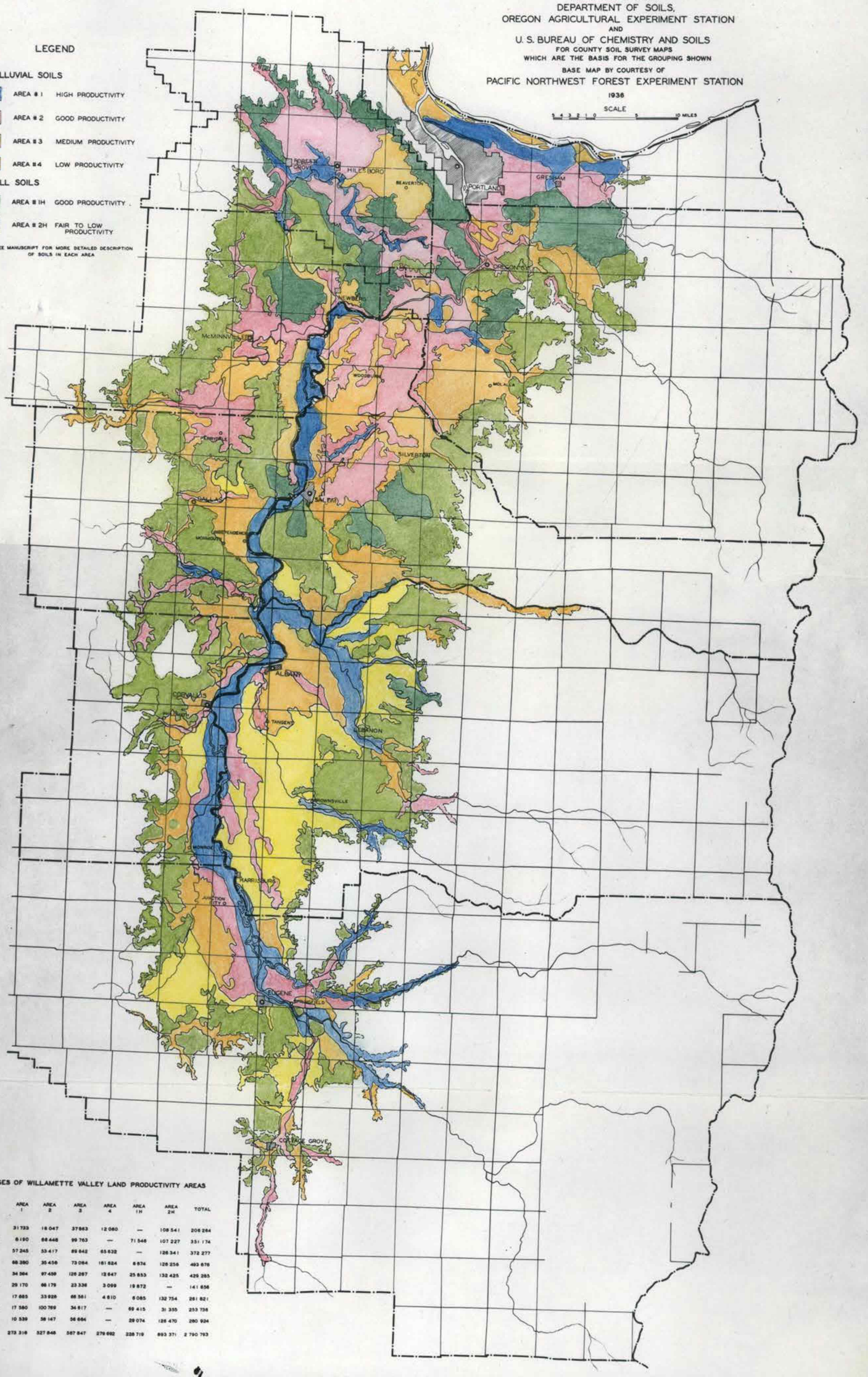
ALLUVIAL SOILS

- AREA # 1 HIGH PRODUCTIVITY
- AREA # 2 GOOD PRODUCTIVITY
- AREA # 3 MEDIUM PRODUCTIVITY
- AREA # 4 LOW PRODUCTIVITY

HILL SOILS

- AREA # 1H GOOD PRODUCTIVITY
- AREA # 2H FAIR TO LOW PRODUCTIVITY

SEE MANUSCRIPT FOR MORE DETAILED DESCRIPTION OF SOILS IN EACH AREA



ACREAGES OF WILLAMETTE VALLEY LAND PRODUCTIVITY AREAS

COUNTY	AREA 1	AREA 2	AREA 3	AREA 4	AREA 1H	AREA 2H	TOTAL
BENTON	31 733	18 047	37 863	12 080	—	106 541	206 264
CLACKAMAS	6 190	68 448	99 763	—	71 548	107 227	351 174
LANE	57 245	53 417	89 842	65 632	—	126 341	372 277
LINN	68 380	35 456	73 084	181 624	8 574	126 256	493 676
MARION	34 864	97 458	126 267	12 647	25 853	132 425	429 265
MULTNOMAH	29 170	66 179	23 336	3 099	19 872	—	141 656
POLK	17 685	33 928	66 561	4 810	6 085	132 754	261 821
WASHINGTON	17 580	100 789	34 817	—	69 415	31 355	253 736
YAMHILL	10 539	38 147	56 684	—	29 074	126 470	280 924
TOTAL	273 316	527 848	567 847	279 692	228 719	893 371	2 790 793

INTRODUCTION

Peter Kropotkin, famous geographer of the last century, once said that a skilled French gardener could produce excellent crops on asphalt pavement. Soil was part of his transportable equipment. If he was forced to change his location, he painstakingly carried his soil with him, spread it on the new site, and continued business as before. A more modern way of beating Nature at her own game is to grow grain and vegetable crops on a wire netting and burlap support in nutrient solutions, as Dr. Gericke (6) has done at Berkeley.

The agricultural industry in the world around us, needless to say, manifests little of such independence of natural physical conditions. Modifications can be made in the way of drainage and fertility improvement, but we have not succeeded in making naturally poor soils into good ones on a large scale basis. An outstanding problem, consequently, is to adapt farming to the varying soil conditions that exist.

A recent attitude toward this problem of agricultural land utilization is that it can be met most effectively through application of good principles of farm management: a farm of proper organization in respect to choice of enterprises and size of business, situated on poor soil, may succeed as well as a farm on good soil. A good soil may, indeed, be regarded in an economic sense as one having a relatively large number of possible uses, and a poor soil as one having few. Thus the strictly qualitative connotation which usually accompanies the mention of "good"or"poor" soil may be avoided.

It seems sound to regard the agricultural land use problem as being one primarily of adapting farm units to their physical substratum. Yet the fact that a particular soil area may be utilized successfully in several different ways over a period of time, and that changes in land value may cause different uses, indicates that our process of adjustment must be dynamic. It must be responsive to economic influences. The physical characteristics of land determine the range of possible uses, and within this range economic factors cause present uses to be selected. These forces are subtle, implicit in the circumstances that surround us, and their effects are in the long run irresistible.

While the immediate purpose of the present thesis study is to show the relation between soil quality and certain features of farm organization, it may be regarded, also, as a report showing the response Willamette Valley agriculture has made to its physical and economic stimuli since development began nearly a century ago. Our present mode of adaptation stands in tacit contrast to that of the pioneer period, when all uses were extensive, - hay, grain, and livestock farming, - and farm ownership units were of approximately uniform sizes. An agricultural community apparently undergoes a periodic development which may be broadly outlined as follows: (1) The period of settlement, marked by uniformity in farm organization and the extensive types of utilization of land. (2) The middle period, during which intensification and specialization occur. And (3) the period of comparative stability, after a more or less permanent adaptation in enterprises

and farm organization has been achieved, as the result of stabilized demands for land and products.

That we are in the middle period, and still far short of a maximum utilization of our soil resources, is clearly shown in Part III of this study.

OBJECTIVES

Specific objectives of this study were:

I. To classify Willamette Valley land into areas having fairly uniform conditions of physical productivity.

II. To compare the areas as classified in respect to important features of farm organization: (1) the choice of enterprises; (2) the size of business, as measured by acreage per farm and by labor input; and (3) the quality of business as shown by crop yields.

III. To interpret the data obtained in-so-far as they indicate the present stage of intensification and specialization.

METHODS

I. Classification of Willamette Valley land into areas having approximately uniform capacity for producing crops was accomplished by (1) grouping the alluvial soil series, and generalizing the county soil survey maps on the basis of this grouping, and (2) designating hill soil areas with regard to soil types and particular local conditions which affect crop production, such as depth of soil, and slope.

II. Comparison of the generalized land areas in regard to important features of farm organization was accomplished by obtaining records of approximately 2000 farms in the nine Willamette Valley counties, locating the farms in reference to the land areas, and tabulating data for each area separately. A measure of the intensity of farming was established by determining the approximate amounts of labor required for producing Willamette Valley crops, and applying this measure to each farm.

SOURCES OF DATA

Records of the use of land and inventories of livestock for 991 farms were supplied by the Oregon Experiment Station, Department of Farm Management. These field records were obtained originally for studies showing the costs and efficiency in various Willamette Valley enterprises and the organization of some of the major types of farms. Crop yield data were available for 330 of these records.

An additional 925 records showing the use of farm land were obtained from A. A. A. wheat allotment contracts. The inventory of livestock, which was necessary to complete these records, was procured from county assessor's offices. Yields of wheat for the base period 1930-33 were shown for 914 of these farms.

The remaining 9 records, making a total of 1924, were obtained from Federal Land Bank appraisers' reports.

The crop land on the farms studied is approximately 18% of the total crop land in the nine Willamette Valley counties, as reported by the 1930 U. S. Census, and the total land in the farms is approximately 13% of the land in farms in the Valley. Tables 1 and 2 show specifically the sources of the records and the scope of the study.

Attention should be called to the character of the sample providing data used for this study. Unavoidably, since the farm records were obtained primarily with other objectives in view, there is some lack of homogeneity in the sample. The large number of the records, and the amount of data covered in the averages,

however, tends to obliterate such a lack of homogeneity, and leaves the main conclusions well supported. See Appendix Table 1 for a comparison of the sample, on certain points, with the U. S. 1930 Census.

Table 1. SOURCES OF THE RECORDS

County	Enterprise cost studies Department of Farm Management Oregon Agricultural Experiment Station								A.A.A. wheat allotment contracts	Federal Land Bank Appraisers reports	Total
	Pasture study	Poultry study	Prune study	Dairy study	Flax study	Turkey study	Forage study	Hop study			
Benton	17	11		24			21		48	4	125
Clackamas	19	21		40	61	1	11	5	149		307
Lane	26	16		44		5	18	5	117	1	232
Linn	11	10		36	14	7	24	1	98	4	205
Marion	17	16	5	31	26	3	21	34	138		291
Multnomah	17	9		27							53
Polk	21	12	13	22			15	14	100		197
Washington	26	17	34	51			16		109		253
Yamhill	21	8	1	31	8	2	16	2	172		261
All counties	175	120	53	306	109	18	142	61	931	9	1924

Table 2. SCOPE OF THE STUDY

County	Number of farms	Crop acreage studied	Total crop acreage by census*	Percentage of crop acreage studied	Total farm acreage studied	Total farm acreage by census*	Percentage of acreage studied
Benton	125	15098	61365	25	36294	222253	16
Clackamas	307	17732	111910	16	33388	290573	11
Lane	232	21040	120681	17	45731	460530	10
Linn	205	21453	170146	12	40209	468706	8
Marion	291	30666	185319	16	51053	399563	13
Multnomah	53	2582	30883	9	8072	76113	11
Polk	197	28590	114749	25	48380	245363	20
Washington	253	22622	122460	18	34717	234798	15
Yamhill	261	33443	124690	26	53820	287771	19
All counties	1924	193226	1042203	18	351664	2685670	13

* United States Census, 1930

Part I. THE PHYSICAL PRODUCTIVITY OF WILLAMETTE VALLEY LAND

A designation of land areas which have approximately uniform capacities for producing crops is a relatively simple undertaking in the Willamette Valley, because soil surveys of all counties in the region have been completed by the Oregon Experiment Station, in cooperation with the United States Bureau of Soils. One can readily complete a broad and fairly accurate classification by grouping the soil series, or the soil types, and generalizing the county soil maps.

Storie and his associates (1), in California, have used the soil type as the unit of classification. Kellogg's (2) system, also, involves the use of basic ratings for the soil types. Bruce and Metzger (3) have made a soil productivity classification in Maryland, on the type basis. Powers (4) evaluates the soil types separately, in a report upon the general agricultural value of Willamette Valley alluvial soils. It is evident in Powers' report, however, that the textural subdivisions of the soil series do not differ materially in capacity for producing crops. The maximum range of texture in the more important and widely distributed Willamette Valley soils is from loam to silty clay loam. Hence the textural limitation is usually absent. It was felt, therefore, that a satisfactory basis for a general classification of the alluvial soil areas might be made by grouping the series.

Productivity Groupings For The Alluvial Soil Series

Preliminary to grouping the various alluvial soil series it is well to have in mind an elementary knowledge of the origin of these soils, since such a knowledge helps us to understand their present agricultural values.

Allison (5) has quite definitely established that each of the four great glacial epochs has left as its heritage in the Willamette Valley a group of deposits which later developed characteristic soils. Ice, which collected on the slopes of the Cascades and the Coast Range simultaneously with the formation of the great continental glaciers, moved toward the foothills of the Valley, and, as it melted, discharged large quantities of outwash material upon the valley floor. Much of this material was removed by the Willamette and its tributaries, during the interglacial epochs, but appreciable quantities remain as terraces representing former valley floor levels.

An occurrence of far-reaching consequences closed this series of geological processes. The Columbia River gorge was partially dammed by floe ice, below its confluence with the Willamette. As a result, the Willamette Valley was transformed into a back-water lake for a considerable length of time, or possibly during several succeeding periods, and a large body of silt was deposited upon the valley floor. This raw silt covered all but the higher terraces of older soil materials, and from it has been weathered our most widely distributed soil series. The accompanying Table 3 shows the geological origin of Willamette Valley's alluvial soil materials.

Table 3. GEOLOGICAL ORIGIN OF WILLAMETTE VALLEY ALLUVIAL SOIL MATERIALS*

Pleistocene Period				Recent Period
Nebraskan Glacial Stage	Kansan Glacial Stage	Illinoian Glacial Stage	Wisconsin Glacial Stage	
600,000 to 750,00 years ago	400,000 to 500,000 years ago	150,000 to 200,000 years ago	15,000 to 30,000 years ago	Contemporary
Local materials	Local materials	Local materials	Imported materials	Local materials
Deposits practically obliterated. Few remnants of very old gravel, mostly on hilltops at 500-600 feet elevation, notably at Lacomb, and N. E. of Buell.	Salkum (mainly from old Cascade materials) Veneta (mainly from old Coast Range materials Probably Powell, as a loessial, or an alluvial, deposit .	Clackamas Holcomb Courtney Sifton (?) Grand Ronde (in part) Salem (in part)	Willamette Amity Dayton Concord Grand Ronde (in part) Salem (in part)	Newberg Chehalis Columbia Camas Cove Wapato Whiteson Sauvie Toutle Muck and Peat

* Based on Ira S. Allison: Pleistocene Alluvial Stages of Northwestern Oregon, Science, n. s., vol. 83, in press.

The character of the original materials has a strong, but decreasing, effect upon the ultimate composition of a soil. Any soil material which is exposed to our humid, moderate climate will undergo internal changes of approximately the same kind. The basic nutrients, and also the finely divided colloidal material, will leach downward. The depletion of calcium will tend, eventually, to make the active colloidal portion of the soil unstable. Acidity will increase, and the soil colloid may finally disintegrate into simple compounds. Since these processes are constantly at work, and may be retarded only by a change in climate or the acts of man, the relative ages of Willamette Valley alluvial soils may be supposed to have a close connection with their present productivity. This supposition is supported by the fact that none of the soils of the Kansan and Illinoian glacial stages, with the exception of Powell, is regarded as being a strong soil. Powell's resistance to aging may reasonably be attributed to its loessial origin.

Among the younger soils, the principal factors which have influenced present productivity are topographical situation, and the direct effect of original composition. The Willamette-Amity-Dayton group of soils illustrates the former. These soils are apparently of the same age and weathered from identical materials. Willamette occupies areas that have been subject to free drainage; Amity occupies areas which have had somewhat restricted drainage; and Dayton occupies broad, flat areas which are subject to seasonal waterlogging. Pedologists* recognize that soils situated in the

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* C. F. Marbut. A Scheme For Soil Classification. Proc. and Papers of First Int. Congress of Soil Science. pp 8.

topographical position of Dayton cannot develop normal, mature profiles. Colloidal material will be precipitated, early in the life of such a soil, in the zone so much influenced by the water table, and the drainage pores will become "plugged."

Willamette Valley alluvial soils which have adverse original compositions are the heavy clays, such as Cove, and the droughty soils, too light-textured, such as Toutle or Camas.

The Willamette Valley alluvial soils were grouped as follows:

Group 1. Soils of high physical productivity, and having a maximum range of possible uses. All are irrigable, and naturally suited for intensive cultivation.

NEWBERG - A soil composed of recent stream alluvium, occupying "first bottom" locations.

CHEHALIS - A soil composed of recent stream alluvium, occupying "second bottom" locations.

COLUMBIA - A soil composed of recent Columbia River alluvium, and closely related to the Newberg series in respect to profile characteristics and circumstances of origin.

HILLSBORO - A sister soil to the Willamette series, but having somewhat better drainage and irrigability conditions.

MUCK and PEAT - Soils of high organic content; often called "beaverdam." Drained areas were included in Group I.

Group II. Soils of good physical productivity, and having a wide range of possible uses.

WILLAMETTE - A well-drained and irrigable member of the Wisconsin group of old valley filling soils.

SALEM (if gravel free) - A soil weathered principally from re-worked alluvial material. Areas where cobbles and gravel were present in the top-soil were dropped to Group III. Salem is irrigable, but its sub-soil is often too open to permit an efficient use of water.

SAUVIE (if drained) - A recent soil, low-lying and subject to seasonal flooding. Areas which have been successfully dyked and drained were included in Group II.

Group III. Soils of medium physical productivity, and having a limited range of possible uses.

AMITY - A soil the physical condition of which has been somewhat impaired by restricted drainage. It has fair irrigability.

CAMAS - A soil composed of coarse-textured recent alluvium. The presence of gravel, a lack of active colloidal material, and a tendency toward excessive drainage are its chief physical deficiencies. It is irrigable.

WAPATO - A recent alluvial soil usually occupying present or former drainage-ways. It is a fertile soil when it is in crop, but it is difficult to manage. Drainage and irrigability are fair.

WHITESON - A recent alluvial soil thought to be composed of re-worked Dayton series materials. It has poor drainage.

CLACKAMAS - A soil showing evidence of advanced weathering. Its good original physical condition has been impaired by accumulation of colloidal material in the sub-soil. Drainage and irrigability are fair.

SIFTON - A soil thought to be weathered from material con-

taining an appreciable amount of cinders or charcoal. Inert organic material is found throughout the profile. Sifton is irrigable.

SALKUM - A high terrace remnant of old valley filling. It usually occupies an elevation of 300 to 400 feet. Weathering is advanced, and drainage is impeded. The better condition of this soil, in comparison with Veneta, may be due to the fact that its original composition was mainly basaltic materials, while Veneta materials were derived mostly from sandstones and shales.

SALEM (gravelly) - The less productive phase of Salem.

SAVIE (undrained) - The less productive phase of Sauvie.

Group IV. Soils of low physical productivity, and having a very limited range of possible uses.

DAYTON - An old valley filling soil occupying areas of flat topography, and subject to seasonal waterlogging. Internal drainage is poor, due to accumulation of fine-textured material in the sub-soil.

CONCORD - An intermediate soil series, related to Dayton and Amity. Drainage is poor.

COURTNEY - A soil closely related to Clackamas, but inferior in fertility and drainage properties.

HOLCOMB - A soil related in origin to Clackamas and Courtney. Drainage is poor.

VENETA - A strongly weathered soil having high acidity, poor drainage, and low general fertility.

GRAND RONDE - A foot-slope soil often affected adversely by drainage from higher levels and having poor internal drainage.

COVE - A recent soil always composed of such fine-textured material that it is extremely waxy and difficult to handle. Fertility is quite good, but drainage is poor, and the soil shrinks and cracks upon drying.

TOUTLE - A coarse-textured pumiceous, non-agricultural soil, bordering on riverwash.

Productivity Ratings For Hill Land

The productivity of Willamette Valley hill land was found to be so closely associated with local physical conditions that a study of these conditions was adapted as the point of departure in making a general classification. It was assumed that successful present use of hill land was a strong indication that the land involved had a deep soil mantle, and was reasonably free from adverse conditions of slope, drainage, frost damage, infertility, or erosion. Preliminary investigation revealed that in practically all highly developed hill land districts in the Willamette Valley, the soils were Olympic loam, Olympic silt loam, Olympic clay loam, Melbourne loam, Cascade silt loam, Aiken clay loam, or Polk clay loam. It was decided tentatively, therefore, that these soil types comprised the better hill areas.

Two categories for hill land classification were established, #1H, and #2H. Soils in the #1H areas are of high physical productivity, corresponding approximately to alluvial Group II., and such soils have a similar range of possible uses. Soils in the #2H areas have fair to low physical productivity, and a relatively limited range of possible uses.

Making The Generalized Land Productivity Map

The county soil survey maps were generalized on the basis of the alluvial soil series groupings. The objective was to outline single areas of land that have uniform capacities for crop production. Generalization was freely practiced, however, in mapping both alluvial and hill areas. Small bodies of soils that occur within an area may be quite different from the area as a whole, but they cannot be isolated in a general classification. Very heterogenuous districts were designated according to a rating of the productivity of the district as a whole. The hill areas were outlined tentatively, as described above, on the generalized maps.

From the generalized county maps a preliminary Willamette Valley land productivity map was made. This map and the work maps were then carried into the individual counties, and, with the aid of the County Agricultural Agents and a representative of the Oregon State College, Soils Department, corrections were made. Particular attention was given to hill soil areas in this phase of the work. The completed map, which was used as the basis for the development of Parts II. and III. of this study, is shown as appendix Map I.

Part II. COMPARISON OF THE WILLAMETTE VALLEY LAND PRODUCTIVITY AREAS IN RESPECT TO IMPORTANT FEATURES OF FARM ORGANIZATION

The present discussion differs from a farm organization study, in the strict sense of that term, particularly because modal adaptations, usually called types or systems of farming have been disregarded. Reporting by averages, - the method used, obliterates the individual schemes of organization which were manifest in the raw data. Such a procedure retains all facts necessary, however, to show the more important differences in farm organization which may be attributed to variations in soil productivity.

It is recognized that factors resembling constants extend through all areas. (1) Dairy farms, for instance, comprise nearly one-fifth of the total area in farms (U. S. 1930 Census), and those who are familiar with Valley conditions know that this type of farm is widely distributed and highly adaptable to different soil conditions. Wherever a dairy farm exists it tends to constitute the same enterprises; there is a strong inducement to grown corn, kale, legume hay, and enough barley and oats for feed, regardless of soil conditions that are adverse to production of legumes and corn, or that favor a more intensive mode of adaptation. The situation may be described in more general terms: the presence of dominant enterprises may compete with soil factors in determining which auxiliary enterprises will be selected.

(2) Some heterogeneity of soils is present in all areas. The effect of this is to mask, slightly, the contrast between areas of

high and low productivity.

Basic relationships which are primary to all data presented in subsequent parts of the study are shown in Charts 1 and 2. The six land productivity areas, naturally, vary in size, and there is a corresponding difference in the acreage per area included in the sample. Much of the data appearing in the tables and charts, consequently, are compiled in terms of percentage of each area total, respectively, in order that comparisons may be made.

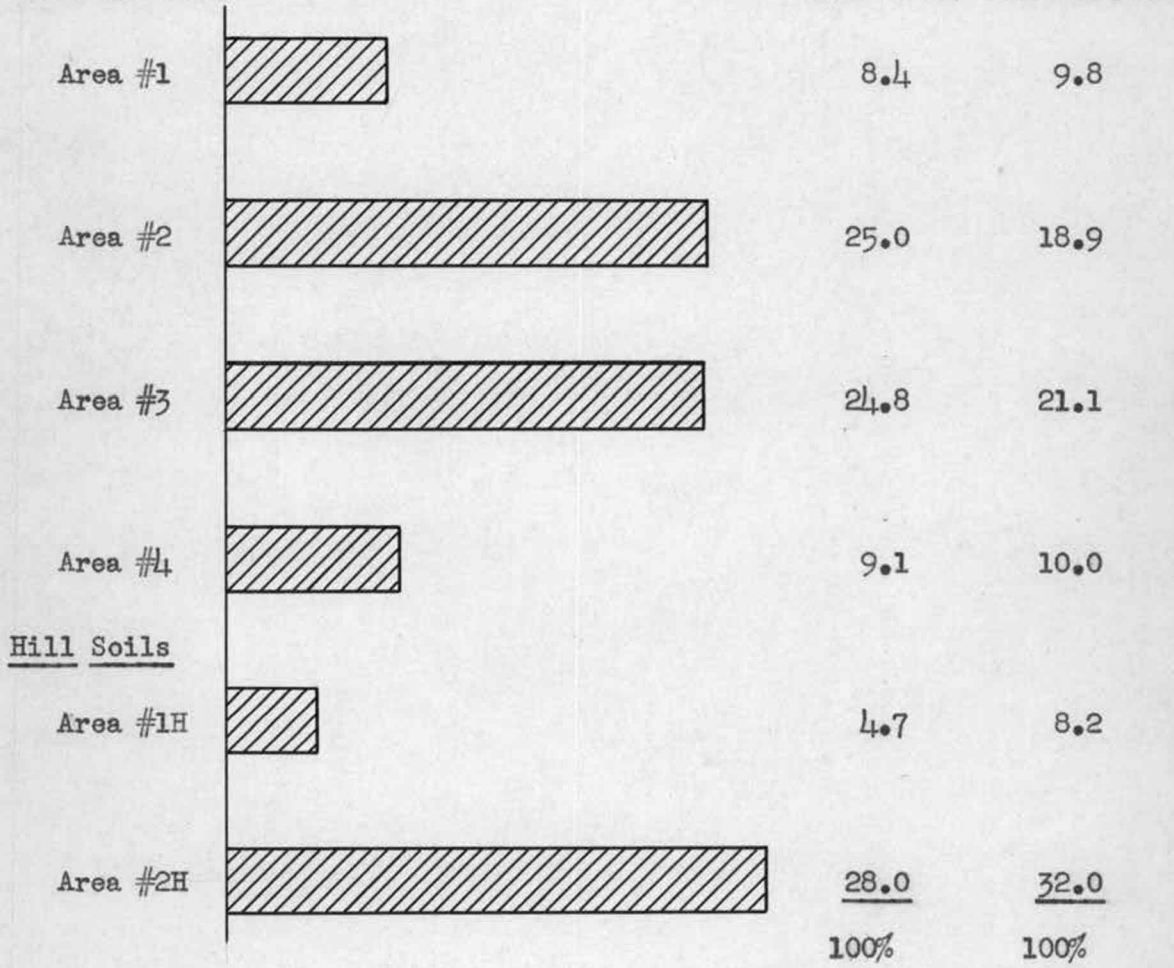
A check upon the distribution of the sample is shown in columns to the right in Chart 1. In one column are shown percentages that the acreage studied per area is of the total acreage in the sample, and in the check column are percentages that the actual acreage per area, as shown by Appendix Map 1, is of the total agricultural acreage in the Willamette Valley. The distribution is considered satisfactory.

The percentages of crop as compared to non-crop land, which the records indicate obtain in the areas, are such that in areas #4 and #2H, only, does non-crop land exceed crop land (Chart 2). A detailed examination, however, reveals that the uniform relationship one might expect, between the quality of land and the proportions of the land devoted to crops, is somewhat impaired by the situation in area #1. Crop land in this area is relatively less than that in either of areas #2 or #3. The explanation is to be found in the fact that river bottom land constitutes most of area #1, hence it is characteristically broken by streams, and often subject to seasonal flooding. Occasion will be found to mention this again when

Chart 1. DISTRIBUTION OF THE SAMPLE

By Willamette Valley Land Productivity Areas
Including a comparison of the sampled acreage with the total acreage as shown in Appendix Map 1.

Sample comprises acreage in 1924 farms



	Percent of acreage in sample	Percent of acreage in entire area (see map)
Alluvial Soils		
Area #1	8.4	9.8
Area #2	25.0	18.9
Area #3	24.8	21.1
Area #4	9.1	10.0
Hill Soils		
Area #1H	4.7	8.2
Area #2H	28.0	32.0
	100%	100%

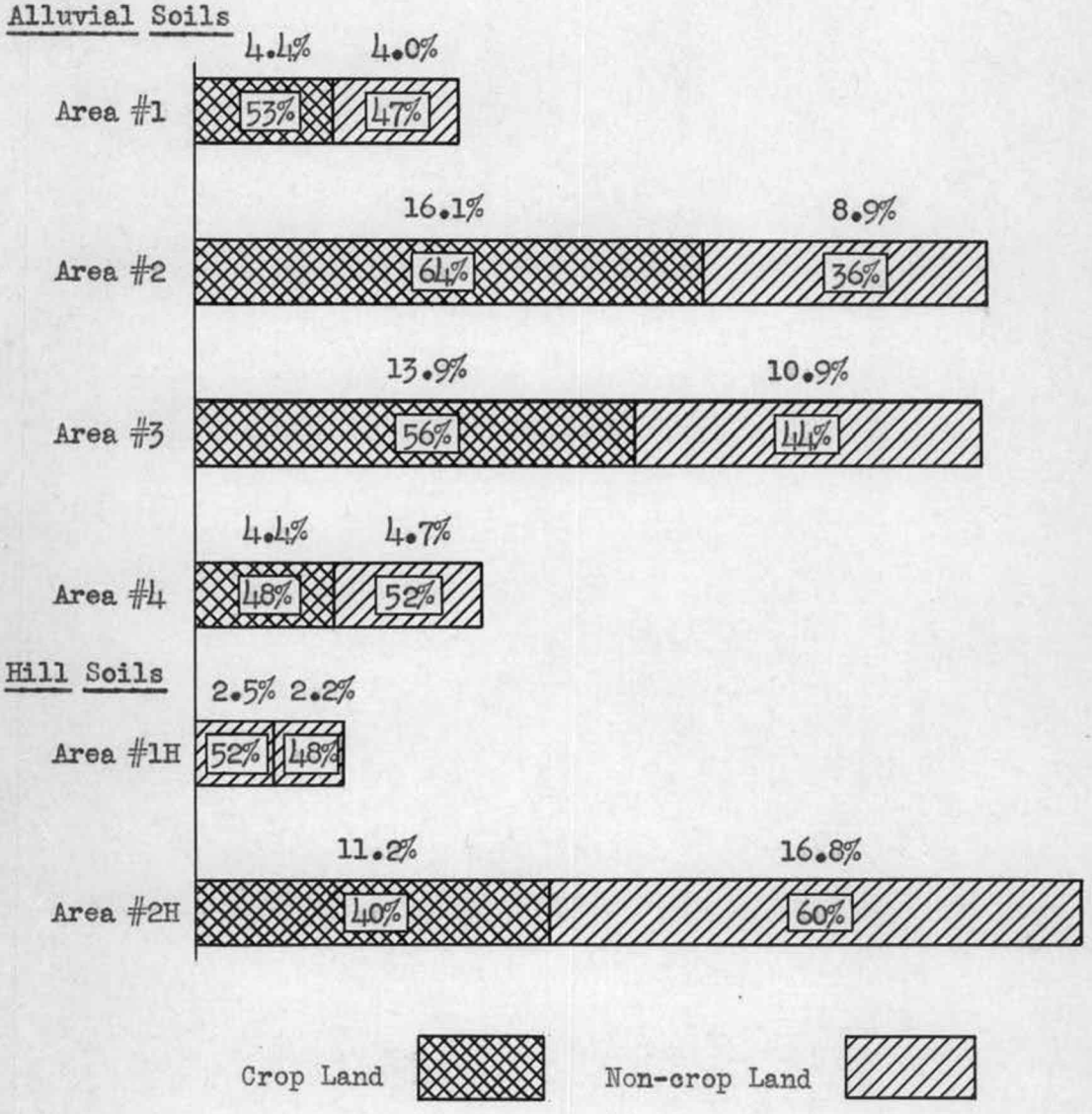
Chart 2. RELATIVE PROPORTIONS OF CROP AND NON-CROP LAND

By Willamette Valley Land Productivity Areas

Compiled from 1924 farm records

Figures above bars are percentages that crop or non-crop land is of total acreage in all areas.

Figures within bars are percentages that crop or non-crop land is of total acreage in each area.



the sizes of the farms are considered. An interesting inference which can be made in regard to the ratios shown is that the highly productive land in area #1 is relatively unimproved.

Crop Enterprises

The outstanding importance of field crop enterprises on farms in all areas became apparent in this study. Even in area #1, 75% of the total crop land was devoted to these more extensive types of crops, and in area #1H, where orchard fruit farming is so prevalent, still 69% of the crop land on sampled farms was in non-intertilled crops (Table 4).

A striking difference, however, was shown in the particular kinds of field crops harvested. The predominance of wheat among grain crops, and alfalfa among hay crops, in area #1, was a feature which did not appear in any other area. There is, indeed, a definite relationship shown between land productivity and the acreage devoted to wheat and alfalfa. A pronounced trend is also noticeable in the case of oats, but it is of an inverse kind. Declines in soil productivity are accompanied by increases in the relative acreage of oats. Vetch hay, similarly, predominates among hay crops in the less productive areas, while clover displaces vetch in area #2.

Farms in area #1 reported a high relative acreage of all hay, despite the fact that intertilled crops were also important. The more intensive crops apparently displaced grain or seed, rather than hay. This may be explained, in part, by the fact that the

Table 4. CROP ENTERPRISES

By Willamette Valley Land Productivity Areas
Compiled from 1,924 Farm Records

Item	Alluvial Soils				Hill Soils	
	Area #1	Area #2	Area #3	Area #4	Area #1H	Area #2H
Total Harvested Crops, Acres	15,565	56,476	48,908	15,368	8,635	39,377
Percent of crop land in:						
Alfalfa hay	10.0	3.7	1.9	1.1	1.5	1.8
Grain or vetch hay	7.6	9.3	12.6	10.0	10.8	13.8
Clover hay and seed	7.9	10.2	9.8	7.1	4.9	8.6
Other hay	2.9	1.4	2.4	3.7	4.1	2.4
TOTAL HAY	28.4%	24.6%	26.7%	21.9%	21.3%	26.6%
Wheat	16.2	22.8	19.1	17.6	13.9	20.5
Oats	12.5	22.9	24.4	27.6	26.0	29.6
Barley	6.7	6.9	7.5	3.3	3.1	4.3
Mixed grain	3.3	3.8	2.9	4.8	2.0	2.8
Vetch seed	1.1	1.4	.8	6.1	.2	.7
Rye grass seed	.8	.8	1.3	9.9	.4	.7
Other grain or seed	2.1	1.2	1.8	3.0	.5	1.1
Soiling crops	.2	.2	.2	.0	.3	.3
Flax fiber	.3	.5	1.6	.6	.1	.0
Seeding and other field crops	3.3	1.8	2.6	1.3	1.4	1.9
TOTAL FIELD CROPS	74.9%	86.9%	88.9%	96.1%	69.2%	88.5%
Corn silage	6.7	5.6	5.7	3.1	5.7	4.0
Kale	.4	.4	.4	.2	.7	.4
Potatoes	2.8	1.2	1.4	.0	2.9	.4
Roots	.3	.2	.1	.0	.1	.0
Truck or garden	1.8	.6	.2	.1	.5	.2
Orchard fruits and nuts	3.2	2.2	1.4	.5	17.3	5.9
Other fruit	1.0	.6	.3	.0	2.2	.4
Hops	8.9	2.3	1.6	.0	1.4	.2
TOTAL INTERTILLED CROPS	25.1%	13.1%	11.1%	3.9%	30.8%	11.5%
TOTAL HARVESTED CROPS	100%	100%	100%	100%	100%	100%

Chart 3. CROP ENTERPRISES

By Willamette Valley Land Productivity Areas

Compiled from 1924 farm records

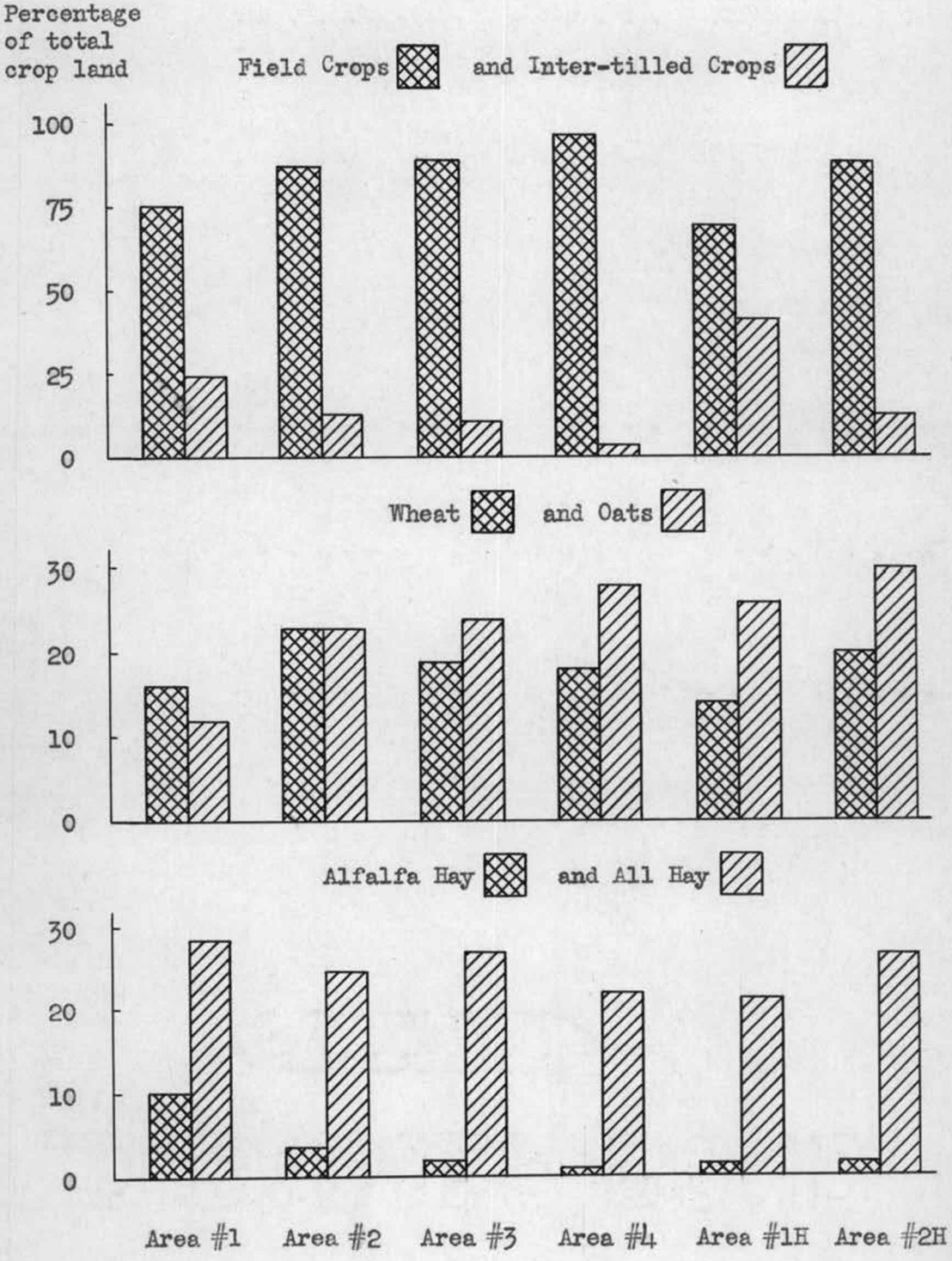
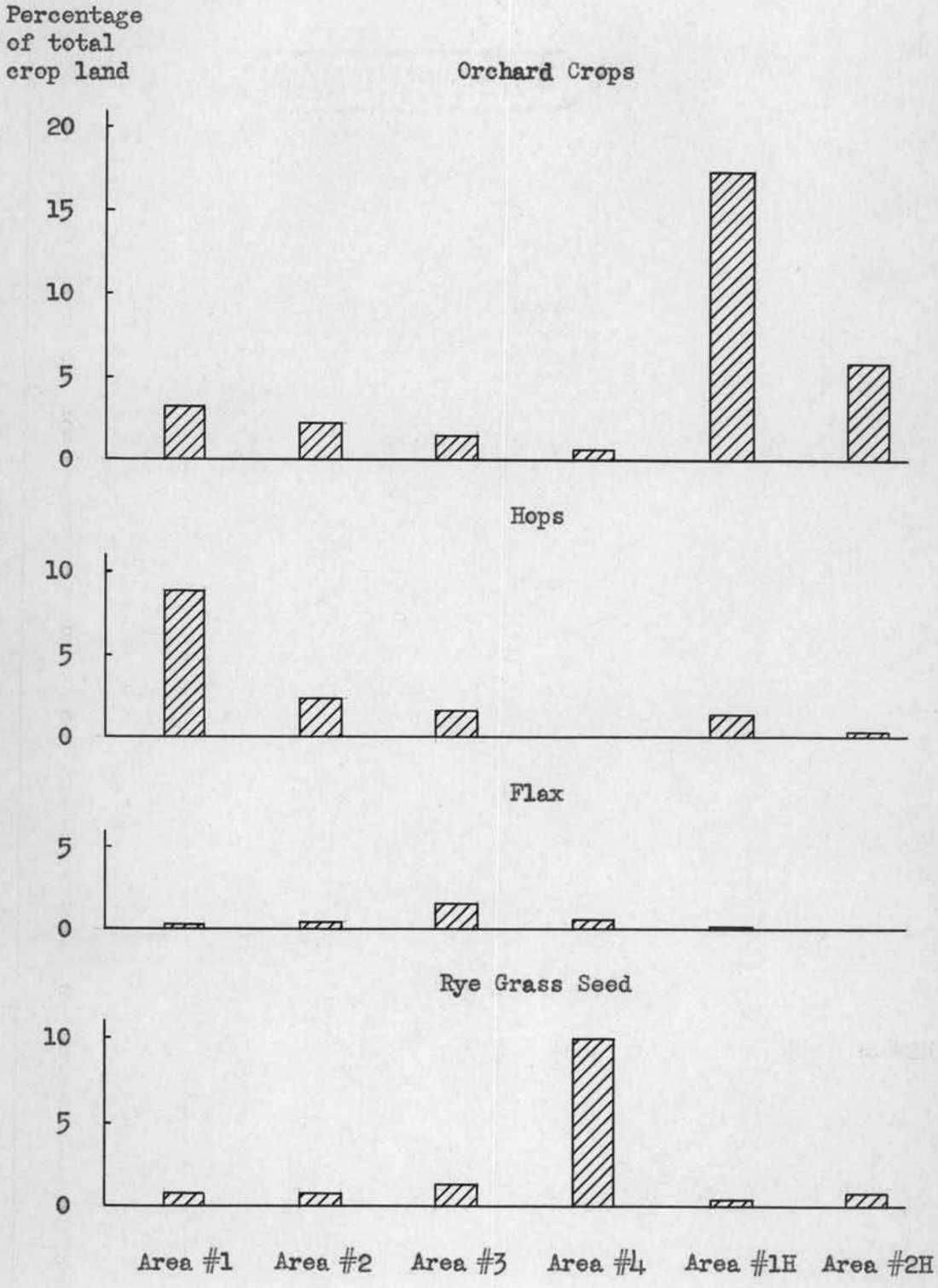


Chart 3. CROP ENTERPRISES (continued)

By Willamette Valley Land Productivity Areas

Compiled from 1924 farm records



amount of hay-consuming livestock per 100 acres in area #1 is relatively large (Table 5), with resulting uniform hay requirement. Greater returns from alfalfa than from grain or seed, as a cash crop, may also be partially responsible.

Corn silage production is closely related to the numbers of diary cows on the farms (compare with Table 5), as might be expected. Intertilled crops which are not subsidiary to other enterprises, however, are found primarily on the more productive soil areas. Specialized enterprises, of a more extensive character, which are particularly important in their adapted areas, are seed production in area #4, and flax fiber in area #3 (Table 4). Chart 3 shows graphically the relation between land productivity and certain crop enterprises.

Livestock Enterprises

Reference has been made to the most interesting feature which tabulation of the numbers of livestock in the areas revealed, namely, the close relation between their numbers and the acreage devoted to forage crops. Chart 4 illustrates this by showing the acres of all hay per cow in each area.

Variable factors, however, may affect the relationship, between livestock and forage crop enterprises. Land in the more productive areas may be assumed to yield more forage per acre than other land, consequently less acreage to produce the same amount of forage would be needed. This factor may be responsible for the lower relative acreages of hay as compared with the numbers of cows

in areas #1 and #1H.

The availability and quality of pasture may, also, influence the numbers of livestock and the forage crop requirements. A higher proportion of non-crop, or pasture, land in area #1 is probably a stimulus to the livestock enterprises in that area. Since forage-feeding is needed to supplement pasturing on most farms in the Valley, the result might be to increase the acreage of forage crops, rather than to displace such acreage.

A final factor which may affect the relation between the comparative importance of livestock and forage crop enterprises on the farms is the production of hay for sale. It cannot be known, at present, whether livestock in any particular area consistently consume a portion of hay produced in other areas.

The data do not indicate that the livestock enterprises compete with intensive crop enterprises under present Willamette Valley conditions. The more productive soil areas tend to have the greatest number of total animal units of livestock (Table 5). It should be recognized that the presence of livestock usually supplements a balanced cropping program, by supplying manure, and converting the legumes necessary for good rotation practice into readily marketable form.

Dairy cows were predominant among livestock in all areas (Table 5). Sampled farms in areas #1 and #1H, however, had more dairy cows and less sheep and turkeys, per 100 acres, than farms in the less productive areas. Farms in area #1H exceeded others in

Table 5. LIVESTOCK ENTERPRISES

By Willamette Valley Land Productivity Areas
Compiled From 1,924 Farm Records

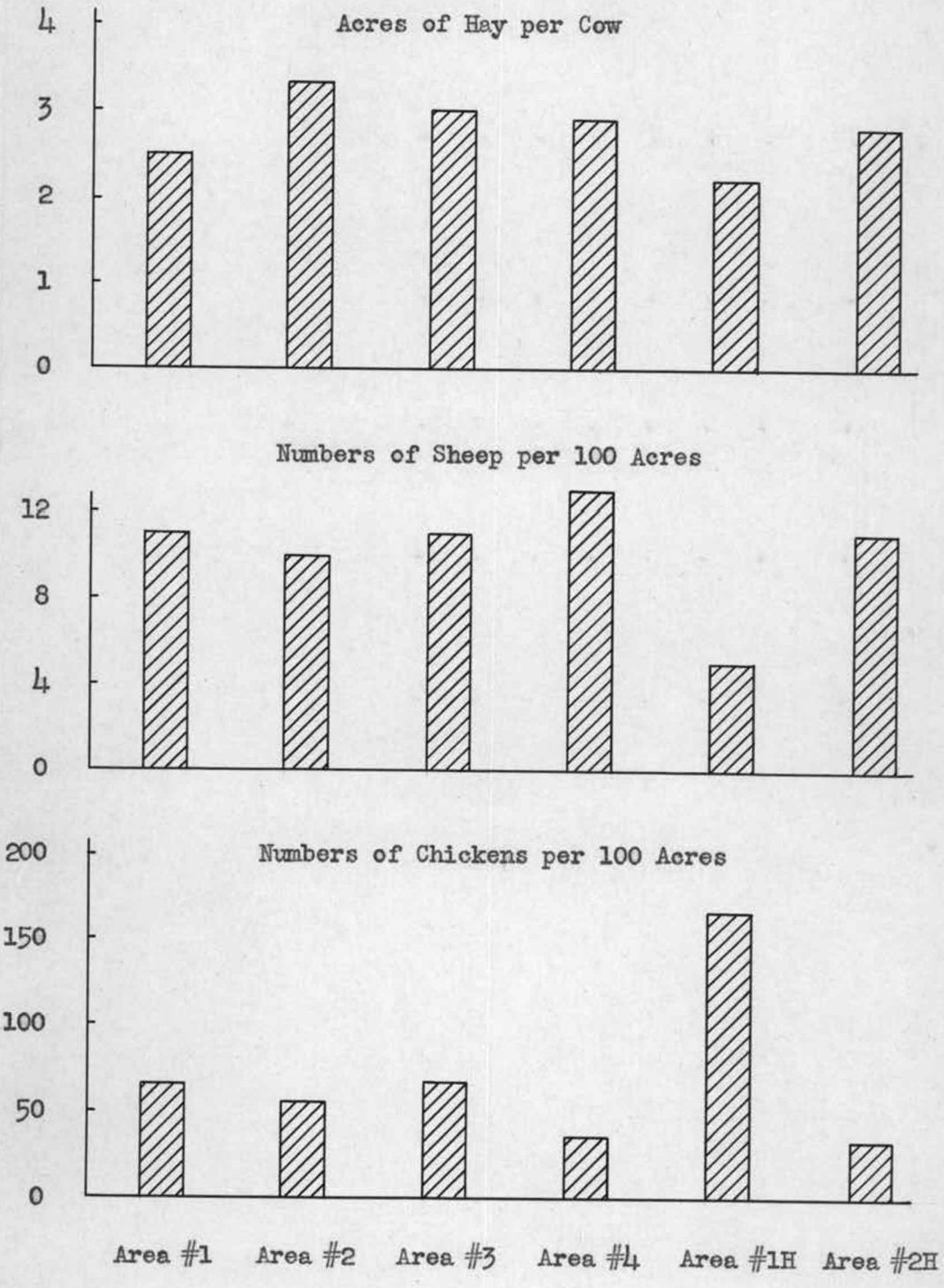
Kind of livestock	Animal Units of Livestock per 100 Acres of Land					
	Alluvial Soils				Hill Soil	
	Area #1	Area #2	Area #3	Area #4	Area #1H	Area #2H
Dairy Cows	6.0	4.7	5.1	3.6	5.1	3.8
Other Cattle	1.7	1.1	1.2	1.1	1.3	1.3
Sheep	2.1	2.0	2.2	2.7	1.0	2.3
Goats	.2	.2	.2	.2	.2	.4
Hogs	1.1	1.2	1.2	.8	.8	.8
Chickens	.7	.5	.7	.4	1.7	.3
Turkeys	-	.1	.2	.4	.1	.1
Total	11.8	9.8	10.8	9.2	10.2	9.0

Note: One animal unit equals 1 cow, 2 other cattle, 5 sheep, 8 goats, 5 hogs, 100 chickens or 75 turkeys.

Chart 4. LIVESTOCK ENTERPRISES

By Willamette Valley Land Productivity Areas

Compiled from 1924 farm records



chickens; this is partially due to the fact that the poultry enterprise supplements fruit farming so well.

The Size Of Business

A standard laymen's criterion for measuring the size of a farm business is the number of acres included in the boundary fence. Another that is currently used, and that gives a much more accurate picture of the true situation, is the amount of capital invested in the farm. Each of these criteria has its especial advantage and its disadvantage. An acre is a relatively stable unit; it is the same in 1936 as in 1929. An acre of Chehalis soil, however, is much more important from a farming standpoint than is an acre of Veneta or Dayton. A 40 acre farm comprising highly productive soil may consequently be a larger business unit than a 200 acre farm comprising poorer soil. Measurement in terms of capital invested corrects, largely, for such a difference in the quality of land, because an acre of Chehalis costs more than an acre of Veneta or Dayton. The value of this investment, however, is subject to material change from year to year, without a corresponding change in the order of activities which is undertaken within the boundary fence. The tendency is to regard the purchase cost of a farm as the true capital investment, and discrepancies occur when farms purchased at different levels of values are compared.

A third criterion for measuring the size of a farming business is the amount of the labor input. This may be regarded as a better measure than either of those mentioned, because the labor factor is

intimately related to the economic program of a farm, yet it is a fairly stable item. An hour's work has approximately the same value throughout a region, and from year to year.

The average sizes of the business units in the land productivity areas were measured both in terms of the acres per farm, and the approximate amounts of labor input annually per farm. Comparable data were not available for computation of the average capital investment per farm in the different areas.

In order to determine the approximate labor input per farm a schedule was made of carefully considered estimates of the amounts of labor that were required annually for Willamette Valley enterprises (Table 6). These estimates were compiled mainly from the numerous enterprise studies which have been made by the Oregon Experiment Station, Department of Farm Management. In the cases where enterprises had not been studied, Warren's estimates or enterprise studies from other regions were used as the basis, and adjustments were made to suit Willamette Valley conditions. The requirements shown in Table 6 were, finally, applied in the cases of all crops and productive livestock recorded for each farm, and totals were tabulated for the separate areas.

The average acreage per farm in areas of low productivity was definitely greater than in areas of high productivity (Table 7 and Chart 5). Area #1 is again anomalous, due to the reason given previously, that a river bottom type of topography prevails. A high average acreage of 187 in all areas, as compared with the

Table 6. PRODUCTIVE WORK UNITS REQUIRED ANNUALLY

Willamette Valley Enterprises
(Ten hours man labor equals one productive work unit.)

Livestock	Productive work units per head
Dairy cows	15.0
Dairy sires	7.5
Heifers	1.3
Brood sows (and litters to weaning)	3.0
Fat hogs (weaning to market)	.5
Sheep	.5
Goats	.3
Hens	.3
Breeding turkeys	.8
Turkeys raised	.3
Bees, per colony	.5

Field crops	Productive work units per acre
Clover hay	1.0
Clover seeding (without nurse crop)	.7
Alfalfa hay	2.3
Alfalfa seeding, alone	1.5
Vetch hay	1.4
Cheat hay	1.3
Rye grass hay	1.0
Canary grass hay	1.0
Timothy hay	1.0
Soiling crops	
Clover, alfalfa, or vetch	2.0
Corn	3.0
Kale	8.8
Mangels	15.0
Corn silage	3.7
Vetch silage	2.4
Small grains	2.0
Corn grain	3.0
Clover seed	1.0
Rye grass seed	1.0
Flax seed	2.0
Cheat seed	2.0
Potatoes	10.0
Mint (not distilled)	2.0
Hops, bearing	50.0
Hops, planting	20.0
Fiber flax	3.0

Truck	
Cannery tomatoes	15.0
Sweet corn	5.0
Cabbage	13.0
Onions	30.0
Orchard crops	
Prunes, dried	11.5
Prunes, packed fresh	9.0
Cherries	11.5
Peaches	11.5
Apples and pears (commercial)	20.0
Apples and pears (non-commercial)	3.0
Walnuts	7.0
Filberts	7.0
Young orchard	2.5
Small fruits	
Strawberries	58.0
Cane fruits	50.0
Grapes	25.0
Gooseberries	20.0

Note: Estimates prepared in consultation with the Department of Farm Management staff, Oregon Agricultural Experiment Station, 1935.

U. S. 1930 Census average for the Willamette Valley counties of 97, may be attributed to the fact that farms included in this study are quite exclusively of the commercial kind, whereas a high percentage of part-time and abnormal farms is included in the Census report.

Area #1 shows a greater average number of productive work units per farm expended annually than on farms in other areas (Table 7). The labor input in this area is approximately 1.7 times that in area #4. The areas throughout, however, are remarkably uniform. An increase in acreage per farm, in the poorer areas, nearly compensates for decrease in intensity of cultivation. This may be expressed in another way: the acreage required to provide opportunity for the standard input of labor increases as the productivity of the soil declines. The farming units tend to be of sizes that will yield an income sufficient to maintain the operator and his family on our average standard of living.

The mode which is shown is equivalent to about 1.6 men's work yearly per farm. This is apparently a standard which applies to a large number of Willamette Valley farms, as the customary yearly labor input commonly required to carry through a satisfactory farming program. Such data indicate also that the residence, or farm living, factor has an important effect upon farm organization. It may be inferred that it is a fundamental factor, which links farm economics with the fields of social study. The family unit system of farming is an important aspect of our democratic, cultural pattern. It is conceivable that, with a

Table 7. SIZE OF BUSINESS

By Willamette Valley Land Productivity Areas
Compiled from 1,924 Farm Records

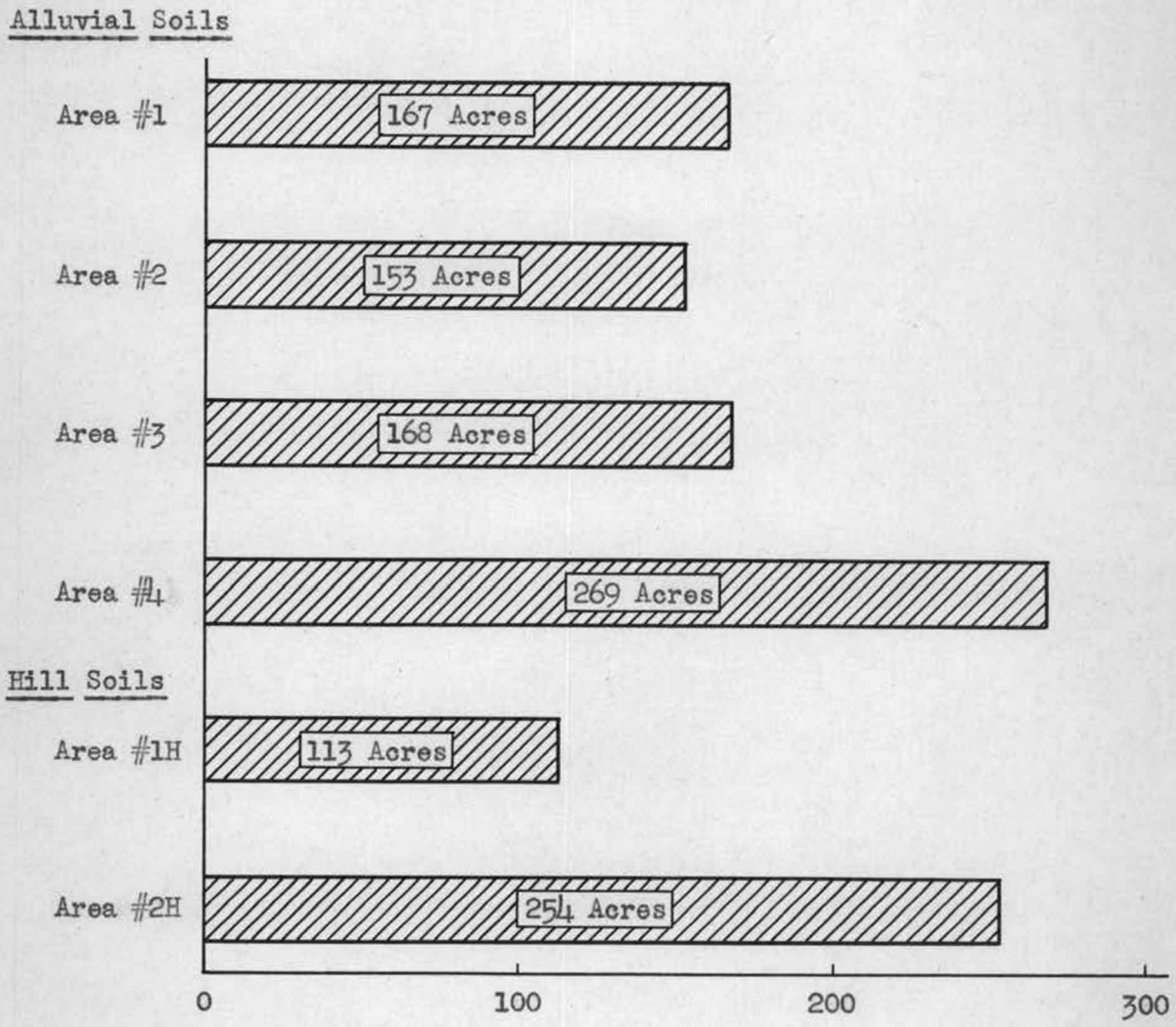
	Alluvial Soils				Hill Soils	
	Area #1	Area #2	Area #3	Area #4	Area #1H	Area #2H
Average acres per farm	167	153	168	269	113	254
Average productive work units expended per farm	812	528	473	479	469	481
Average labor input per farm (full-time men)	2.7	1.8	1.6	1.6	1.6	1.6

Note: 10 hours of man labor equals 1 productive work unit; 300 hours is assumed to be 1 man's yearly work.

Chart 5. AVERAGE ACRES PER FARM

By Willamette Valley Land Productivity Areas

Compiled from 1924 farm records



change in social values, the agricultural industry might be reorganized into larger units, and the farmer-operator be replaced by the agricultural manager and laborer.

Larger business units, as measured by labor input, might be expected in area #1H, corresponding to its relatively high intensity of cultivation. The fruit farming which is prevalent in this area, however, tends to be specialized. The labor load is seasonal, and slack periods apparently offset periods of greater-than-average activity. Diversification, to balance labor programs, and to stabilize incomes is needed on such farms.

Quality Of Business

The method which is employed in farm management procedure to measure the quality or yield factor is to compare the yields of crops on a given farm, or in a particular district, with the average in the community or region. This is done by means of a crop index, which states in one figure the yields of the crops in any one area with the average yield of the same crops in all areas.

Crop indices were computed from the reports of 330 farms and involved 19,161 acres distributed among wheat, oats, barley, grain hay, clover hay, corn silage, and potatoes. A close relationship was shown between original soil quality and the yields of crops, excepting that hill land farms, as a whole, compared unfavorably with farms in the alluvial areas (Table 8).

The advantage in capacity for producing crops which obtains

Table 8. QUALITY OF BUSINESS

By Willamette Valley Land Productivity Areas

Item	Alluvial Soils				Hill Soils	
	Area #1	Area #2	Area #3	Area #4	Area #1H	Area #2H
Crop index:						
Number of records	38	95	75	29	25	68
Acreage of crops	1770	5505	4442	1907	1038	4498
Index of yields	115	110	103	91	95	85
Wheat yields:						
Number of records	57	310	237	55	49	206
Acreage of wheat	809	5123	3755	880	441	3211
Yield per acre (bu.)	26.0	25.6	23.6	21.2	24.0	21.4
Excess above area #4 yield (bu.)	4.8	4.4	2.4	-	2.8	.2

Note: Crop index was computed from reported yields of 4756 acres of wheat, 5705 of oats, 1267 of barley, 4179 of grain hay, 1736 of clover hay, 1167 of corn silage, and 351 of potatoes; Oregon Agricultural Experiment Station. Dept. of Farm Mgt. records.

Wheat yield data were compiled from A. A. A. Wheat allotment contract records, reporting average yields for the base period 1930-33.

in the areas having favorable physical characteristics is shown explicitly in the portion of Table 8 which was compiled from 914 A. A. A. wheat allotment contract records. A comparison of the areas reveals a maximum difference in average yield of 4.8 bushels per acre. This apparently small difference assumes real magnitude when it is converted into a corresponding difference in land value. Extra labor, threshing, and tax costs involved in obtaining this premium are small items, certainly reducing the advantage by no more than 1/4. The net advantage of approximately 3.6 bushels, sold at .75 per bushel, and capitalized at 5% would justify a difference in land value of approximately $54 per acre. Even this figure, however, does not fully express the true warrented difference in land values which might obtain. For the singular value of our most productive land derives from its capacity to produce crops, such as hops or fruit, which cannot be grown elsewhere.

A cause related to this may be partially responsible for the low index of area #1H, when comparison is made of crop indices in Table 8. Crops for which this area is eminently adapted, namely fruits and nuts, cannot be grown in all areas, consequently a full comparison cannot be made.

Data regarding the crop yield factor show clearly the varying productive capacities of the different soil areas. To obtain satisfactory incomes from farms under these varying conditions, specific attention must be given to the farm organization set-up,-through selection of enterprises, and adjustments in volume of business

- to compensate for the differences in yield capacity.

This adaptation, of farm organization to the quality and character of the soil, is the problem of the farmer in each soil area. Its presence indicates a field of necessary future research.

Part III. THE UTILIZATION OF LABOR IN THE LAND PRODUCTIVITY AREAS

A primary significance of soil productivity is that this native factor tends to regulate the amount of labor that can be expended profitably in the production of crops. Extremes may be used for illustration: on land of least productivity, grazing land, the maximum of labor that can be spent profitably is for herding, fencing, or otherwise caring for livestock; on land of highest productivity, Lake Labish peat, for instance, man labor may be combined with other factors of production in large amounts, up to 500 or 600 hours per acre annually. On marginal land, practically all labor is spent on livestock enterprises, or on crops subsidiary to production of livestock products; on land having greatest capacity for producing crops, practically all labor is spent on independent cash crop enterprises. Specialization, in this sense, marks both extremes in agricultural land utilization.

Distribution Between Crops And Livestock

Table 9 shows the differences in distribution of labor between crop and livestock enterprises which obtained on sampled farms in the land productivity areas: 74% of all labor input went to crops in area #1; only 50% in area #4. Area # 1H corresponded exactly with area #2, with 66% of labor devoted to crop enterprises. The distributions are entirely harmonious with conditions of natural productivity.

Table 9. DISTRIBUTION OF LABOR INPUT
Between Livestock and Crop Enterprises

By Willamette Valley Productivity Areas
Compiled From 1,924 Farm Records

Item	Alluvial Soils				Hill Soils	
	Area #1	Area #2	Area #3	Area #4	Area #1H	Area #2H
Productive work units expended on crop enterprises, percent	74	66	59	50	66	56
Productive units expended on livestock enterprise, percent	26	34	41	50	34	44
	100%	100%	100%	100%	100%	100%
Average productive work units per farm on crops	601	348	279	238	311	270
Average productive work units per farm on livestock	211	180	194	241	158	211
Total productive work units per farm	812	528	473	479	469	481

Note : Computed on the basis of estimated labor requirements shown in Table 6 one productive work unit equals 10 hours of man labor, only.

The question may be raised, - is there an absolute diminution in the importance of livestock enterprises in area #1, or is the low percentage of labor input to livestock entirely due to a relative increase in production of intensive cash crops? The answer to this question is given, also, in Table 9. Area #1 is equal to area #2H, and second only to area #4 in absolute expenditure of productive work units per farm on livestock. Disregarding the irregularity of area #1, however, there is a trend in absolute reduction of labor input to livestock, corresponding to increases in soil productivity and increases in labor spent on cash crop enterprises. The situation in area #1 may be explained as the result of the high proportion of non-crop land, useable only for livestock. It is felt that bottom land development, similar to that which now obtains in the valley floor areas, will be marked by a considerably greater relative labor investment in cash crops, and in an absolute decline in the amount of labor expended per farm on livestock.

Labor Input Per Crop Acre

The distribution of labor between crops and livestock indicates in a general way the comparative degrees of intensification in the land areas. This may be appreciated more fully, however, by a study of computed* data showing the man hours of labor input per crop acre (Chart 6).

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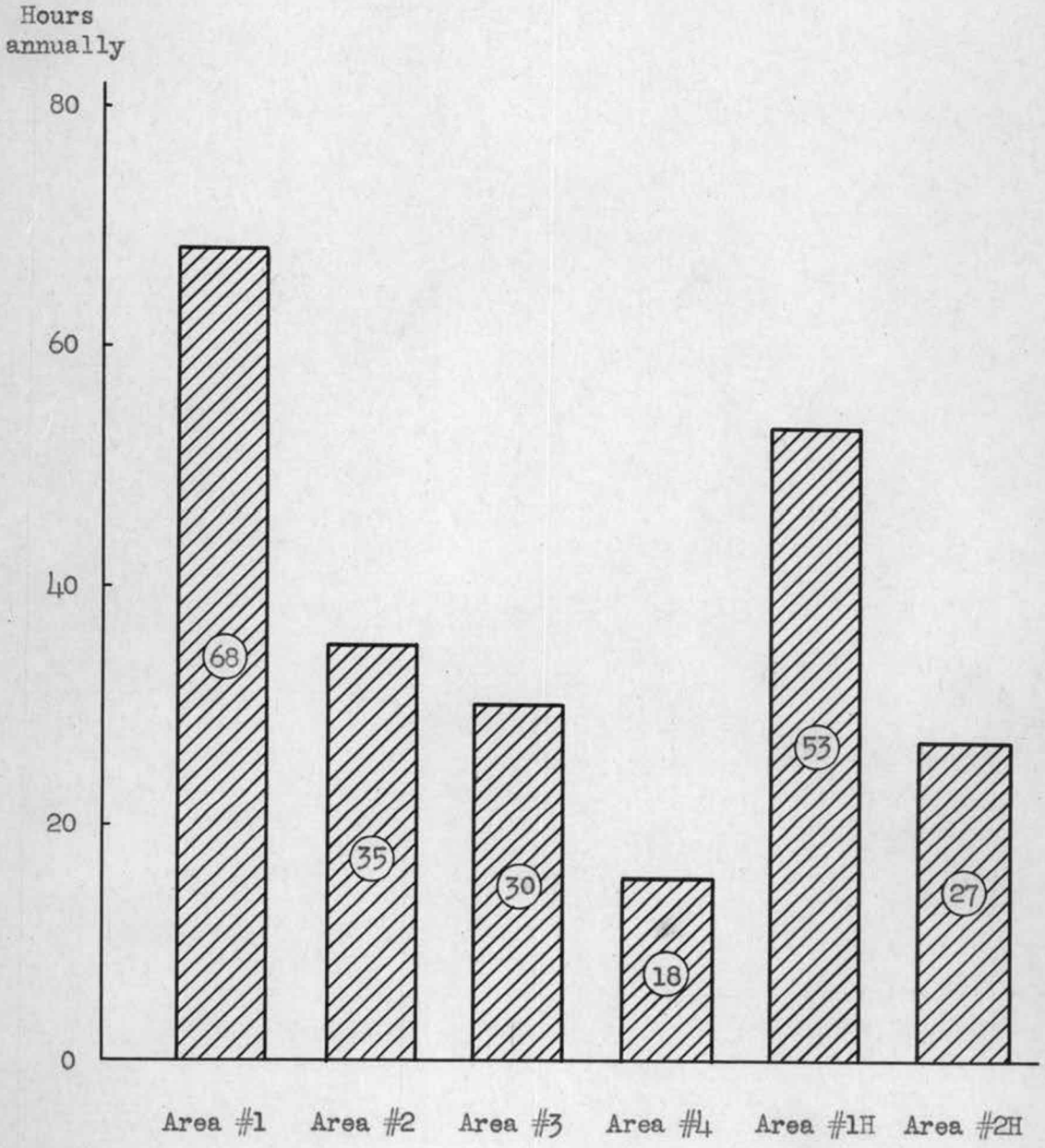
* Computed on the basis of estimated labor requirements shown in Table 6.

Chart 6. AVERAGE LABOR INPUT PER CROP ACRE
By Willamette Valley Land Productivity Areas

1924 Farm Records



Note: Computed on basis of estimated labor requirements shown in Table 6.

Crop production in area #1 apparently involved the average expenditure of 68 hours of man labor per acre harvested, compared with 18 hours for area #4. Even in area #2, the average labor input per acre was but one-half that in area #1. An outstanding degree of intensification was shown, also, in area #1H, with an average of 53 hours of labor input per crop acre.

Our Present Stage Of Development

The foregoing report upon present adaptation of certain farms in the Willamette Valley to differences in land productivity may be presented with a great deal more certitude than an attempt to orient the present in reference to the past or future. The study would not be complete, however, without a brief interpretation of the data assembled in-so-far as it indicates our present stage in farm organization adjustment and intensification.

A reference was made in the introduction to the fact that Willamette Valley agriculture is relatively young; in most districts land has been cultivated for no longer than 75 years. We should expect, and we find, a pronounced impression of the pioneer period upon the present program of farming.

The relative lack of development in area #1 may be attributed to this influence. Data show that this rich, bottom land area has a high proportion of non-crop land, and that livestock enterprises and crops subsidiary to livestock production are of singular importance. It is reasonable that development of this fertile soil should

have been retarded, because it bore a tangled, brushy cover, it is often of broken topography, and seasonal overflow is a common occurrence. The smooth-lying main valley floor adjacent was naturally exploited first, its soils being eminently adapted for producing the forage and grain crops which are the basis for a pioneer stage of farming.

The result of four generations of extensive crop farming in the Valley is that the grain and hay habit has been thoroughly established, often regardless of potentialities which certain soils have for yielding more valuable products. The situation is by no means alarming, except possibly that single-cropping without rotation, which occurs in some areas, may impair fertility. But it may be expected that economic pressure will cause a gradual shift, on all eligible soils, to the higher types of crops which can be grown in a temperate, humid climate.

The recent and growing emphasis given to supplemental irrigation is an important indication of a rapid change. Of the 740,000 acres* of good irrig ble soils in the Willamette Valley, it is estimated** that only 7,000 acres are at present under irrigation. Supplemental irrigation can probably be supplied to 250,000** acres before serious economic limitations are encountered. Comparatively

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* Dr. W. L. Powers. Twenty-five Years of Supplemental Irrigation Investigations in Willamette Valley. Oregon Agricultural Experiment Station Bulletin 302, 1932.

** Dr. W. L. Powers estimates, unpublished.

rapid development in this direction, and a consequent intensification and adaptation in farm organization, may be expected. Control of seasonal flooding should be a concurrent development.

Specialization is closely related to intensification, since it, also, involves a response to soil and economic factors. Areas which are more or less specialized and intensive are discernable at present in the Willamette Valley: Independence for hops; Powell Valley and the Woodburn district for berries; David's Hill, Dundee Hills, and Liberty Hills for orchard fruits and nuts; and the Columbia River and Lake Labish districts for truck gardening, are examples. Some evidence of specialization in extensive cash crops has appeared, also, as in the concentration of ryegrass seed production in certain districts of area #4 soils, and of flax fiber production in areas #3 districts.

Limitations are more readily encountered in specialization of farming, however, than in intensification. A diversified farm, as a rule, yields a more stable income, and its operation may be more economically managed. From a community standpoint, diversified farming usually favors soil conservation, and it offers a broader and steadier basis for economic and cultural development. Single-crop communities are particularly susceptible to serious injury by price and trade fluctuations. These factors may limit specialization without affecting intensification, because intensive farms may be either diversified or specialized.

CONCLUSIONS

It is felt that the following general conclusions are warranted:

(1) Willamette Valley farms show a marked degree of adaptation to conditions of soil quality and character.

(2) A higher proportion of intertilled crops are grown in the more productive land areas.

(3) The acreage per farm tends to be less in the more productive areas, but the size of business, as measured by labor input per farm, tends to be greater.

(4) A higher quality of business, as measured by crop yields, prevails in the more productive areas, but the disadvantage of lower yields in the less productive areas may be offset successfully by proper adaptation in farm organization.

(5) A greater proportion of labor input is devoted to crops, as compared to livestock, in the more productive areas.

(6) Intensity of cultivation is distinctly greater in the more productive areas, as shown by the average labor input per crop acre.

(7) Our present stage of development in adaptation of farm organization to soil differences, and in intensification, is no more than intermediate, as shown by the prevalence of extensive types of adaptation in all areas, despite the fact that a large acreage is irrigable, and well adapted for production of intensive crops.

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(6) W. F. Gericke. Aquaculture, a means of crop-production. American Journal of Botany 16:862. 1929

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Appendix Table 1. COMPARISON OF THE SAMPLE WITH 1930 U. S. CENSUS

By Major Crop Groups

Crop	Acreage in sample	Percent of Total (sample)	Average in Valley by census	Percent of Total (census)
Hay	47,061	29.6	274,064	35.6
Grains	98,859	62.1	375,032	48.7
Orchard fruit and nuts	6,353	4.0	67,361	8.7
Other fruits	964	.6	18,493	2.4
Potatoes	2,247	1.4	19,676	2.5
Hops	3,692	2.3	15,943	2.1
Totals	159,176	100%	770,569	100%

Note: Census data compiled by E. L. Potter and R. Wilcox, Intensification of Agriculture in the Willamette Valley, unpublished.